Received: 2 April 2023 | Accepted: 4 November 2023

DOI: 10.1111/ecot.12405

ECONOMICS of TRANSITION AND INSTITUTIONAL CHANGE

WILEY

ORIGINAL ARTICLE

It's all in the stars: The Chinese zodiac and the effects of parental investments on offspring's cognitive and noncognitive skill development

Chih Ming Tan[1] | **Xiao Wang**[2] | **Xiaobo Zhang**[3,4]

[1]Department of Economics & Finance, Nistler College of Business and Public Administration, University of North Dakota, Grand Forks, North Dakota, USA

[2]International Institute of Finance, School of Management, University of Science and Technology of China, Hefei, Anhui, China

[3]Guanghua School of Management, Peking University, Beijing, China

[4]International Food Policy Research Institute (IFPRI), Washington, DC, USA

Correspondence
Xiao Wang.
Email: iriswx@ustc.edu.cn

Funding information
Greg and CIndy Page Faculty Distribution Fund; National Natural Science Foundation of China, Grant/Award Number: 72003181; Tang Scholar Fund, Grant/Award Number: KY2040000037

Abstract

Parental investments in children's cognitive and noncognitive outcomes are deeply important to policymakers. However, because parental investments are arguably endogenous, estimating their importance empirically poses a challenge. To address this challenge, this paper exploits a rich and novel dataset, the China Family Panel Studies, and proposes a culture-specific instrumental variable based on the Chinese zodiac. By comparing the outcomes of children born just before and just after the cutoff for a "lucky" (or 'unlucky') zodiac sign, we find that parents' investments have significant effects on offspring's development of both cognitive and noncognitive skills.

KEYWORDS
China, cognitive skills, noncognitive skills, parental investments, zodiac signs

JEL CLASSIFICATION
I10, I15, J24, O12, O53

1 | INTRODUCTION

Early investments by parents play an important role in shaping cognitive and noncognitive skills in their offspring. It has been postulated that early life investments generate higher returns than investments made later in the child's life (Anger & Schnitzlein, 2017; Carneiro & Heckman, 2005; Kirchsteiger

All authors contributed equally to the work.

& Sebald, 2010; Shonkoff & Phillips, 2000).[1] However, a major challenge in the empirical literature is to properly identify the economic returns on early childhood educational investments because such investments are arguably endogenous. Parental investment decisions are based on their own private knowledge about their children, which are often not observable by the econometrician. For example, parents may know something about the differences in innate motivation among their children and may allocate scarce resources among their children to maximize the children's overall outcomes based on this knowledge.[2]

Using data from the China Family Panel Studies (CFPS), this paper employs a particular culture-specific determinant of parental investment behavior as a source of exogenous variation to identify and consistently estimate the returns on early parental investments. Specifically, this analysis employs the child survey module in the 2010, 2012, and 2014 waves of the CFPS which includes direct measures of both cognitive (word recognition and mathematical ability) and noncognitive (curiosity, organization, optimism, mistake tolerance, and anger control) skills for children.

The proposed set of instrumental variables (IVs) for parental investments are specific to Chinese/Asian culture. The Chinese zodiac is a traditional categorization scheme that assigns an animal to each lunar year in a repeating 12-year cycle.[3] The 12 zodiac signs are Rat, Ox, Tiger, Rabbit, Dragon, Snake, Horse, Sheep, Monkey, Rooster, Dog, and Pig. It is well known that some parents plan the birth of their children to coincide with the "lucky" signs. For example, because positive characteristics are associated with the Dragon zodiac sign, some parents plan their children's birth to fall in the year of the Dragon (Lim, 2012). This phenomenon exists even among Asian immigrants to the United States (Johnson & Nye, 2011). Based on established beliefs in Chinese culture, we categorize the zodiac signs into (1) "lucky" signs: Tiger and Dragon, (2) "unlucky" signs: Snake and Sheep, and (3) "neutral" signs: all others.

The zodiac signs may impact parental investments through the following two channels.[4] The first channel is superstition, a purely cultural mechanism that is specific to the Asian (Chinese, in this case) context, whereby some parents hold strong beliefs about children born under particular (e.g., "lucky") signs. Their beliefs in turn drive their decisions about investments in their children. Mocan and Yu (2020) posit that parents have higher expectations for children born under the Dragon sign, which leads them to invest more in such children, thereby improving their educational outcomes and chances for success —hence, generating a self-fulfilling prophecy.

The second channel arises from rational responses to the superstition-based behavior of other parents. If some parents believe in the mysterious power of zodiac signs and invest more in their

[1]The literature on the economic return of parental investment includes Heckman and Rubinstein (2001), Heckman et al. (2006), Borghans et al. (2008), Chetty et al. (2011), Heckman et al. (2013), Cadena and Keys (2015), Hanushek and Dennis (2000), and Hanushek and Woessmann (2008). See also Heckman and Mosso (2014) for a comprehensive survey.

[2]Heckman and Mosso (2014) explained how parents' decisions to either reinforce or compensate for a child's disadvantages rely critically on both the parents' preference for equality of outcomes across their children as well as the curvature of the human capital production function.

[3]Lunar zodiac signs (as opposed to the solar signs common in Western cultures) originated in China and spread to other Asian countries. But there are minor differences in practices across those countries. For example, in Vietnam, zodiac signs are combined with the five essential elements (Do & Phung, 2010). People in China generally know and care only about the zodiac signs, not their interactions with other astrological constructs.

[4]Other works in the literature have explored how zodiac-related factors affect economic outcomes. However, establishing causality has been a serious issue. For example, in the context of Hong Kong, Vere (2008) employed variations in fertility across different lunar years as an instrument to estimate the effect of fertility on female labor supply. Do and Phung (2010) and Johnson and Nye (2011) found that children born in the year of the Dragon have longer schooling in Vietnam and among Asian immigrants to the United States. In contrast, Wong and Yung (2005), using Hong Kong census data, found no evidence that children born in the year of the Dragon have better earnings.

children accordingly, other non-superstitious parents may feel compelled to follow suit by increasing their own investment in their children. This response can be thought of in terms of social interaction effects (Blume et al., 2011; Durlauf & Ioannides, 2010), whereby the actions of some parents (in this case, the rational ones) are dependent upon the optimal choices of other (superstitious) parents. Under the assumption that sufficient numbers of parents are superstitious about zodiac signs, the combination of the channels justifies the potential relevance of zodiac-related IV's in influencing parental investments.

The validity of the IV approach, however, relies on the assumption that zodiac signs are randomly assigned to children. If parents purposefully choose their children's birth dates to favor lucky zodiac signs, then selection bias will arise when comparing children's outcomes. Therefore, we need to exclude the children born to parents who have intentionally planned for their children to be born under a particular (e.g., "lucky") sign.

Our strategy for excluding such children is based on the assumption that parents who are intent on achieving a particular zodiac sign for their child would be very unlikely to plan for their child to be born close to the margins of the targeted lunar year. This is because they would want to avoid the risk of their child being born in the "wrong" lunar year. Instead, they would plan for their child's birth date to be somewhere in the middle of a lunar year, away from the margins of the preferred zodiac sign. We assume that parents whose offspring are born within a small window around the end of one lunar year and the beginning of the next lunar year, that is, a window across two signs (one of which is 'desirable' and the other 'less desirable'), are not engaging in sign selection. Their child just happens to be born under one sign as opposed to the other (adjacent) sign. Specifically, we define the signs of children born within such a window as being born under "random zodiac signs."

We assume that children born, within this window, under lucky signs and those born under adjacent neutral or unlucky signs (together, the 'non-lucky' signs) are otherwise exchangeable in terms of their unobserved characteristics. Thus, the random assignment of zodiac signs across children born within the window between two lunar years provides a source of exogenous variation in culturally induced differences in parental investments, allowing us to identify the effects of these investments on children's cognitive and noncognitive outcomes. These random zodiac signs form our IVs for parental investments. The proposed IV approach is therefore closely related to a regression discontinuity design approach. We further restrict our comparison to children from pairs of adjacent zodiac signs who are in the same schooling cohort and would be therefore facing the same (future) market for jobs and educational opportunities.

We first show that parents invest differently between children with lucky (unlucky) random zodiac signs and those with adjacent neutral random zodiac signs, supporting the choice of the IV. In the second stage of the IV regression, we find that (i) a 10% increase in total education costs can improve the word recognition test score by 0.712 (9.5% of its standard deviation) and math test score by 0.387 (9.3% of its standard deviation). These are economically large magnitudes of improvement. (ii) a 10% increase in total education costs can improve the assessment scores for children's curiosity, organizational skills, the ability to cope with or tolerate others' mistakes, and the ability to control anger or anxiety by between 0.022 (2.5% of its standard deviation) and 0.054 (5.8% of its standard deviation). Alternative specification and a variety of checks confirm our results are robust.

Our work contributes to the literature about the impact of parental investment on child development. Heckman and Mosso (2014) summarize that parental investment, especially at the early stage, is a critical determinant of human capital development. Moreover, human capital accumulation helps economic agents to improve their labor market performance (Heckman et al., 2006) and contributes to economic growth (Hanushek & Woessmann, 2008). However, identifying the causal impact of parental investment on child skills is difficult due to parents' private information on children and the

resulting endogeneity in investment choice (Do & Phung, 2010; Vere, 2008; Wong & Yung, 2005; Zhang et al., 2014). Our work not only provides new direct evidence of the positive impact of parental investment on children's cognitive and noncognitive skills (Chuan et al., 2010, 2022; Cunha & Heckman, 2008), but also proposes a new identification strategy by exploiting the relatively random assignment of Chinese zodiac signs around narrow birth windows.

Our paper is also related to an emerging literature that employs exogenous shocks toward initial endowments to investigate the effects of early investments on children's cognitive and noncognitive outcomes. For example, Tan et al. (2023) examined the impact of in utero famine exposure on later-life cognitive outcomes in the context of the Great Chinese Famine of 1959–1961. Leight et al. (2015) exploited early rainfall shocks to study how children's cognitive and noncognitive skills develop over time, finding that parents invest to reduce the impact of negative shocks. Other studies have used policy experiments to study the impact of childhood investment, such as Adhvaryu and Nyshadham (2016) on pre-birth exposure to iodine, Ludwig and Miller (2007) on a discontinuity in Head Start funding, and Chetty et al. (2011) on the random assignment of teachers and students to classrooms. Our paper differs from this body of literature by looking at the impact of parental investment in the absence of exogenous shocks.

Finally, our paper also speaks to the literature on the role of hope/aspirations in development (Beaman et al., 2012; Sen, 1999) and the role of parental belief in their investment (Boneva & Rauh, 2018). A growing body of literature shows that inaccurate parental beliefs can reduce investment in children and that differences in parental beliefs can explain their investment choices (Cunha, 2014; Cunha et al., 2013; Dizon-Ross, 2019). This paper shows culture-specific belief can affect parental investment, which in turn explains children's skill development.

The rest of the paper is organized as follows. Section 2 describes the data and the details of the methodology. Section 3 discusses the findings, and Section 4 concludes.

2 | DATA AND METHODOLOGY

2.1 | Data

Our main dataset is from the CFPS surveys conducted in 2010, 2012, and 2014. The CFPS is a nationally representative, annual longitudinal survey of Chinese communities, families, and individuals funded by the Chinese government and conducted by the Institute of Social Science Survey of Peking University, China. The CFPS was formally launched in 2010. All individuals in families surveyed in 2010 are followed up in every subsequent survey, which takes place every two years. The CFPS includes four questionnaires: community, family, adult, and child. Our data are constructed using the child questionnaires for 2010, 2012, and 2014, complemented by the corresponding adult and family survey questionnaires. Because the CFPS provides a unique identification number for each individual, we are able to combine information from the three waves. The CFPS also provides direct measures of children's cognitive and noncognitive skills, parents' investments, and family background information. We can obtain the exact birth dates for children surveyed in CFPS surveys in 2010, 2012, and 2014, which is essential for us to define children's zodiac signs.[5]

The child module includes all children with age 15 and below from 2010 core households and children with the same age range from the new households added in the later two waves. In the child

[5]CFPS has updated the data privacy policy so that only birth year and month of each child are released to the public in later surveys. Because the exact birth date is no longer available, we cannot use CFPS data in later waves in this research.

survey, parents answer all questions for children with age below 10. For children aged 10 and above, both parents and children answer questionnaires.

CFPS enumerators mainly conduct face-to-face interviews. For example, the ratio of face-to-face interviews in CFPS 2014 child survey was 93.68%. They also conducted interviews by phone if interviewees physically reside in another residence rather than the one in which they were registered. All interviews are recorded for cross-checking. If the interviews were interrupted by unpredictable factors, enumerators complemented the initially unfinished questions with a second interview. However, some variables such as gestational age and birth weight may be missing if information was not known. Overall, the work by CFPS data collectors guarantees the completeness and accuracy of the survey information.

2.2 | Defining key variables

2.2.1 | Cognitive skills

Cognitive skills are related to general intelligence (e.g., IQ, g-factor). The literature has measured cognitive skills in largely two ways; using psychometric cognitive assessment tests (e.g., Ampaabeng & Tan, 2013) including word-based episodic memory/recall tests, and employing achievement tests. An example of the latter is Heckman et al. (2006) who employed tests for arithmetic reasoning, word knowledge, paragraph comprehension, mathematical knowledge, and coding speed based on the Armed Services Vocational Aptitude Battery. Our measures for cognitive skills are based on achievement tests. The CFPS 2010 survey includes word recognition and math tests as measures of cognitive skills.

The word recognition and math tests have 34 and 24 questions, respectively, ordered from the easiest to the most difficult. The starting point from which a respondent answers questions depends on his or her education level. The ultimate test score is the number (rank) of the most difficult question that the respondent is able to answer correctly. If a respondent fails to correctly answer any question among those for his or her education group, the score is the lowest for that education level minus 1. For example, in the word recognition test, children with 7–9 years of education start at the 9th question. If the most difficult question a child answers correctly is the 11th, his or her test score is 11. If the child starts at question 9 but fails to answer questions 9, 10, and 11 correctly, his or her score is 8.

CFPS 2014 survey generally follows the word recognition and math tests in CFPS 2010 but adjusts the setup of the starting point for respondents.[6] It allows the respondents with a high starting point to re-start with a lower one if they answer three consecutive questions incorrectly. Nonetheless, CFPS 2014 survey also computes the scores for respondents assuming the fixed starting point, in order to make scores comparable with 2010 tests. We use comparable scores in CFPS 2014. We further compare the mean and standard deviation of scores with and without the fixed starting point and find that these two are almost identical, indicating that the fixed starting point design has little impact on children's test scores.[7]

[6]CFPS 2012 survey did not include word recognition and math tests.

[7]The mean (s.d.) of word test with/without the fixed starting point for all children in 2014 is 21.399 (7.462) versus 21.382 (7.499); The mean (s.d.) of math test with/without the fixed starting point for all children in 2014 is 10.517 (4.514) versus 10.432(4.558).

2.2.2 | Noncognitive skills

Noncognitive skills are associated with the "big five" noncognitive skills: openness to experience, conscientiousness, extroversion, agreeableness, and neuroticism versus emotional stability (OCEAN); see, Cunha and Heckman (2008). The CFPS includes questions regarding noncognitive skills for children in the 2010, 2012, and 2014 surveys. We derive five measures corresponding to the "big five". Specifically, the proxy variables for OCEAN are the survey questions that ask parents, respectively, whether the child is curious, whether the child is organized, whether the child is optimistic, whether the child can tolerate others' mistakes, and whether the child can control his or her anger. These five noncognitive skill variables, based on parents' survey answers, take values of 1 for "strongly disagree," 2 for "disagree," 3 for "neutral," 4 for "agree," or 5 for "strongly agree."

2.2.3 | Parental investments

We measure parental investments as total education expenditures for the child in the previous year.[8] These expenditures are deflated to 2010 Chinese renminbi (that is, to real values).

2.2.4 | Children's and parents' characteristics

Using demographic and household information from the CFPS, we can control for a set of family characteristics including the child's gender, whether the family lives in a city, the number of siblings for the child, the father's and mother's age and education, and family income (in thousands of 2010 renminbi).

2.3 | Random zodiac signs

2.3.1 | Defining random zodiac signs

In this sub-section, we discuss the importance of zodiac signs in Chinese culture, show evidence of parents' birth planning for lucky zodiac signs, and then formally define random zodiac signs.

Zodiac signs are deeply rooted in Chinese culture. In the recurring 12-year cycle, each zodiac is believed to have distinct attributes, and children born with different zodiac signs are believed to have these attributes. In particular, children with the more auspicious Tiger or Dragon zodiac signs are thought to have good fortune and to have higher achievements in education and careers (Mocan & Yu, 2020; Vere, 2008; Wong & Yung, 2005). In contrast, children with Snake or Sheep signs are believed to have relatively bad luck (Wan, 2014; Wang, 2014). This cultural superstition and its variations remain popular in East Asian and Southeast Asian countries, such as Japan, South Korea, Vietnam and Singapore, and among immigrants from these countries.

We identify the zodiac signs for children born between 1997 and 2010 in the CFPS surveys 2010 to 2014 based on their birth dates. A new zodiac sign starts on each Lunar New Year and continues throughout the lunar year. The zodiac signs form a recurring 12-year cycle. We categorize these 12

[8]Parental investments are measured per child in the survey.

signs into three groups according to common culture superstitions: Tiger and Dragon as lucky signs, Snake and Sheep as unlucky signs, and the others as neutral signs.

There is certainly ambiguity about which zodiac signs are actually viewed positively and which are not in the Asian context. In our reading of the literature, there is consensus that the Dragon sign is universally viewed as positive, and there is a sizeable literature investigating the impact of the Dragon birth sign on outcomes, such as educational attainment, labor market outcomes, and fertility outcomes, in a range of settings including Vietnam (Do & Phung, 2010), Hong Kong, Singapore, Taiwan (Johnson & Nye, 2011), and China. Snake and Sheep signs are generally viewed negatively in China, with people born in those years believed to be followers, have failed marriages, or end up with unsuccessful businesses (Lu & Hunt, 2015). The Tiger sign is generally viewed as positive in mainland China and Hong Kong, but, not in Taiwan, for example, where it is viewed negatively (Cima, 2015). In non-Chinese cultures, for example, Korean culture, the Horse sign is viewed as positive for males but not for females.

The exact classification of signs as lucky or otherwise is not critical to our identification strategy. From the perspective of establishing relevance for the IVs that we will be employing (see Section 2.5 below), all we require is that parents respond to zodiac signs in terms of their investment decisions for the first stage findings to be valid. Here, Yang (2014) suggests that parents born after the 1970s still believe in the cultural superstitions related to their children's zodiac sign.

As discussed in the Introduction, our identification strategy relies on a child's zodiac sign being effectively randomly assigned within a window around the threshold of a zodiac sign. We define a child's zodiac sign as randomly assigned only if his or her birth date falls within the first two or last 2 months of the sign,[9] as illustrated in Figure 1. Therefore, we keep in the sample only children who were born within the first two or last 2 months of each lunar year, treating these children's zodiac signs as if they were randomly assigned.

Before formally defining the random zodiac signs, we provide some supporting evidence for our key identifying assumption that parents plan their children's birth dates to fall within the middle portions (i.e., away from the boundaries) of lucky zodiac years. This assumption implies that children's birth dates are *more* likely to fall into the middle months of a lucky zodiac year in comparison with other years. Conversely, parents plan their children's birth dates to avoid unlucky zodiac years. Consequently, children's birth dates are *less* likely to fall into the middle months of an unlucky zodiac

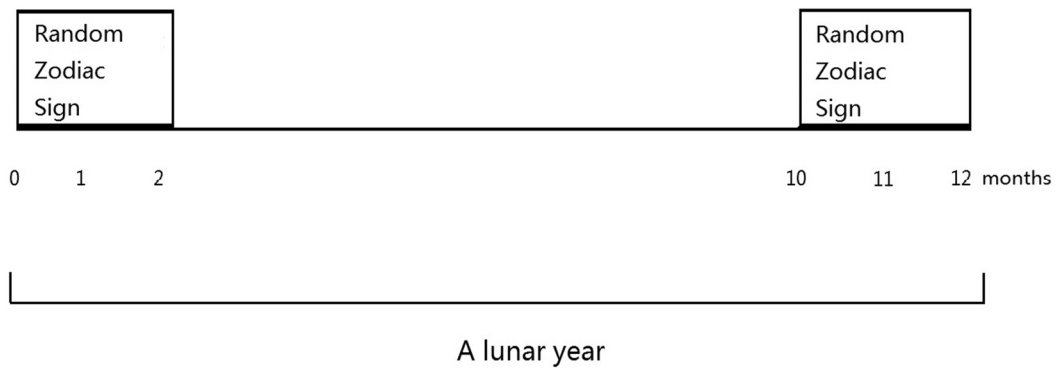

FIGURE 1 Lunar years and random zodiac signs.

[9]We normalize 2 months as 60 days in our definition, in order to avoid any inconsistency in the number of days of a month. Results are consistent if we define the window length using the actual months.

year. We check the validity of the assumption using the 2005 mini-census survey by National Bureau of Statistics of China, which has the most complete coverage of people's birth years and months.

The 2005 mini-census survey covers 2.5 million people born between 1895 and 2005. We select two sub-samples that include the most recent three zodiac cycles (from 1972, the year of the Rat, to 2005, the most recent year) and the most recent five zodiac cycles (from 1948, the year of the Rat, to 2005) respectively. We cannot use the entire sample of people's birth dates because the survival bias becomes severe among elderly people.

We define the birth ratio in the middle months of a lunar year as the percentage of people born in those months. In Panel A of Table A1, we test the null hypothesis that the birth ratios in the middle months of lucky zodiac years are not different from those born in other lunar years. We reject the hypothesis for both Tiger and Dragon. Take Dragon as an example, the birth ratio in the middle eight months of the Dragon years in the recent three zodiac cycles (1976, 1988, and 2000) is 0.697, significantly higher than 0.675, the birth ratio in the middle eight months of other lunar years. In 2000, a Dragon year, approximately 391,000 more children were born in the middle eight months than in other years.[10] As a robustness check, we also compare the birth ratios in the middle 10 months of the Dragon years (0.868) versus other years (0.836), which are statistically significant at the 1% level. Additionally, the differences in the birth ratio between Tiger and other zodiac signs are also statistically significant in the most recent three and five zodiac cycles, no matter whether the interval is eight or 10 months.

Panel B in Table A1 presents the difference in birth ratios between unlucky zodiac signs and other signs. In the most recent three zodiac cycles, the birth ratios in the middle eight months of the Snake years (1977, 1989, and 2001) versus other years are 0.673 versus 0.677, with the difference being significant at the 5% level. In the recent five zodiac cycles, the birth ratios in the middle 8 months between Snake and others are 0.673 versus 0.676, and in the middle 10 months 0.841 versus 0.841. However the difference in the middle-ten-month birth ratio is not significant. By comparison, the birth ratio in the middle months for the years of Sheep is significantly smaller than that in other years in all tests, regardless of whether the middle months are measured as eight or ten.

In summary, our exploration of the 2005 mini-census survey confirms that some parents do plan their children's birth time according to the lucky or unlucky zodiac signs. Therefore, if parents who want to select signs for their children plan ahead and aim for the middle months of their preferred zodiac signs, then it is conceivably the case that children born within a (small) window across two zodiac signs can be credibly viewed as having been "randomly" assigned their zodiac signs.

Defining random zodiac signs. We are now ready to define the random zodiac signs. Due to the data availability of children's birth dates, cognitive skills, and noncognitive skills, we define 12 pairs of late/early "random" zodiac signs as the last/first two months of a lunar year. Take children born in 1997 as an example: The Lunar New Year was on February 7th. Children born between January 1st and February 6th are "late Rat"[11] and children born between February 7th and April 7th are "early Ox," as shown in Figure 2. Similarly, using this nomenclature, the remaining 11 pairs of random zodiac signs are late Ox versus early Tiger (1998), late Tiger versus early Rabbit (1999), late Rabbit versus early Dragon (2000), late Dragon versus early Snake (2001), late Snake versus early Horse (2002), late Horse versus early Sheep (2003), late Sheep versus early Monkey

[10]China's population in 2000 was 1,267,430,000. Given the birth rate in 2000 was 0.01403, 1,267,430,000*0.01403*(0.697–0.675) = 391,000. Data resource: Bureau of National Statistics of China.

[11]We do not have birth date data for children born in 1996 and consequently the late Rat includes children born from 1 January 1997, onward. In the definitions of other late random zodiac signs, we include 2 months whenever data are available.

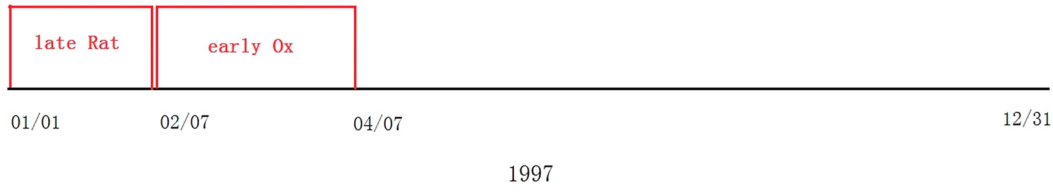

FIGURE 2 Late rat and early ox in 1997. [Colour figure can be viewed at wileyonlinelibrary.com]

(2004), late Monkey versus early Rooster (2005), late Rooster versus early Dog 2 (2006), late Dog 2 versus early Pig 2 (2007), and late Rat 2 versus early Ox 2 (2009). Too few children born in 2008 took noncognitive skill tests.[12] Children born in 2010 have noncognitive skill measures only and no information on other control variables. Therefore, we do not define random zodiac signs for children born in 2008 or 2010.

We further define the indicators of lucky and unlucky zodiac signs in each sample, assuming other neutral zodiac signs as the reference group. Specifically, the lucky dummy includes children with early Tiger (1998), late Tiger (1999), early Dragon (2000), and late Dragon (2001) and the unlucky dummy incorporates early Snake (2001), late Snake (2002), early Sheep (2003), and late Sheep (2004). Details regarding the definitions of the above five groups of variables are in Appendix Panel A of Table A2.

2.3.2 | More on random zodiac signs

As random zodiac signs are the key identification strategy for our specification, we further examine whether parents "manipulate" their children's birth dates within the random birth windows. Even if parents may not purposely plan their children's birth date into the middle of a lucky year, after they find out due date and realize that their children may be born either with a lucky/unlucky zodiac or a neighbor zodiac around the lunar new year, parents may choose early birth inductions or birth delays in order to get their offspring past a threshold into a preferred zodiac sign. This is a key concern and possible violation of our identification. However, both strategies are risky from the point of view of the health of both the child and mother. Standard medical advice is not to induce labor until at least 39 gestational weeks has been reached (normal gestation is 40 weeks). In terms of birth delays, the literature mainly deals with delaying birth (after labor has occurred) for preterm babies. On top of the health risks, tocolytics may delay labor for just a few days. The key point is that the ability of parents to select their child's zodiac signs outside of planning ahead is limited.

We further test whether children are more (less) likely to be born in the random lucky (unlucky) zodiac window part rather than the neighbor zodiac window part to examine the possibility of parents' intervention in children's birth date distribution around the lunar new year. Imagine that parents realize their children's birth dates fall in the end of a neighbor year or in the beginning of a lucky year (for example, the due date is the last day of the Rabbit year or the first day of the Dragon year), parents may

[12]Only 22 Children born within the random zodiac window of 2008 took noncognitive skill tests, in comparison with 206 children born within the window of 2007. Moreover, values of associated control variables (family income, parents' information, etc.) are missing for these children born within the window of 2008. Therefore, we do not include these children in the sample.

employ medical technique to guarantee that their children are born in the lucky year. Parents may also "manipulate" birth dates for pairs of late lucky versus neighbor signs, early unlucky versus neighbor signs, and late unlucky versus neighbor signs in similar scenarios.

Thus, we define the random birth rate as the probability that a child's birth date falls into a specific random window part in a lunar year. Then we compare two birth probabilities of the lucky/unlucky sign and its neighbor sign. Continuing with the pair of late Rabbit and early Dragon, if parents can "control" children's birth dates to some degree, we would observe the probability of a child's birth date in the last 2 months of the Rabbit year is different with the probability of a child's birth date in the first 2 months of the Dragon year. Results in Table A3 show that we do not observe a statistically significant difference in birth probability between early lucky versus neighbor signs, or between late lucky versus neighbor signs. Similarly, the *t* tests for birth probability comparison between early unlucky and neighbor signs and between late unlucky and neighbor signs are again statistically insignificant.

Alternatively, we will address the issue of birth induction/delays by further modifying the window around the threshold of the zodiac sign in a robustness check (see Section 3.4.2 below).

We note two additional points regarding our definition of random zodiac signs. First, Chinese zodiac signs depend on the lunar year, not the month, of birth. We can control for the effect of birth months that have potential influence on children's skills, such as duration of exposure to sunshine. Second, because of the window of months around which our random zodiac is defined, all children in this sample were born from December through April. As the cutoff birth date in China for primary school entrance is September 1, the children within each pair of late and early zodiac signs are in the same grade. Hence, we automatically control for all schooling cohort fixed effects.

2.4 | Summary statistics of the sample within the "window"

Panels B and C of Table A2 display the summary statistics for the two window samples: children with the measures of cognitive skills and noncognitive skills. There are 1098 and 1257 observations for cognitive skills (Panel B) and noncognitive skills (Panel C), respectively. The relatively small number of observations in two samples results from the identification strategy that we analyze parents' investment and children's performance within the birthdate falling in the window of random zodiac signs, not all the birth months.

In the sample for cognitive skills, the average scores on the word recognition and math tests are approximately 21.3 and 10.4, respectively. On average, parents spent 2051 renminbi (RMB) on each child's education over the previous year, and the average family income is RMB 31,263; in other words, a representative family spent approximately 6.6% of its income on each child's education. 51.7% of children are male. A typical child's father is 41.0 years old and has 7.3 years of education, whereas his or her mother is 39.1 years old with 5.9 years of education.

In the sample for noncognitive skills, average scores on the five survey questions for noncognitive skills—curiosity, organization, optimism, mistake tolerance, and anger control—are 3.8, 3.5, 3.9, 3.6, and 3.4, respectively. These values indicate that parents, on average, evaluate their child's noncognitive skills to be between "neutral" (3) and "agree" (4) for these questions. Approximately 54.3% of

children are male. Because children that have measures of noncognitive skills are younger than those with measures of cognitive skills, their parents are also younger.

2.5 | Methodology

We estimate the impact of parental investments on children's cognitive and noncognitive skills using a two-stage model, whereby parental investments are instrumented by the random zodiac signs. The first-stage regression takes the following specification:

$$\text{pin}\boldsymbol{v_i} = \boldsymbol{c} + \boldsymbol{r}\text{zodiac}_i\boldsymbol{\delta} + \boldsymbol{X}_i\boldsymbol{\Gamma} + \boldsymbol{v_i}, \tag{1}$$

where $\text{pin}v_i$ is the investments by the parents of child i; c is a constant; $\boldsymbol{rzodiac}_i$ is child i's $1 \times k$ random zodiac sign vector; $\boldsymbol{\delta}$ is a $k \times 1$ coefficient vector; $\boldsymbol{X}_i$ is a $1 \times m$ vector of control variables that include the child's gender, the number of siblings, the father's and mother's age and educational attainment, family income, and the survey year dummies; $\boldsymbol{\Gamma}$ is a $m \times 1$ coefficient vector; v_i is the residual.

The second-stage regression is given by

$$\text{skill}_i = \boldsymbol{\alpha} + \boldsymbol{\beta}\widehat{\text{pin}\boldsymbol{v_i}} + \boldsymbol{X_i}\boldsymbol{\Theta} + \boldsymbol{\varepsilon_i}, \tag{2}$$

where the dependent variable, skill_i, is a measure of the cognitive or noncognitive skills of child i; α is a constant; $\widehat{\text{pin}v_i}$ is the fitted parental investment from the first stage and β is its coefficient; $\boldsymbol{\Theta}$ is the $m \times 1$ coefficient vector for the control variables in the second stage; $\boldsymbol{\varepsilon}_i$ is the residual. Standard errors are clustered at the level of the birth year and month. In addition to our benchmark specifications, we also conduct a series of robustness exercises that we discuss below.

3 | FINDINGS

3.1 | Simple ordinary least squares results

Before we present the estimation results for Equations (1) and (2), we show simple ordinary least squares (OLS) regression results. Specifically, we regress children's cognitive or noncognitive skills on parental investments, after controlling for the children's gender, the number of siblings, father's and mother's age and education, family income, children's birth year-month dummies, and the survey year dummies. Parental investments and family income are logged.[13] Chetty et al. (2011) points out that child and parent demographic characteristics may affect their skill development.

In Panel A of Table 1 we find that parental investments (as measured by education costs in the previous year) have statistically significant impacts on children's word recognition and math test scores. As shown in Panel B, parental investments are positively correlated with a child's level of optimism and mistake endurance. These OLS results reveal a positive relationship between parental investments and children's cognitive and noncognitive skills. However, these preliminary results do not account for the potential endogeneity of parents' investments.

[13]To avoid the missing observation problem caused by the value of zero, we use log (1 + parental investment) and log (1 + family income).

TABLE 1 The impact of parental investments on children's cognitive skills: Ordinary least squares regressions.

	Panel A: Cognitive skills		Panel B: Noncognitive skills				
	Word recognition test	Math test	Curiosity	Organization	Optimism	Mistake endurance	Anger control
Variable	(1)	(2)	(1)	(2)	(3)	(4)	(5)
Log (Education cost last year + 1)	2.109***	1.244***	0.043	0.027	0.075***	0.067*	0.016
	(0.334)	(0.249)	(0.045)	(0.056)	(0.030)	(0.037)	(0.067)
Gender	−1.796***	−0.058	0.055	−0.207***	0.058	−0.003	−0.024
	(0.353)	(0.234)	(0.079)	(0.045)	(0.045)	(0.044)	(0.049)
No. of siblings	−0.472	−0.104	−0.003	0.023	−0.004	−0.021	0.016
	(0.290)	(0.088)	(0.008)	(0.025)	(0.023)	(0.033)	(0.028)
Father's age	−0.017	−0.045	−0.001	0.003	0.002	0.009	−0.010
	(0.062)	(0.035)	(0.012)	(0.010)	(0.008)	(0.008)	(0.012)
Father's education	0.251***	0.127***	0.011	−0.006	−0.011	−0.003	−0.009
	(0.060)	(0.030)	(0.010)	(0.013)	(0.007)	(0.012)	(0.012)
Mother's age	0.047	0.087**	−0.001	0.016	0.011	0.003	0.026**
	(0.056)	(0.038)	(0.010)	(0.012)	(0.007)	(0.010)	(0.012)
Mother's education	0.147***	0.099***	0.011	−0.001	0.017	−0.001	0.001
	(0.060)	(0.036)	(0.010)	(0.010)	(0.007)	(0.009)	(0.009)
Log (Family	0.681***	0.293***	−0.003	0.005	−0.020	−0.001	0.026
Income+1)	(0.215)	(0.120)	(0.020)	(0.021)	(0.016)	(0.024)	(0.037)
Birth year-month	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Survey year	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.254	0.283	0.094	0.044	0.064	0.112	0.108
Observations	1098	1098	1257	1257	1257	1257	1257

Note: Panel A displays preliminary results on the impacts of parental investments on children's cognitive skills, in the sample of children born within the last 2 months or the first 2 months of a lunar year. Panel B displays preliminary results for the impacts of parental investment on children's noncognitive skills, in the sample of children born in the last 2 months or first 2 months of a lunar year. Appendix Table A2 provides detailed explanations for all variables. All regressions are clustered at birth year-month levels. ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

3.2 | Benchmark results

We next estimate a standard two-stage least squares regression, as described by Equations (1) and (2). The control variables include children's gender, the number of siblings, parents' age[14] and education, logged family real income, and the survey year dummies. Note that random zodiac sign dummies already contain information on children's age. For example, in the sample for cognitive skills that

[14]Alternatively, we have used parents' zodiac signs that are defined by parents' birth dates to control for the possible parents' selection of children's zodiac signs due to the cultural superstition on the zodiac match between parents and children. Results are qualitatively and quantitatively consistent.

includes children born between 1997 and 2004, if a child was defined as a late Rat, we know that the child was born in 1997 and was 13 years old during the 2010 survey.

Table 2 Panel A displays the first-stage regression for children whose cognitive skill scores are available. We run the regression of parental investments on random zodiac signs and other control covariates,[15] and cluster standard errors at the level of children's birth year and month. We also list the category (lucky, neutral, or unlucky) of each random zodiac sign. The Kleibergen-Paap Wald *F* statistics show that the random zodiac signs are not weak instruments. As children born in 2004 are set as the reference, the coefficient for each random zodiac sign indicates the magnitude of parental investment in comparison with the reference group. For example, parents invest 47.7% more on "late Rat" children born in 1997 than those born in 2004.

How do we explain the difference in coefficients for the random zodiac signs? Recall that parents may invest differently for children with random lucky/unlucky signs and their neighboring signs due to the superstition channel and the social interaction channel. Continuing with the example of "late Rabbit" versus "early Dragon", parents may invest more in the early Dragon children due to their belief on Dragon children's bright fate, or invest more in the late Rabbit in order to help Rabbit children compete with Dragon children. It is ultimately an empirical question, and we find that parents do invest more in early Dragon children.

In Figure 3, we further depict a graphical comparison in parental investments between lucky (unlucky) and their neighboring random zodiac signs. We observe that parents, on average, invest more (less) on children with random lucky (unlucky) zodiac signs, and the differences are statistically significant.[16] Parents may invest more (less) in children with random lucky (unlucky) signs simply because they believe that their children are more (less) likely to succeed. The induced different parental investments generate exogenous variations and enable us to examine the effect of parental investments on children's skills.

Panel B summarizes the second-stage results on how parental investments affect children's cognitive skills. Increased education expenditure significantly improves children's word recognition and math test scores. The magnitude of the effect of parents' investments on cognitive skill development is quantitatively large. For example, a 10% increase in education expenditure raises a child's word recognition test score, on average, by 0.712, or 9.5% of the standard deviation of this score (7.510). Similarly, a 10% increase in education expenditure raises the average math test score by 0.387, or 9.3% of a standard deviation of this score (4.182).

Our estimation results are comparable with findings in other scenarios that also examine the impact of parental investment on children's skills. Chuan et al. (2022) finds that a 50% increase in parental investment can raise English score of a child between 8 and 14 years old by 0.2 standard deviation in a survey conducted between 2010 and 2014 in Chicago.

Next, we examine the two-stage least squares regression results for noncognitive skills. Panel A of Table 3 summarizes the first-stage results.[17] The Kleibergen-Paap Wald *F* statistics confirm that the random zodiac signs are not weak instruments. As with the case of cognitive skills above, the coefficients here are also different between a lucky (unlucky) zodiac sign and its neighboring group. We

[15]We have considered the interaction between lucky (unlucky) zodiac signs and children's gender, as there are superstitions that Tiger girls or Sheep girls may have a different fate with their male counterparts. However, we do not find statistically significant differences between males and females and thus do not include the interaction in the benchmark results.

[16]In Figure 3 (the sample of cognitive skills), the *t*-statistics for the comparison in logged education cost between the lucky and neighboring groups, and between the unlucky and neighboring groups are 1.984 (significant at the 5% level) and −1.852 (significant at the 10% level), respectively.

[17]There are no observations for children born in the random zodiac window of 1998. Due to missing values in control variables, children born in the random zodiac window of 2000 are dropped from regressions.

TABLE 2 The impact of parental investments on children's cognitive skills.

Variable	Log (Education cost last year+1)	Zodiac sign category
Panel A. First-stage regression		
Late rat	0.477***	Neutral (1997)
	(0.120)	
Early ox	0.380***	Neutral (1997)
	(0.115)	
Late ox	0.238**	Neutral (1998)
	(0.115)	
Early tiger	0.242**	Lucky (1998)
	(0.112)	
Late tiger	0.646***	Lucky (1999)
	(0.099)	
Early rabbit	0.488***	Neutral (1999)
	(0.094)	
Late rabbit	0.218**	Neutral (2000)
	(0.095)	
Early dragon	0.272***	Lucky (2000)
	(0.095)	
Late dragon	0.219***	Lucky (2001)
	(0.093)	
Early snake	−0.068	Unlucky (2001)
	(0.113)	
Late snake	−0.204*	Unlucky (2002)
	(0.123)	
Early horse	0.101	Neutral (2002)
	(0.111)	

TABLE 2 (Continued)

Variable	Log (Education cost last year+1)	Zodiac sign category
Late horse	0.102	Neutral (2003)
	(0.119)	
Early sheep	−0.081	Unlucky (2003)
	(0.120)	
Other controls	Yes	
R^2	0.296	
Kleibergen-paap wald F	22.946**	
Hansen's J statistic	20.452	
(p for Hansen's J)	(0.116)	
Observations	1098	

Variable	Word recognition test (1)	Math test (2)
Panel B. Second-stage regression		
Log (Education cost last year + 1)	7.115***	3.870***
	(1.851)	(1.092)
Gender	−1.608***	0.103
	(0.405)	(0.209)
No. of siblings	−0.474	−0.165
	(0.448)	(0.178)
Father's age	−0.032	−0.066
	(0.066)	(0.043)
Father's education	0.240***	0.119***
	(0.062)	(0.033)

(Continues)

TABLE 2 (Continued)

Variable	Word recognition test (1)	Math test (2)
Mother's age	0.031	0.101***
	(0.057)	(0.039)
Mother's education	−0.052	−0.002
	(0.099)	(0.055)
Log (Family income+1)	−0.317	−0.309*
	(0.290)	(0.162)
R^2	0.043	0.052
Observations	1098	1098

Note: The sample includes all children that were born within the last two months or first two months of a lunar year and have cognitive skill test results available. Children born in 2004 are used as the reference. Appendix Table A2 provides detailed explanations for all variables. In Panel A, other control variables include gender, number of siblings, father's age and education, mother's age and education, logged family income, and the survey year dummies. The significance for the Kleibergen-Paap Wald *F* is from the Stock-Yogo weak instrument test. Panel B shows the second-stage results. All regressions are clustered at children's birth year-month levels.

***, **, and * denote significance at 1%, 5%, and 10%, respectively.

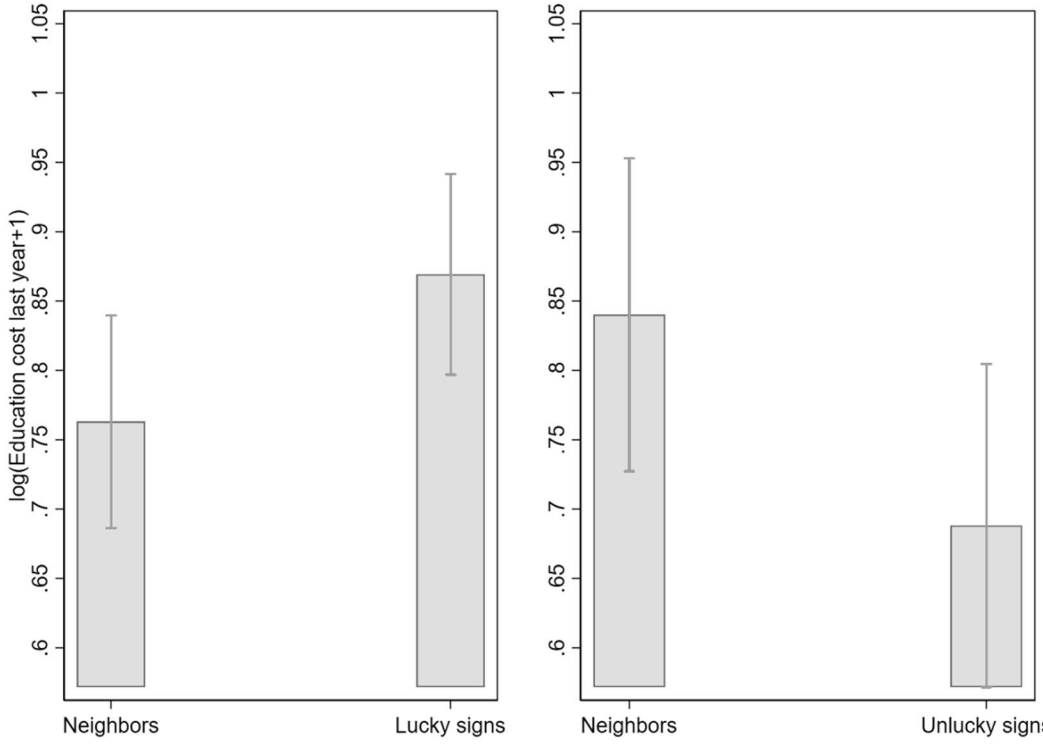

FIGURE 3 Random zodiac signs and parental investment: In the sample for cognitive skills. This figure depicts the average parental investments measured as mean log (education cost last year + 1) between lucky random zodiac signs and their neighboring signs, and between unlucky random zodiac signs and their neighboring signs, in the sample for cognitive skills. The bars are means of logged education costs, and the lines on bars indicate plus/minus two standard deviations from the mean. The lucky random zodiac signs include early Tiger (1998), late Tiger (1999), early Dragon (2000), and late Dragon (2001); their neighboring signs include late Ox (1998), early Rabbit (1999), late Rabbit (2000), and early Snake (2001). The unlucky signs are early Snake (2001), late Snake (2002), and early Sheep (2003); their neighboring signs are late Dragon (2001), early Horse (2002), and late Horse (2003).

also show the comparison in parental investments between lucky (unlucky) and neighboring random zodiac signs in Figure 4. Again, we observe that parents invest differently between the children with random lucky (unlucky) signs and the children born in the neighboring sign windows.[18]

In the second-stage regressions displayed in Panel B, we find that for all pairs of random zodiac signs, parental investments (as measured by total education costs in the previous year) improve a child's curiosity, organization, tolerance of others' mistakes, and anger control, except that the coefficient of logged education cost is not significant in the regression for optimism. The magnitudes of the impacts are substantial and important. For example, a 10% increase in parents' investment has an effect on the score for being organized of 0.022, or 2.5% of the standard deviation (0.882). Columns 4 through 5 of Table 4 show that a 10% increase in parents' investment can increase a child's scores on

[18]In Figure 4 (the sample of non-cognitive skills), the *t*-statistics for the comparison in logged education cost between the lucky (unlucky) and neighbor groups, and between the unlucky and neighbor groups are 2.835 (significant at the 1% level) and −2.088 (significant at the 5% level), respectively.

TABLE 3 The impact of parental investments on children's noncognitive skills.

Variable	Log (Education cost last year+1)	Category/year of random zodiac sign
Panel A. First-stage regression		
Late rat	0.673***	Neutral (1997)
	(0.151)	
Early ox	0.467***	Neutral (1997)
	(0.144)	
Late tiger	0.501***	Lucky (1999)
	(0.145)	
Early rabbit	0.328***	Neutral (1999)
	(0.139)	
Late rabbit	0.107	Neutral (2000)
	(0.141)	
Early dragon	0.707**	Lucky (2000)
	(0.254)	
Late dragon	0.869**	Lucky (2001)
	(0.236)	
Early snake	0.236*	Unlucky (2001)
	(0.136)	
Late snake	0.187	Unlucky (2002)
	(0.153)	
Early horse	0.008	Neutral (2002)
	(0.127)	
Late horse	0.139	Neutral (2003)
	(0.129)	
Early sheep	0.154	Unlucky (2003)
	(0.135)	

TABLE 3 (Continued)

Variable	Log (Education cost last year+1)	Category/year of random zodiac sign
Late sheep	0.249*	Unlucky (2004)
	(0.140)	
Early monkey	0.037	Neutral (2004)
	(0.190)	
Late monkey	0.321	Neutral (2005)
	(0.190)	
Early rooster	0.176	Neutral (2005)
	(0.303)	
Late rooster	−0.166	Neutral (2006)
	(0.136)	
Early dog 2	−0.164	Neutral (2006)
	(0.117)	
Late dog 2	−0.057	Neutral (2007)
	(0.121)	
Early pig 2	−0.164	Neutral (2007)
	(0.131)	
Late rat 2	−0.125	Neutral (2009)
	(0.200)	
Early ox 2	−0.100	Neutral (2009)
	(0.211)	
Other controls	Yes	
R^2	0.310	
Kleibergen-Paap Wald F	23.847**	
Hansen's J statistic	19.988	
(p for Hansen's J)	(0.522)	
Observations	1257	

(Continues)

TABLE 3 (Continued)

Variable	Curiosity (1)	Organization (2)	Optimism (3)	Mistake tolerance (4)	Anger control (5)
Panel B. Second-stage regression					
Log (Education cost last year + 1)	0.093	0.221***	0.001	0.412***	0.541***
	(0.092)	(0.087)	(0.092)	(0.089)	(0.088)
Gender	0.076	−0.199***	0.062	0.001	−0.021
	(0.052)	(0.046)	(0.042)	(0.047)	(0.056)
No. of siblings	0.007	0.051**	−0.003	0.001	0.056*
	(0.024)	(0.023)	(0.019)	(0.029)	(0.031)
Father's age	−0.009	−0.003	0.001	0.005	−0.014
	(0.007)	(0.010)	(0.007)	(0.007)	(0.012)
Father's education	0.005	−0.008	−0.009	−0.011	−0.019
	(0.011)	(0.011)	(0.007)	(0.011)	(0.012)
Mother's age	0.001	0.005	0.004	0.006	0.017
	(0.009)	(0.011)	(0.006)	(0.009)	(0.012)
Mother's education	0.010	−0.008	0.019*	−0.014	−0.017
	(0.010)	(0.011)	(0.011)	(0.009)	(0.012)
Family income	0.010	−0.005	−0.006	−0.021	0.014
	(0.023)	(0.023)	(0.016)	(0.025)	(0.036)
R^2	0.023	0.033	0.011	0.048	0.072
Observations	1257	1257	1257	1257	1257

Note: The sample includes all children whose birth dates fall in the first or last two months of a lunar year and whose noncognitive skill measures are available. Children born in 2010 are used as the reference. Appendix Table A2 provides detailed explanations for all variables. In Panel A, other control variables include gender, number of siblings, father's age and education, mother's age and education, logged family income, and the survey year dummy. There are no observations with children's birth date in 1998 (late Ox and early Tiger) or 2008 (late Pig2 and early Rat2) due to missing values in control variables. The significance of the Kleibergen-Paap Wald F is from the Stock-Yogo weak instrument test. Panel B displays the second-stage regression results for the impacts of parental investment on children's noncognitive skills. All regressions are clustered at children's birth year-month levels.

***, **, and * denote significance at 1%, 5%, and 10%, respectively.

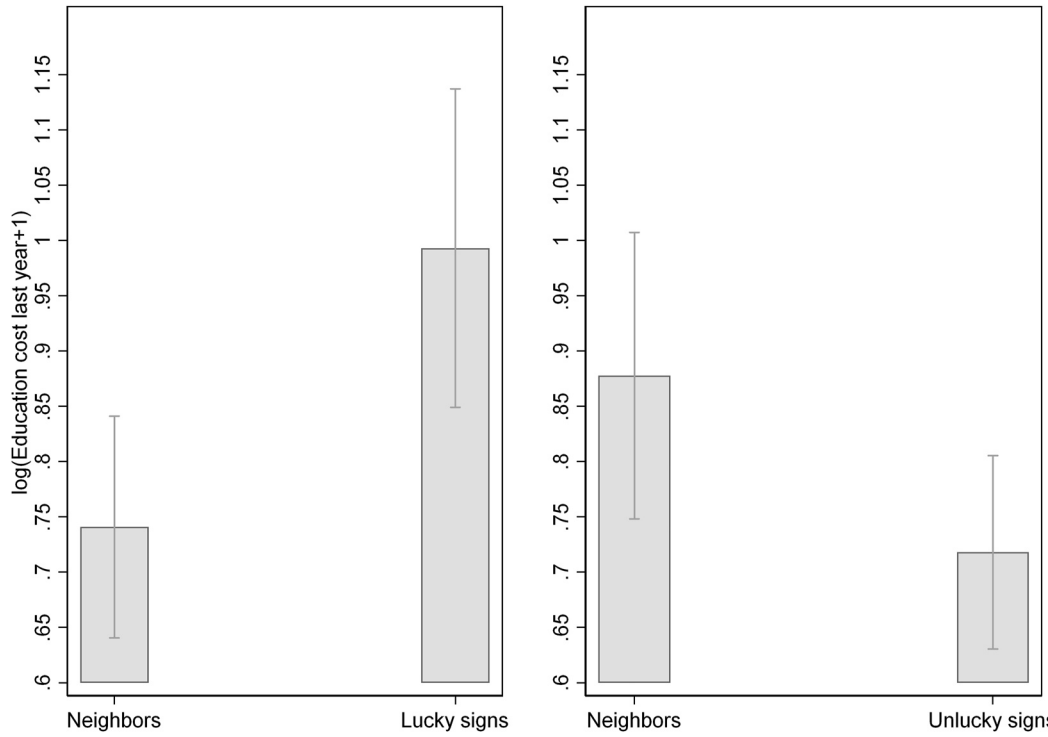

FIGURE 4 Random zodiac signs and parental investment: In the sample for noncognitive skills. This figure depicts the average parental investments measured as mean log (education cost last year + 1) between lucky random zodiac signs and their neighboring signs, and between unlucky random zodiac signs and their neighboring signs, in the sample for noncognitive skills. The bars are means of logged education costs, and the lines on bars indicate plus/minus two standard deviations from the mean. The lucky random zodiac signs include late Tiger (1999), early Dragon (2000), and late Dragon (2001); their neighboring signs include early Rabbit (1999), late Rabbit (2000), and early Snake (2001). Early Tiger (1998) and its neighboring sign late Ox (1998) are not included due to no observations. The unlucky signs are early Snake (2001), late Snake (2002), early Sheep (2003), and late Sheep (2004); their neighboring signs are late Dragon (2001), early Horse (2002), late Horse (2003), and early Monkey (2004).

mistake tolerance and anger control, respectively, by 0.041 (4.8% of the standard deviation, 0.852) and 0.054 (5.8% of the standard deviation, 0.930).

Our estimation results provide further supporting evidence on the impact of parental investment on children's non-cognitive skills as documented in Cunha and Heckman (2008) based on a dynamic factor model.

3.3 | An alternative specification

The benchmark specification employs random zodiac signs as IVs. Alternatively, we may group these zodiac indicators into lucky signs (Tiger and Dragon) and unlucky signs (Sheep and Snake) to instrument parents' investment. Then the alternative first-stage regression becomes:

$$\text{pin}\boldsymbol{v}_i = \boldsymbol{c}^{\boldsymbol{a}} + \boldsymbol{\delta}_{\mathbf{1}}^{\boldsymbol{a}}\text{lucky}_i + \boldsymbol{\delta}_{\mathbf{2}}^{\boldsymbol{a}}\text{unlucky}_i + \boldsymbol{X}_i\boldsymbol{\Gamma}_{\boldsymbol{a}} + \boldsymbol{FE}_i + \boldsymbol{v}_i^{\boldsymbol{a}}, \quad (3)$$

TABLE 4 The impact of parental investments on children's cognitive skills: An alternative specification.

Variable	Log (Education cost last year + 1)	Random zodiac sign
Panel A. First-stage regression		
Lucky	0.094**	Tiger, dragon
	(0.048)	
Unlucky	−0.177***	Snake, sheep
	(0.064)	
Pair fixed effects	Yes	
Other controls	Yes	
R^2	0.290	
Kleibergen-Paap Wald F	15.214*	
Hansen's J statistic	11.458	
(p for Hansen's J)	(0.110)	
Observations	1098	
Variable	**Word recognition test (1)**	**Math test (2)**
Panel B. Second-stage regression		
Log (Education cost last year + 1)	7.370***	3.857***
	(1.737)	(1.078)
Gender	−1.600***	0.015
	(0.409)	(0.215)
No. of siblings	−0.465	−0.161
	(0.434)	(0.183)
Father's age	−0.034	−0.069
	(0.067)	(0.042)

TABLE 4 (Continued)

Variable	Word recognition test (1)	Math test (2)
Father's education	0.208***	0.104***
	(0.061)	(0.033)
Mother's age	0.042	0.101***
	(0.057)	(0.039)
Mother's education	−0.063	−0.004
	(0.099)	(0.056)
Log (Family income + 1)	−0.296	−0.253
	(0.300)	(0.174)
R^2	0.060	0.068
Observations	1098	1098

Note: The sample includes all children that were born within the last two months or first two months of a lunar year and have cognitive skill test results available. Appendix Table A2 provides detailed explanations for all variables. In panel A, pair fixed effects include indicators for birth windows that cover adjacent zodiac signs around lunar new year. Other control variables include gender, number of siblings, father's age and education, mother's age and education, logged family income, and the survey year dummies. The significance for the Kleibergen-Paap Wald *F* is from the Stock-Yogo weak instrument test. Panel B displays the the second-stage regression results for the impacts of parental investment on children's cognitive skills. All regressions are clustered at children's birth year-month levels.

***, **, and * denote significance at 1%, 5%, and 10%, respectively.

where c^a is a constant; lucky_i and unlucky_i are indicators for lucky or unlucky random zodiac signs and the neutral zodiac indicator is absorbed; δ_1^a and δ_2^a are coefficients to be estimated; $\boldsymbol{X}_i$ is a $1 \times m$ vector of control variables that include the child's gender, the number of siblings, the father's and mother's age and educational attainment, family income, and the survey year dummies; Γ_a is a $m \times 1$ coefficient vector; FE_i is a vector of fixed effects with each component denoting a birth window for adjacent zodiac pairs; υ_i^a is the residual. Since we control for the fixed effects of birth windows, the first stage specification evaluates whether, within each of the birth windows, lucky/unlucky zodiac signs jointly lead to higher/lower parental investment than neutral zodiac signs.

We next estimate a two-stage least squares regression employing the alternative specification (3) as the first stage regression and keeping the second stage specification (2) unchanged. Panel A of Table 4 summarizes the first-stage regression results in the sample for cognitive skills. The Kleibergen-Paap Wald F statistics again show that lucky/unlucky dummies are not weak instruments. Moreover, the coefficient for the lucky dummy is statistically positive and that for the unlucky dummy is statistically negative, namely parents invest more on children with lucky zodiac signs. Parents with random lucky sign children invest 9.4% more than those with neutral sign children, and parents with random unlucky sign children invest 17.7% less than those with neutral sign children. Note that in this alternative specification, we compare parental investment in children with lucky (unlucky) signs and those with neutral (signs) jointly, not just between lucky (unlucky) signs and their neighbor signs. The induced different parental investments generate exogenous variations and enable us to examine the effect of parental investments on children's skills.

Panel B of Table 4 displays the second-stage results, showing that increased education expenditure significantly improves children's word recognition and math test scores. Parents may invest more in children with lucky zodiac signs by 19.5% than children with neutral signs but statistically indifferent on children with unlucky signs in comparison with neutral sign children. The magnitude of the effect of parents' investments on cognitive skill development is consistent with the benchmark estimation results in Table 2. A 10% increase in education cost increases a child's word test score by 0.737, and a 10% increase in education expenditure raises the average math test score by 0.386.

We further show the two-stage least squares regression results for noncognitive skills in Table 5. Panel A displays the first stage results, confirming that the lucky/unlucky signs are not weak instruments in the sample for noncognitive skills either. In the second-stage regressions displayed in Panel B, we find that parental investments help to strengthen a child's curiosity, organization, tolerance of others' mistakes and anger control, quantitatively comparable with the benchmark results in Table 3.

3.4 | More robustness checks

We now consider a range of robustness checks. The first check verifies whether control covariates are statistically indifferent across neighboring zodiac signs. The second check examines an alternative definition of the random zodiac window, the third check invalidates an alternative explanation from children's self-consciousness, and the fourth check restricts the sample size to minimize the measurement error. The last check explores whether there are other channels for parents to affect children's skill formation.

TABLE 5 The impact of parental investments on children's noncognitive skills: An alternative specification.

Variable	Log (Education cost last year + 1)	Random zodiac sign
Panel A. First-stage regression		
Lucky	0.195**	Tiger, dragon
	(0.085)	
Unlucky	−0.058	Snake, sheep
	(0.075)	
Pair fixed effects	Yes	
Other controls	Yes	
R^2	0.290	
Kleibergen-Paap Wald F	13.742*	
Hansen's J statistic	10.451	
(p for Hansen's J)	(0.576)	
Observations	1257	

Variable	Curiosity (1)	Organization (2)	Optimism (3)	Mistake tolerance (4)	Anger control (5)
Panel B. Second-stage regression					
Log (Education cost last year +1)	0.206*	0.261***	−0.044	0.422***	0.550***
	(0.117)	(0.096)	(0.082)	(0.111)	(0.109)
Gender	0.082	−0.076	0.043	0.037	0.069
	(0.055)	(0.054)	(0.036)	(0.054)	(0.050)
No. of siblings	0.002	0.072***	−0.013	0.029	0.089***
	(0.023)	(0.024)	(0.019)	(0.027)	(0.032)
Father's age	−0.021***	0.001	−0.002	−0.003	−0.017*
	(0.007)	(0.008)	(0.005)	(0.008)	(0.009)

(Continues)

TABLE 5 (Continued)

Variable	Curiosity (1)	Organization (2)	Optimism (3)	Mistake tolerance (4)	Anger control (5)
Father's education	0.013	−0.001	−0.003	−0.010	−0.021***
	(0.008)	(0.009)	(0.006)	(0.010)	(0.008)
Mother's age	0.008	0.001	0.006	0.007	0.021**
	(0.007)	(0.008)	(0.005)	(0.008)	(0.009)
Mother's education	−0.001	−0.019**	0.015**	−0.0148	−0.018**
	(0.008)	(0.010)	(0.006)	(0.007)	(0.008)
Family income	0.011	−0.050**	0.018	−0.018	−0.023
	(0.022)	(0.023)	(0.014)	(0.023)	(0.033)
R^2	0.060	0.020	0.032	0.048	0.078
Observations	1257	1257	1257	1257	1257

Note: The sample includes all children whose birth dates fall in the first or last two months of a lunar year and whose noncognitive skill measures are available. Appendix Table A2 provides detailed explanations for all variables. In Panel A, pair fixed effects include indicators for birth windows that cover adjacent zodiac signs around lunar new year. Other control variables include gender, number of siblings, father's age and education, mother's age and education, logged family income, and the survey year dummy. The significance of the Kleibergen-Paap Wald *F* is from the Stock-Yogo weak instrument test. Panel B displays the second-stage regression results for the impacts of parental investment on children's noncognitive skills. All regressions are clustered at children's birth year-month levels.

***, **, and * denote significance at 1%, 5%, and 10%, respectively.

3.4.1 | Covariate balance

The first robustness check is on the assumption of the estimation method. The identification strategy relies on the underlying smoothness of the forcing variable (time, in this case) across the threshold. This smoothness may be violated if, for example, parental characteristics that determine offspring's skill formation are systematically different across the zodiac cutoff. In Table 6, we check whether control covariates are differentiated across late and early zodiac signs using *t* tests. We concisely report only the mean values and *t* statistics if the tests reject the null hypotheses. In 96 *t* tests (8 control variables × 12 birth years), only 7 tests reject the null hypotheses of equal means of the control variables. Therefore, there is no systematic difference in personal, parental, or family characteristics among children with different random zodiac signs.

3.4.2 | Birth induction/delay

The second robustness check addresses the issue of birth induction or delays by using different window periods to designate the random zodiac signs.[19] We consider two alternative random zodiac sign designation strategies: an asymmetric window period design and 1-month window period design. We first consider an asymmetric window period design, which is based on the medical fact that a baby can be delivered as early as the 28th week of pregnancy with a relatively high survival rate (but not without significant health risks), but can only be delivered as late as the 41st to 42nd week of pregnancy.[20] We design the asymmetric random zodiac window as the first 3 months and the last month of a lunar year, in order to cover the unexpected early or late delivery. Take Dragon children as an example, given the medical fact, parents plan their children's birth between the fourth and eleventh month of the year of the Dragon to avoid the extreme early delivery (three months earlier) or the extreme late delivery (one month later) that may make their children's zodiac into Rabbit (by early delivery) or Snake (by late delivery). In Panel A of Table 7, we designate as random the zodiac signs of children born in the first 3 months or last month of the lunar year, and then repeat the two-stage least squares regressions for cognitive and noncognitive skills, as in the benchmark cases. The new results are both qualitatively and quantitatively consistent with the benchmark results.

As an additional check, in Panel B of Table 7, we randomly assign the zodiac signs of children born in the first or last month of the lunar year (i.e., we move away from an asymmetric window and just use the first and last months of the zodiac months). We then run the same two-stage least squares regressions for cognitive and noncognitive skills. The results are again consistent with the benchmark results.

We have conducted another robustness check: Exclude the first and the last weeks in each lunar year in the random zodiac sign window to rule out the possibility that parents may choose the child's zodiac sign through induced early or late delivery. The results are almost identical to the benchmark, so we omit them for brevity.

[19]We thank Octasiano M. Valerio Mendoza for suggesting this robustness check.
[20]https://www.mayoclinic.org

TABLE 6 Falsification tests: Comparisons of control variables between late and early zodiac signs.

	Gender		Number of siblings		Father's age		Father's education		Mother's age		Mother's education		Log (Family Income+1)	
Birth year/zodiac sign	**Mean**	***t***	**Mean**	***t***	**Mean**	***t***	**Mean**	***t***	**Mean**	***t***	**Mean**	***t***	**Mean**	***t***
1997														
Late rat											6.492	3.343***		
Early ox											4.730			
1998														
Late ox														
Early tiger														
1999														
Late tiger									38.337	−2.166**				
Early rabbit									39.661					
2000														
Late rabbit														
Early dragon														
2001														
Late dragon									37.539	−2.370**				
Early snake									39.123					
2002														
Late snake														
Early horse														
2003														
Late horse														
Early sheep														
2004														
Late sheep														
Early monkey														

TABLE 6 (Continued)

	Gender		Number of siblings		Father's age		Father's education		Mother's age		Mother's education		Log (Family Income+1)	
Birth year/zodiac sign	**Mean**	***t***	**Mean**	***t***	**Mean**	***t***	**Mean**	***t***	**Mean**	***t***	**Mean**	***t***	**Mean**	***t***
2005														
Late monkey														
Early rooster														
2006														
Late rooster														
Early Dog 2														
2007														
Late dog 2														
Early pig 2														
2009														
Late rat 2			1.646	−2.863***			7.884	−2.113**						
Early ox 2			2.068				9.104							

Note: This table reports comparisons in control variables between late and early zodiac sign pairs, in the samples of children for whom cognitive or noncognitive skill test results are available and who were born within the last or first 2 months of a lunar year. Appendix Table A1 provides detailed explanations for all variables. To make the table concise, only variables that are significantly different between pairs are presented.

*** and **denote significance at 5% and 10% respectively.

TABLE 7 The impact of parental investments on children's skills: Different windows.

	Cognitive skills		Noncognitive skills				
	Word recognition test	Math test	Curiosity	Organization	Optimism	Mistake tolerance	Anger control
Variable	(1)	(2)	(1)	(2)	(3)	(4)	(5)
Panel A. An alternative window							
Log (Education cost last year + 1)	7.757***	4.527***	0.098	0.215***	−0.045	0.313***	0.483***
	(1.770)	(1.038)	(0.108)	(0.083)	(0.067)	(0.098)	(0.098)
R^2	0.131	0.163	0.033	0.010	0.016	0.014	0.050
Observations	1105	1105	1190	1190	1190	1190	1190
Panel B. One-month window							
Log (Education cost last year + 1)	8.674***	5.186***	0.188*	0.281**	0.101	0.229**	0.351***
	(1.342)	(0.03)	(0.111)	(0.122)	(0.088)	(0.117)	(0.129)
R^2	0.156	0.161	0.031	0.007	0.016	0.004	0.007
Observations	645	645	625	875	725	725	725

Note: In Panel A, the sample for cognitive skills includes all children for whom cognitive skill test results are available and who were born within the last month or the first three months of a lunar year; the sample for noncognitive skills includes all children for whom noncognitive skill test results are available and who were born within the last month or the first three months of a lunar year. Children born in 2004 and in 2010 are used as the reference in regressions for cognitive skills and noncognitive skills respectively. In Panel B, the sample for cognitive skills includes all children for whom cognitive skill test results are available and who were born within the last month or the first month of a lunar year; the sample for noncognitive skills includes all children for whom noncognitive skill test results are available and who were born within the last month or the first month of a lunar year. Children born in 2004 and in 2011 are used as the benchmark in regressions for cognitive skills and noncognitive skills respectively. Appendix Table A2 provides detailed explanations for all variables. All regressions are controlled for children's gender, number of siblings, parents' age and education, family income, and the survey year dummies, and are clustered at children's birth year-month levels.

***, **, and * denote significance at 1%, 5%, and 10%, respectively.

3.4.3 | Children's self-consciousness/confidence

In the third robustness check, we investigate whether the outcomes from zodiac signs are a result of the child's innate self-consciousness of her zodiac sign rather than because of her interactions with her parents. We cannot directly control for children's self-consciousness about their zodiac signs because the CFPS does not have survey questions on it. To address this, our first approach is to limit the sample to the set of younger children, specifically those no more than 12 years old when taking the survey.[21] The assumption is that younger children are more strongly shaped in their worldviews by their parents, and therefore have a purer response to parental investments, whereas older children may develop their identity and "self-consciousness", taking into account broader extraneous influences. As shown in Table 8, the benchmark results hold qualitatively. Interestingly we find that parents' investments have a quantitatively smaller effect on young children's cognitive skills but a quantitatively larger effect on their noncognitive skills.

The second approach we take is to control for children's self-confidence, which is closely related with children's self-consciousness. Moreover, self-confidence itself may affect children's cognitive

[21]Children who took word recognition and math tests were between 10 and 15 years old. Therefore, 12 is a reasonable cutoff age for the robustness check.

and noncognitive skills, in addition to parents' investments induced by random zodiac signs, because children with random lucky zodiac signs have more innate confidence in themselves by virtue of their birth sign. CFPS provides a number of measures on children's self-confidence including "I feel that I am on an equal plane with others" (Equal), "I feel that I have a number of good qualities" (Quality), "I am able to do things as well as most other people" (Do well), "I take a positive attitude toward myself" (Positive), "I am satisfied with myself" (Satisfy), "I wish I could have more respect for myself" (Respect), and "I am in control of whatever happens to me" (Control). All seven variables take values of 1 for "strongly disagree," 2 for "disagree," 3 for "neutral," 4 for "agree," or 5 for "strongly agree."

To address this concern, we control for all seven self-confidence variables in the second stage of the benchmark regressions for the cognitive skill tests. The results, reported in Table 9, are qualitatively consistent with the benchmark results, showing that self-confidence has no effect on children's cognitive skills. However, only 15% of children answered the self-confidence questions in the population data, so sample size for this analysis (reported in Table 9) is reduced to 430. Furthermore, only 55 observations in the sample of noncognitive skills have non-missing values for self-confidence, hence, we could not perform the robustness check for children's noncognitive skills. Nevertheless, our findings suggest that parental investments, rather than any innate response of children to their birth signs, are responsible for our benchmark findings.

3.4.4 | Falsified birthdates

The fourth check verifies that our results are robust to possible "man-made" birth dates. Huang et al. (2016) find that parents may manipulate children's birth dates under pressure due to the one child policy. For example, parents may change the birth dates of their two children into the same day on their birth certificate, creating a "man-made" twin and avoiding fines of having children beyond the quota. In this scenario, children's birth dates may not be accurate. To prevent our results from possible contamination by manipulated birth dates, we restrict our sample to single children. Table 10 reports the results. Only 429 and 519 children that satisfy the criteria are in the samples for cognitive skill and noncognitive skill regressions, respectively. In Panel A, parental investment induced by children's

TABLE 8 The impact of parental investments on children's skills: Young children.

	Panel A: Cognitive skills		Panel B: Noncognitive skills				
	Word recognition test	Math test	Curiosity	Organization	Optimism	Mistake tolerance	Anger control
Variable	(1)	(2)	(1)	(2)	(3)	(4)	(5)
Log (Education cost last year + 1)	2.856**	−0.255	0.260***	0.304***	0.001	0.467***	0.592***
	(1.360)	(0.684)	(0.096)	(0.930)	(0.109)	(0.110)	(0.102)
R^2	0.147	0.120	0.008	0.032	0.015	0.047	0.100
Observations	653	653	1090	1090	1090	1090	1090

Note: The sample includes all children who were born within the last 2 months or the first 2 months of a lunar year and were no more than 12 years old when taking the survey. Children born in 2004 and in 2010 are used as the reference in regressions for cognitive skills and noncognitive skills respectively. All regressions are controlled for children's gender, number of siblings, parents' age and education, family income, and the survey year dummies, and are clustered at children's birth year-month levels. Appendix Table A2 provides detailed explanations for all variables.

***, **, and * denote significance at 1%, 5%, and 10%, respectively.

TABLE 9 The impact of parental investments on children's skills: Children's self-confidence.

Variable	Word recognition test (1)	Math test (2)
Log (Education cost last year + 1)	8.777***	5.892***
	(1.689)	(0.998)
Equal	−0.426	−0.047
	(0.564)	(0.277)
Quality	0.216	−0.351
	(0.523)	(0.259)
Do well	0.658	0.342
	(0.860)	(0.459)
Positive	0.014	0.200
	(0.299)	(0.225)
Satisfy	−0.462	−0.158
	(0.651)	(0.303)
Respect	1.095*	0.360
	(0.655)	(0.349)
Control	0.370	0.038
	(0.456)	(0.186)
R^2	0.049	0.025
Observations	430	430

Note: The sample includes all children who were born within the last 2 months or the first 2 months of a lunar year. Children born in 2004 are used as the reference in regressions. All regressions are controlled for children's gender, number of siblings, parents' age and education, family income, and the survey year dummies, and are clustered at children's birth year-month levels. Appendix Table A2 provides detailed explanations for all variables.

***, **, and * denote significance at 1%, 5%, and 10%, respectively.

random zodiac signs exerts a positive influence on children's cognitive skill measures, consistent with the benchmark results. In Panel B, parental investment has positive effects on children's organization, mistake tolerance, and anger control, while its effects on children's curiosity and organization are not statistically significant. Overall, due to the reduced sample size, parental investments have weaker positive effects on children's skills. Nevertheless, the findings here are still qualitatively consistent with the benchmark results.

3.4.5 | Other parental investments

The last check considers the role of other parental investments beyond pecuniary education cost. Specifically, we discuss two questions: (1) whether the random assignment of a "lucky" or "unlucky" zodiac sign triggers parents to invest in non-pecuniary forms such as time and attention; (2) whether education cost still has explanatory power after controlling for other dimensions of parental investments. The first question examines the assumption of the exclusion restriction in the first stage of IV regression, that is, whether the random zodiac sign triggers parents to change their education cost only. If the first examination shows that parents do not have differentiated non-pecuniary investments, the

TABLE 10 The impact of parental investments on children's skills: One Child Only.

	Panel A: Cognitive skills		Panel B: Noncognitive skills				
	Word recognition test	Math test	Curiosity	Organization	Optimism	Mistake tolerance	Anger control
Variable	(1)	(2)	(1)	(2)	(3)	(4)	(5)
Log (Education cost last year + 1)	5.957***	3.162***	0.122	0.314***	0.013	0.250**	0.385***
	(2.254)	(0.762)	(0.102)	(0.119)	(0.101)	(0.115)	(0.119)
R^2	0.049	0.051	0.018	0.042	0.040	0.001	0.017
Observations	429	429	519	519	519	519	519

Note: The sample includes all children who were born within the last 2 months or the first 2 months of a lunar year and were the only child in the household. Children born in 2004 and in 2010 are used as the reference in regressions for cognitive skills and noncognitive skills respectively. All regressions are controlled for children's gender, number of siblings, parents' age and education, family income, and the survey year dummies, and are clustered at children's birth year-month levels. Appendix Table A2 provides detailed explanations for all variables.

***, **, and * denote significance at 1%, 5%, and 10%, respectively.

second question focuses on whether there are additional channels for other parental investments to affect children's skill development in the second stage regression.

CFPS provides rich measures of non-pecuniary parental investments. In our sample, we exploit three measures that have the highest response rate and reflect parents' time and attention investment on children: average frequency per week for a child to meet parents, frequency of intimate talks with parents last month, and average frequency per week to have dinner with parents. In the limited subsamples for cognitive and noncognitive skills, respectively, a child on average meets his or her parents 3.85 (3.91) times per week, has heart-to-heart talks with parents 2.53 (2.84) times last month, and has dinner with parents 5.68 (5.35) times per week.

We first explore whether random lucky (unlucky) zodiac signs are correlated with parental investments in time and attention. Table 11 summarizes the results of regressing each non-pecuniary investment on children's random lucky (unlucky) zodiac signs. These results demonstrate that the random

TABLE 11 Other parental investments.

	Panel A: In the sample for cognitive skills			Panel B: In the sample for noncognitive skills		
	Meet with parents	Talk with parents	Dine with parents	Meet with parents	Talk with parents	Dine with parents
Variable	(1)	(2)	(3)	(1)	(2)	(3)
Lucky	0.484	−0.144	0.465	0.167	1.849	1.670
	(0.367)	(0.563)	(0.291)	(0.644)	(1.233)	(0.922)
Unlucky	−0.030	0.084	0.030	0.089	1.260	0.376
	(0.494)	(0.490)	(0.250)	(0.626)	(1.041)	(0.574)
R^2	0.107	0.030	0.030	0.190	0.099	0.017
Observations	417	530	532	305	290	104

Note: The sample includes all children who were born within the last 2 months or the first 2 months of a lunar year. All regressions are controlled for children's gender, number of siblings, parents' age and education, family income, and the survey year dummies, and are clustered at children's birth year-month levels. Appendix Table A2 provides detailed explanations for all variables.

***, **, and * denote significance at 1%, 5%, and 10%, respectively.

TABLE 12 The impact of parental investments on children's skills: Other parental investments.

Variable	Word recognition test (1)	Math test (2)
Log (Education cost last year + 1)	7.483***	5.089***
	(2.039)	(1.332)
Meet with parents	0.301	0.199
	(0.258)	(0.136)
Talk with parents	0.150	0.150
	(0.132)	(0.063)
Dine with parents	0.113	0.092
	(0.273)	(0.144)
Observations	220	220

Note: The sample includes all children who were born within the last 2 months or the first 2 months of a lunar year. All regressions are controlled for children's gender, number of siblings, parents' age and education, family income, and the survey year dummies, and are clustered at children's birth year-month levels. Appendix Table A2 provides detailed explanations for all variables.

***, **, and * denote significance at 1%, 5%, and 10%, respectively.

realization of lucky (unlucky) zodiac signs does not induce parents to have statistically different non-pecuniary investments. Due to relatively low response rate, we can explore the second question in the sample of cognitive skills only. We run the benchmark instrument variable regression with non-pecuniary parental investments as additional control variables. Table 12 shows that non-pecuniary investments have no additional explanatory power on children's cognitive skill development besides education cost in a limited sample of 220 observations.

4 | CONCLUSION

The literature faces a great challenge in properly identifying the potential impact of parental investments in education on children's cognitive and noncognitive development because parental investments may be endogenous. That is, parents may make investment decisions in their children according to their own private information about their offspring, but not observable to outsiders. This paper proposes a culture-specific IV based on the Chinese zodiac as a source of exogenous variation influencing parental investments in their offspring and thereby impacting their cognitive and non-cognitive skills formation. By defining a window around the boundary of a zodiac sign, and assuming that observations are randomly assigned across this boundary, we establish, using a regression discontinuity approach, that parental investments matter to children's cognitive and noncognitive skill development.

ACKNOWLEDGEMENTS

We would like to thank the editor Wei Huang, two anonymous referees, Xin Zhang, and all participants at conferences and seminars that provided us insightful comments and suggestions. Tan thanks the Greg and CIndy Page Faculty Distribution Fund for financial support. Wang thanks the financial support from NSFC (72003181) and the Tang Scholar Fund (KY2040000037).

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

ORCID

Xiao Wang https://orcid.org/0000-0003-3884-0702

REFERENCES

Adhvaryu, A., & Nyshadham, A. (2016). Endowments at birth and parents' investments in children. *Economic Journal*, *126*(593), 781–820. https://doi.org/10.1111/ecoj.12186

Ampaabeng, S. K., & Tan, C. (2013). The long-term cognitive consequences of early childhood malnutrition: The case of famine in Ghana. *Journal of Health Economics*, *32*(6), 1013–1027. https://doi.org/10.1016/j.jhealeco.2013.08.001

Anger, S., & Schnitzlein, D. D. (2017). Cognitive skills, non-cognitive skills, and family background: Evidence from sibling correlations. *Journal of Population Economics*, *30*(2), 591–620. https://doi.org/10.1007/s00148-016-0625-9

Beaman, E. E. D., Pande, R., Topolova, P., & Topalova, P. (2012). Female leadership raises aspirations and educational attainment for girls: A policy experiment in India. *Science*, *335*(6068), 582–586. https://doi.org/10.1126/science.1212382

Blume, L., Brock, W., Durlauf, S. N., & Ioannides, Y. (2011). Identification of social interactions. In J. Benhabib, A. Bisin, & M. Jackson (Eds.), *Handbook of social economics* (pp. 853–964). North Holland.

Boneva, T., & Rauh, C. (2018). Parental beliefs about returns to educational investment—The later the better? *Journal of the European Economic Association*, *16*(6), 1669–1711. https://doi.org/10.1093/jeea/jvy006

Borghans, L., Duckworth, A. L., Heckman, J., & ter Weel, B. (2008). The economics and psychology of personality traits. *Journal of Human Resources*, *43*(4), 972–1059. https://doi.org/10.3368/jhr.43.4.972

Cadena, B. C., & Keys, B. J. (2015). Human capital and the lifetime costs of impatience. *American Economic Journal: Economic Policy*, *7*(3), 126–153. https://doi.org/10.1257/pol.20130081

Carneiro, P., & Heckman, J. (2005). Human capital policy. In B. M. Friedman (Ed.), *Inequality in America: What role for human capital policies?* (pp. 77–208). MIT Press.

Chetty, R., Friedman, J. N., Hilger, N., Saez, E., Schanzenbach, D. W., & Yagan, D. (2011). How does your kindergarten classroom affect your earnings? Evidence from project star. *Quarterly Journal of Economics*, *126*(4), 1593–1660. https://doi.org/10.1093/qje/qjr041

Chuan, A., List, J., Samek, A., & Samujjwala, S. (2022). Parental investments in early childhood and the gender gap in math and literacy. *American Economic Review Papers and Proceedings*, *112*(2), 603–608. https://doi.org/10.1257/pandp.20221036

Cima, R. (2015). *How the Chinese zodiac affects national birth rates*. Priceonomics. https://priceonomics.com/how-the-chinese-zodiac-affects-national-birth/

Cunha, F. (2014). Gaps in early investments in children. Working paper.

Cunha, F., Elo, I., & Culhane, J. (2013). Estimating the Technology of cognitive and noncognitive skill formation. NBER working paper No. 19144.

Cunha, F., & Heckman, J. (2008). Formulating, identifying and estimating the technology of cognitive and noncognitive skill formation. *Journal of Human Resources*, *43*(4), 738–782. https://doi.org/10.3368/jhr.43.4.738

Cunha, F., Heckman, J., & Schennach, S. M. (2010). Estimating the technology of cognitive and noncognitive skill formation. *Econometrica*, *78*(3), 883–931.

Dizon-Ross, R. (2019). Parents' beliefs about their children's academic ability: Implications for educational investments. *The American Economic Review*, *109*(8), 2728–2765. https://doi.org/10.1257/aer.20171172

Do, Q., & Phung, T. D. (2010). The importance of being wanted. *American Economic Journal: Applied Economics*, *2*(4), 236–253. https://doi.org/10.1257/app.2.4.236

Durlauf, S. N., & Ioannides, Y. (2010). Social interactions. *Annual Review of Economics*, *2*(1), 451–478. https://doi.org/10.1146/annurev.economics.050708.143312

Hanushek, E. A., & Dennis, D. K. (2000). Schooling, labor-force quality, and the growth of nations. *The American Economic Review*, *90*(5), 1184–1208. https://doi.org/10.1257/aer.90.5.1184

Hanushek, E. A., & Woessmann, L. (2008). The role of cognitive skills in economic development. *Journal of Economic Literature*, *46*(3), 607–668. https://doi.org/10.1257/jel.46.3.607

Heckman, J., & Mosso, S. (2014). The economics of human development and social mobility. *Annual Review of Economics*, *6*(1), 689–733. https://doi.org/10.1146/annurev-economics-080213-040753

Heckman, J., Pinto, R., & Savelyev, P. (2013). Understanding the mechanisms through which an influential early childhood program boosted adult outcomes. *The American Economic Review*, *103*(6), 2052–2086. https://doi.org/10.1257/aer.103.6.2052

Heckman, J., & Rubinstein, Y. (2001). The importance of noncognitive skills: Lessons from the GED testing program. *The American Economic Review*, *91*(2), 145–149. https://doi.org/10.1257/aer.91.2.145

Heckman, J., Stixrud, J., & Urzua, S. (2006). The effects of cognitive and noncognitive abilities on labor market outcomes and social behavior. *Journal of Labor Economics*, *24*(3), 411–482. https://doi.org/10.1086/504455

Huang, W., Lei, X., & Zhao, Y. (2016). One-child policy and the rise of man-made twins. *The Review of Economics and Statistics*, *98*(3), 467–476. https://doi.org/10.1162/rest_a_00567

Johnson, N. D., & Nye, J. V. C. (2011). Does fortune favor dragons? *Journal of Economic Behavior & Organization*, *78*(1), 85–97. https://doi.org/10.1016/j.jebo.2010.12.010

Kirchsteiger, G., & Sebald, A. (2010). Investments into education—Doing as the parents did. *European Economic Review*, *54*(4), 501–516. https://doi.org/10.1016/j.euroecorev.2009.09.004

Leight, J., Glewwe, P., & Park, A. (2015). *The impact of early childhood rainfall shocks on the evolution of cognitive and non-cognitive skills. Gansu survey of children and families paper 51*. University of Pennsylvania.

Lim, R. (2012). *Enter the dragons: A baby boom for Chinese across Asia*. BBC News. www.bbc.com/news/world-asia-16589052

Lu, S., & Hunt, K. (2015). *Chinese couples shun year of the Sheep babies*. CNN News. https://www.cnn.com/2015/02/08/asia/china-sheep-babies/index.html

Ludwig, J., & Miller, D. L. (2007). Does Head start improve children's life chances? Evidence from a regression discontinuity design. *Quarterly Journal of Economics*, *122*(1), 159–208. https://doi.org/10.1162/qjec.122.1.159

Mocan, N. H., & Yu, H. (2020). Can superstition create a self-fulfilling prophecy? School outcomes of dragon children of China. *Journal of Human Capital*, *14*(4), 485–534. https://doi.org/10.1086/712476

Sen, A. (1999). *Development as freedom*. Oxford University Press.

Shonkoff, J. P., & Phillips, D. A. (2000). *From neurons to neighborhoods: The science of early childhood development*. National Academies Press.

Tan, C. M., Tan, Z., & Zhang, X. (2023). The intergenerational legacy of the 1959-61 great Chinese famine on children's cognitive development. *Economics and Human Biology*, *51*, 101300. https://doi.org/10.1016/j.ehb.2023.101300

Vere, J. P. (2008). Dragon children: Identifying the causal effect of the first child on female labour supply with the Chinese lunar calendar. *Oxford Bulletin of Economics & Statistics*, *70*(3), 303–325. https://doi.org/10.1111/j.1468-0084.2008.00501.x

Wan, W. (2014). *Chinese couples rush to get pregnant before dreaded year of the Sheep*. Washington Post. http://wapo.st/1st8MnB?tid=ss_mail&utm_term=.519213c0558c

Wang, Q. (2014). *Babies bloom in propitious years of the Chinese zodiac*. China Daily. http://www.chinadaily.com.cn/china/2014-05/14/content_17505363.htm

Wong, K. F., & Yung, L. (2005). Do dragons have better fate? *Economic Inquiry*, *43*(3), 689–697. https://doi.org/10.1093/ei/cbi048

Yang, Z. (2014). *Nothing black about the Sheep baby*. China Daily. http://www.chinadaily.com.cn/opinion/2014-12/11/content_19065099.htm

Zhang, H., Behrman, J., Fan, S., Wei, X., & Zhang, J. (2014). Does parental absence reduce cognitive achievements? Evidence from rural China. *Journal of Development Economics*, *111*, 181–195. https://doi.org/10.1016/j.jdeveco.2014.09.004

How to cite this article: Tan, C. M., Wang, X., & Zhang, X. (2024). It's all in the stars: The Chinese zodiac and the effects of parental investments on offspring's cognitive and noncognitive skill development. *Economics of Transition and Institutional Change*, *32*(3), 877–920. https://doi.org/10.1111/ecot.12405

APPENDIX A

TABLE A1 Birth rates in the middle months of lunar years.

	Tiger						Dragon					
	Born in the middle 8 months			Born in the middle 10 months			Born in the middle 8 months			Born in the middle 10 months		
	Tiger	Others	*t*	Tiger	Others	*t*	Dragon	Others	*t*	Dragon	Others	*t*
Panel A. Lucky zodiac signs												
Recent 3 zodiac cycles	0.681	0.676	3.550***	0.841	0.838	2.326**	0.697	0.675	15.170***	0.868	0.836	28.895***
No. of obs.	114,552	1,153,596		114,552	1,153,596		108,965	1,159,183		108,965	1,159,183	
Recent 5 zodiac cycles	0.682	0.676	5.534***	0.843	0.841	2.398**	0.687	0.675	10.975***	0.856	0.840	19.257***
No. of obs.	192,075	2,030,242		192,075	2,030,242		192,226	2,030,091		192,226	2,030,091	
	Snake						**Sheep**					
	Born in the middle 8 months			Born in the middle 10 months			Born in the middle 8 months			Born in the middle 10 months		
	Snake	Others	*t*	Snake	Others	*t*	Sheep	Others	*t*	Sheep	Others	*t*
Panel B. Unlucky zodiac signs												
Recent 3 zodiac cycles	0.673	0.677	−2.350**	0.840	0.839	1.124	0.674	0.676	−1.718*	0.836	0.839	−2.452**
No. of obs.	112,872	1,155,276		112,872	1,155,276		107,198	1,160,950		107,198	1,160,950	
Recent 5 zodiac cycles	0.673	0.676	−3.214***	0.841	0.841	0.144	0.670	0.677	−5.534***	0.838	0.841	−3.776***
No. of obs.	198,219	2,024,098		198,219	2,024,098		189,935	2,030,382		189,935	2,030,382	

Note: A zodiac cycle refers to a set of 12 years from the year of Rat to the year of Pig.

Data resource: 2005 mini-census by National Bureau of Statistics of China.

TABLE A2 Summary statistics.

Variable	Definition
Panel A. Definitions of variables	
Word test	The child's word recognition test score based on the number of questions answered correctly. Minimum: 0, maximum: 34.
Math test	The child's math test score based on the number of questions answered correctly. Minimum: 0, maximum: 24.
Curiosity	The parent's answer on whether the child is curious. 1: Strongly disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly agree.
Organization	The parent's answer on whether the child is organized. 1: Strongly disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly agree.
Optimism	The parent's answer on whether the child is optimistic. 1: Strongly disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly agree.
Mistake tolerance	The parent's answer on whether the child can tolerate others' mistakes. 1: Strongly disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly agree.
Anger control	The parent's answer on whether the child can control his or her anxiety/anger. 1: Strongly disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly agree.
Total education cost last year	The total real expenditure by parents on the child's education last year (thousand RMB, 2010 as the base year).
Gender	The child's gender: 1 male, 0 female.
No. of siblings	Number of siblings.
Family income	The total real income of the family last year (thousand RMB, 2010 as the base year).
Father's age	The father's age.
Father's education	Education years of the father: 0 for illiteracy/near-illiteracy, 6 years for primary school, 9 years for middle school, 12 years for high school, 14 years for associate's degree, 16 years for bachelor's, 19 years for master's, 22 years for PhD.
Mother's age	The mother's age.
Mother's education	Education years of the mother; see “Father's education.”
Late rat	1 if child was born in 1997 and in the last 2 months of the rat year, 0 otherwise. Cutoff: 02/07/1997.
Early ox	1 if child was born in 1997 and in the first 2 months of the ox year, 0 otherwise. Cutoff: 02/07/1997.
Late ox	1 if child was born in 1998 and in the last 2 months of the ox year, 0 otherwise. Cutoff: 01/28/1998.
Early tiger	1 if child was born in 1998 and in the first 2 months of the tiger year, 0 otherwise. Cutoff: 01/28/1998.
Late tiger	1 if child was born in 1999 and in the last 2 months of the rat year, 0 otherwise. Cutoff: 02/16/1999.
Early rabbit	1 if child was born in 1999 and in the first 2 months of the ox year, 0 otherwise. Cutoff: 02/16/1999.

TABLE A2 (Continued)

Variable	Definition
Late rabbit	1 if child was born in 2000 and in the last 2 months of the rabbit year, 0 otherwise. Cutoff: 02/05/2000.
Early dragon	1 if child was born in 2000 and in the first 2 months of the dragon year, 0 otherwise. Cutoff: 02/05/2000.
Late dragon	1 if child was born in 2001 and in the last 2 months of the dragon year, 0 otherwise. Cutoff: 01/24/2001.
Early snake	1 if child was born in 2001 and in the first 2 months of the snake year, 0 otherwise cutoff: 01/24/2001.
Late snake	1 if child was born in 2002 and in the last 2 months of the snake year, 0 otherwise. Cutoff: 02/12/2002.
Early horse	1 if child was born in 2002 and in the first 2 months of the horse year, 0 otherwise cutoff: 02/12/2002.
Late horse	1 if child was born in 2003 and in the last 2 months of the horse year, 0 otherwise cutoff: 02/01/2003.
Early sheep	1 if child was born in 2003 and in the first 2 months of the sheep year, 0 otherwise. Cutoff: 02/01/2003.
Late sheep	1 if child was born in 2004 and in the last 2 months of the sheep year, 0 otherwise cutoff:01/22/2004.
Early monkey	1 if child was born in 2004 and in the first 2 months of the monkey year, 0 otherwise. Cutoff:01/22/2004.
Late monkey	1 if child was born in 2005 and in the last 2 months of the monkey year, 0 otherwise. Cutoff: 02/09/2005.
Early rooster	1 if child was born in 2005 and in the first 2 months of the rooster year, 0 otherwise. Cutoff: 02/09/2005.
Late rooster	1 if child was born in 2006 and in the last 2 months of the rooster year, 0 otherwise. Cutoff:01/29/2006.
Early dog 2	1 if child was born in 2006 and in the first 2 months of the dog year, 0 otherwise. Cutoff:01/29/2006.
Late dog 2	1 if child was born in 2007 and in the last 2 months of the dog year, 0 otherwise. Cutoff: 02/18/2007.
Early pig 2	1 if child was born in 2007 and in the first 2 months of the pig year, 0 otherwise. Cutoff: 02/18/2007.
Late rat 2	1 if child was born in 2009 and in the last 2 months of the rat year, 0 otherwise. Cutoff: 01/26/2009.
Early ox 2	1 if child was born in 2009 and in the first 2 months of the ox year, 0 otherwise. Cutoff: 01/26/2009.
Equal	The child's answer on "I feel that I am on an equal plane with others". 1: Strongly disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly agree.
Quality	The child's answer on "I feel that I have a number of good qualities". 1: Strongly disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly agree.
Do well	The child's answer on "I am able to do things as well as most other people". 1: Strongly disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly agree.
Positive	The child's answer on "I take a positive attitude toward myself". 1: Strongly disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly agree.
Satisfy	The child's answer on "On the whole, I am satisfies with myself". 1: Strongly disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly agree.
Respect	The child's answer on "I wish I could have more respect for myself". 1: Strongly disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly agree.

(Continues)

TABLE A2 (Continued)

Variable	Definition
Control	The child's answer on "I am in control of whatever happens to me". 1: Strongly disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly agree.
Meet with parents	Average times per week for the child meeting his/her parents
Talk with parents	Frequency of heart-to-heart talk with parents last month.
Dine with parents	Number of times a child dines with parents every week (evening).

Variable	Mean	St. dev.	Min	Max	# of obs.
Panel B. Summary statistics: The sample for cognitive skills					
Word recognition test	21.262	7.510	0	34	1098
Math test	10.433	4.182	0	24	1098
Total education cost last year	2.051	3.384	0	15.900	1098
Gender	0.517	0.500	0	1	1098
No. of siblings	1.818	0.869	1	7	1098
Family income	31.263	45.663	0	183.406	1098
Father's age	40.980	5.033	28	57	1098
Father's education	7.311	4.007	0	19	1098
Mother's age	39.113	4.745	26	51	1098
Mother's education	5.891	4.505	0	22	1098
Late rat	0.049	0.216	0	1	1098
Early ox	0.060	0.238	0	1	1098
Late ox	0.060	0.238	0	1	1098
Early tiger	0.069	0.254	0	1	1098
Late tiger	0.084	0.277	0	1	1098
Early rabbit	0.102	0.303	0	1	1098
Late rabbit	0.104	0.305	0	1	1098
Early dragon	0.098	0.298	0	1	1098

TABLE A2 (Continued)

Variable	Mean	St. dev.	Min	Max	# of obs.
Late dragon	0.092	0.289	0	1	1098
Early snake	0.046	0.211	0	1	1098
Late snake	0.032	0.176	0	1	1098
Early horse	0.040	0.196	0	1	1098
Late horse	0.036	0.185	0	1	1098
Early sheep	0.036	0.187	0	1	1098
Late sheep	0.040	0.196	0	1	1098
Early monkey	0.050	0.217	0	1	1098
Lucky	0.343	0.476	0	1	1098
Unlucky	0.154	0.353	0	1	1098
Equal	3.798	0.844	1	5	430
Quality	3.760	0.797	1	5	430
Do well	4.002	0.601	1	5	430
Positive	3.642	0.995	1	5	430
Satisfy	3.879	0.712	1	5	430
Respect	4.063	0.737	1	5	430
Control	3.442	1.027	1	5	430
Meet with parents	3.847	2.980	0	7	417
Talk with parents	2.534	4.484	0	35	530
Dine with parents	5.676	2.241	0	7	532

(Continues)

TABLE A2 (Continued)

Variable	Mean	St. dev.	Min	Max	# of obs.
Panel C. Summary statistics: The sample for noncognitive skills					
Curiosity	3.768	0.792	1	5	1257
Organization	3.545	0.882	1	5	1257
Optimism	3.941	0.617	1	5	1257
Mistake tolerance	3.557	0.852	1	5	1257
Anger control	3.352	0.930	1	5	1257
Total education cost last year	1.813	3.517	0	15.152	1257
Gender	0.543	0.498	0	1	1257
No. of siblings	1.808	0.902	1	8	1257
Family income	35.029	41.649	0	186.026	1257
Father's age	36.997	6.056	24	53	1257
Father's education	7.967	3.861	0	19	1257
Mother's age	35.089	6.107	20	50	1257
Mother's education	6.792	4.448	0	22	1257
Late rat	0.033	0.180	0	1	1257
Early ox	0.043	0.205	0	1	1257
Late tiger	0.038	0.192	0	1	1257
Early rabbit	0.067	0.250	0	1	1257
Late rabbit	0.038	0.192	0	1	1257
Early dragon	0.006	0.074	0	1	1257
Late dragon	0.026	0.160	0	1	1257
Early snake	0.051	0.220	0	1	1257
Late snake	0.029	0.169	0	1	1257
Early horse	0.032	0.176	0	1	1257

TABLE A2 (Continued)

Variable	Mean	St. dev.	Min	Max	# of obs.
Late horse	0.038	0.192	0	1	1257
Early sheep	0.056	0.231	0	1	1257
Late sheep	0.040	0.196	0	1	1257
Early monkey	0.010	0.097	0	1	1257
Late monkey	0.034	0.182	0	1	1257
Early rooster	0.056	0.231	0	1	1257
Late rooster	0.055	0.228	0	1	1257
Early dog 2	0.038	0.182	0	1	1257
Late dog 2	0.076	0.264	0	1	1257
Early pig 2	0.053	0.225	0	1	1257
Late rat 2	0.034	0.182	0	1	1257
Early ox 2	0.069	0.254	0	1	1257
Lucky	0.070	0.280	0	1	1257
Unlucky	0.176	0.393	0	1	1257
Meet with parents	3.910	3.122	0	7	305
Talk with parents	2.843	5.107	0	35	290
Dine with parents	5.350	2.438	0	7	104

TABLE A3 Random zodiac signs.

Zodiac signs	Mean	*t*
Random early lucky signs versus .random neighbor signs		
Random early lucky signs (tiger and dragon)	0.174	1.028
Random neighbor signs (ox and rabbit)	0.163	
Random late lucky signs versus .random neighbor signs		
Random late lucky signs (tiger and dragon)	0.159	
Random neighbor signs (rabbit and snake)	0.156	0.319
Random early unlucky signs versus .random neighbor signs		
Random early unlucky signs (snake and sheep)	0.172	
Random neighbor signs (dragon and horse)	0.183	−0.536
Random late unlucky signs versus .random neighbor signs		
Random late unlucky signs (snake and sheep)	0.194	
Random neighbor signs (horse and monkey)	0.175	−1.234