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Comparisons of academic achievements of one-only children vs. children with siblings in China

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Abstract
In 2015, the "One Child Per Family" policy which had been in place for nearly 40 years was terminated in China. This policy has had a significant historical impact on the society. Comparing the populations of one-only children and children with siblings is an effective way to reflect on this policy. This study used data between 2014 and 2017 from the National Assessment Center for Education Quality in China. Samples with hundreds of thousands of 4th grade and 8th grade students were Meta-analyzed to reveal the significant large magnitude of differences in academic achievement between one-only children and children with siblings. These differences vary across several demographic group factors, such as subjects, grade years, Social Economic Status (SES), locations, and achievement levels. However, there are no significant gender differences between the two groups. With an increase in the number of one-child families in some Western countries, the finding would be very beneficial to learn about the strength and weakness of this family structure and also provides insights to schoolteachers and counselors.

Keywords Academic achievements · One-only children · Children with siblings · China

Introduction

Since 1925, over 200 studies have been published which either focused directly on the families with only one child or included one-only children within a larger framework of investigation. One-only children have long been a topic of inquiry by parents, psychologists and sociologists regarding their personality, cognitive development, mental health, and social adjustment. In the United States, one-only-child families are becoming increasingly common, partly because of limited financial resources, as well as the rising trend of individuals choosing to start families at a later age than what has been historically practiced (Newman, 2001). In China, a country on the other side of the world, the "One Child Per Family" policy took effect in 1979 to plan and control the population of the country. However, this policy was terminated in 2015. Over the past 40 years, this policy has yielded one of the most significant historical impacts on the society. Although this policy was terminated, the population structure will not change significantly in a short period of time. One-only children and children with siblings will coexist for a long time and their differences will be evaluated consistently. Learning about the population of one-only children and promoting their healthy development would be of great value. Research in this field would provide insights into the cognitive and social development of these children.

In such research, the most commonly used keywords include birth orders, family size, family dynamics, and so on. In

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addition, previous studies have explored the differences between one-only children and children with siblings in the areas of academic achievement, personal characteristics, and social development. In the old days, some psychologists, such as G. Stanley Hall, concluded that "being an only child is a disease in itself" based on an extremely small sample size of one-only children (Hall, 1898). Some recent studies did find that one-only children were more self-centered, maladjusted, selfish, lonely, and dependent (Cameron, Erkal, Gangadharan, & Meng, 2013; Roberts & Blanton, 2001). Similar negative stereotypes about the one-only children still persist nowadays, despite the growing trend of having only one child, as well as the large body of evidence revealing the strengths of the one-only children. For example, several studies found no differences between one-only children and those with siblings in the domains of adjustment and sociability (Falbo, 2012; Falbo & Polit, 1986; Mancillas, 2006). In addition, the strongest advantage of one-only children is their high achievement, which was consistently found across many studies in both Western and Eastern countries (e.g., Booth & Kee, 2009; Downey, 2001; Falbo & Polit, 1986; Travis & Kohli, 1995; Wei et al., 2016). For example, Falbo and Polit (1986) conducted a meta-analysis of 115 studies on one-only children and demonstrated that they had significantly higher achievement scores than their peers with siblings.

Several major theoretical perspectives have been developed to explain the achievement advantage of one-only children. The first one is called the confluence hypothesis (Zajonc & Markus, 1975). It claimed that birth order has an important impact on one's cognitive achievement because it largely influences the attention one receives from family members and the intellectual opportunities that are provided. In other words, as sibling size increases, the amount of attention and resources that the subsequent siblings receive is lessening. Moreover, Falbo and Polit (1986) found that only children were not reliably different from firstborns. Therefore, under this perspective, one-only children who had the most attention would have a higher IQ than other younger children.

The second perspective is resource dilution hypothesis (Downey, 2001). This model posits that parental resources are limited. As the number of children in the family increases, the resources received by any one child will decline. In this case, the fewer siblings result in less competitions for parents' time, energy, attention, and financial resources. This model also claimed that the richness of parental resources also affects one's educational success. Parental resources include parents' communications and expectations. Parents with one child exhibited significantly higher parent-child communication, learning assistance (Chen, 2007) and academic expectations (Tsui & Rich, 2002). The study of Benner, Boyle, and Sadler (2016) found that parents' educational expectation of their children is an important predictor of children's academic achievement. This is because parents' communication of educational expectations will impact the children on their beliefs about education and themselves, and in turn affect their academic achievement (Hill & Tyson, 2009). Other than these, the advantages of one-only children remain after statistically controlling for parents' educational levels and family income (Blake, 1989; Polit & Falbo, 1988).

Besides academic achievement, researchers have documented the interaction effects of one-only children advantage and demographic variables such as SES, location, and age. First, SES has always been considered as a contributor of the associations between only child advantage and academic achievement. High-income families have more surplus resources for children so siblings usually compete with each other for these educational resources. However, low-income families spend most resources to meet basic needs so they often save little for education anyway. This is why high-income families experience more one-only child advantage in educational resources (Downey & Nerbauer, 1998). Consistent with these results, Booth and Kee (2009) found that the impact of birth order affects children's educational attainment more negatively for highly educated women, because they often give more priority to education. Second, urbanicity impacts the one-only child effect in a similar way. A few studies found that one-only child advantage in academic achievement is only significant in urban areas, while these was no effect in rural areas (Bao & Su, 1989; Poston & Falbo, 1990a, b) because it affects educational resources and ideology. Lastly, as children grow older, the superiority of only children is weakened by schooling (Falbo & Polit, 1986; Jiao, Ji, & Jing, 1996). In addition, samples with different ages—elementary school students (Wei et al., 2016) and middle to high school students (Iqbal, Bibi, & Iqbal, 2015; Marks, 2006) were all used to demonstrate the academic advantage of one-only children. However, there were studies that suggested birth order was unrelated to academic achievement in college students. For instance, Edwards and Thacker (1979) recruited 326 college freshmen from two-children families and discovered no association between birth order and grade point average. Hauser and Sewell (1985) found no relationship between birth order and educational attainment among 9000 high school graduates when other confounding variables were controlled. Furthermore, this study also found no relationship between parent-child relationship and academic performance.

The current study was carried out for three main reasons. First, the differences between one-only children and children with siblings are affected by culture. Falbo (2018) found that parents evaluated their only children born after the One Child Policy more positively than did parents of only children born before this policy in China. Therefore, the one-only children in China are a special outcome of policy in which unique political and social factors are involved. Due to the great cultural differences between China and Western countries, the

results of Western studies on one-only children could not be applied to Chinese children. Hence, this study hopes to examine this topic with a special cultural perspective. Second, due to the lack of data for publicly released student achievement, there are few large-scale studies examining academic differences between one-only children and children with siblings in China. Finally, in most previous studies, the differences of academic achievements between one-only children and children with siblings were examined with different subjects. For example, studies of elementary school children in China have found that one-only children are more likely to outscore children with siblings in verbal tests (Falbo & Poston, 1993; Jiao et al., 1996), as well as in eighth grade mathematics achievement (Tsui & Rich, 2002). Other researchers, such as Yang, Kao, and Wang (1980) used imagination, language ability, imitation, and productive thinking scores in their study; Iqbal et al. (2015) used eighth grade science grades; Marks (2006) used mathematics and reading scores in examinations. As far as we know, no research has compared the achievements among multiple subjects between one-only children and children with siblings.

The Program of Regional Education Assessment is a large-scale assessment that is implemented annually in China, including both of the survey of students and teachers from 2013. Drawing on the data from 2014 to 2017, the current study attempts to address two questions:

1 What is the magnitude of difference between one-only children and children with siblings in their academic achievement? How did it change in the three year span from 2014 to 2017?
2 How do the differences between one-only children and children with siblings in academic achievement vary by different subjects, grade years, achievement levels, locations, and socioeconomic status?

Method

Data and Participants

This study employed data from year 2014 to 2017 of the National Assessment Center for Education Quality, which is a government institute for montiring the quality of compulsory education in China and used students of 4th grade and 8th grade in China as participants. The average ages of the 4th and 8th graders are ten and fourteen respectively. These students were chosen because of their less stressful learning achedule, which led to higher response rate. The sample size for the subject of Math is 891,978, in which 462,278 are from 4th grade and 429,700 are from 8th grade. The sample size for the subject of Chinese is 879,738, with 462,846 from 4th grade and 416,892 from 8th grade. For the subjects of English and Science, only data from 8th grade students was collected—with 349,854 students included for English and 430,081 included for Science. Please see Table 1 for sample sizes as well as sample makeup for all the subjects across years. The study was reviewed and approved by the research committee, as well as by the committee in local government. All subjects and their parents were provided with written informed consent.

Test and Other Variable- Students' Socioeconomic Status (SES)

According to China's national curriculum standard of each subject, all tests were developed by experts and teachers. For students in Grade 4 and Grade 8, eight and sixteen tests were conducted separately in 2014–2017. The details of the number, the percentage of items and internal consistency reliability(Cronbach's Alpha)for each test are also presented in Table 1.

In this paper, we also study the variables of school locations and socioeconomic status (SES). The student questionnaire contained a range of questions about students' family background. This information was used to compute the students' socioeconomic status (SES) according to the guidelines of international academic assessment project-PISA (Program for International Student Assessment) (OECD, 2013). SES scores are obtained by the principal of component analysis of the following three indicators: highest occupational status of parents, highest education level of parents, and family cultural economic resources which is based on student reports on home possessions (Li, Liu, Zhang, & Liu, 2020; OECD, 2013). Specifically, the variable of parents' occupational status is coded corresponding to International Socio-Economic Index (ISEI) of occupational status (Cresswell, Schwantner, & Waters, 2015). Parents' education level is divided into seven categories: no school, elementary school, junior high school, senior high school, junior college, college, graduate school. The means of home possessions determine a student's family cultural economic resources by investigating the situation of his or her family material conditions, with questions such as "Do you have your own room?", "Do you have a personal laptop at home for study or work?", "Does your family own a car?", "Does your house have a bathroom with a bathtub?" and "Does your family have a quiet study space for you?" Based on this, the potential characteristic value of a student's family cultural economic resources can be estimated through standardized value of these five scores of family property. The internal consistency reliabilities(Cronbach's Alpha)of the SES scale were between 0.657 and 0.691.

Meta-Analytic Procedure

As this project recruits from independent samples, it is reasonable to hypothesize that students' academic achievements may change across years of sampling. To compare the results of

Table 1 The details of the number, internal consistency reliability and Sample size information for each test

Subject	Year	Grade	The number of items	Alpha reliability	Number of One-Only Children	Percentage of One-Only Children	Total size across Grades	Total size across subjects
Math	2014	4	33	0.854	62,052	36.3%	462,278	891,978
	2015	4	27	0.855	16,641	25.4%		
	2016	4	30	0.859	43,120	27.1%		
	2017	4	29	0.845	15,229	22.7%		
	2014	8	26	0.875	73,157	43.1%	429,700	
	2015	8	25	0.904	17,404	29.9%		
	2016	8	31	0.892	52,776	34.5%		
	2017	8	31	0.923	11,435	23.5%		
Chinese	2014	4	40	0.828	62,080	36.1%	462,846	879,738
	2015	4	37	0.856	16,756	25.6%		
	2016	4	36	0.826	43,092	27.1%		
	2017	4	27	0.780	15,192	22.8%		
	2014	8	20	0.869	70,002	43.3%	416,892	
	2015	8	21	0.868	17,284	30.0%		
	2016	8	20	0.873	51,818	34.6%		
	2017	8	22	0.876	11,265	23.6%		
English	2014	8	70	0.964	54,563	40.9%	349,854	349,854
	2015	8	70	0.966	17,289	29.9%		
	2016	8	61	0.964	34,027	31.0%		
	2017	8	49	0.958	11,396	23.5%		
Science	2014	8	41	0.792	73,062	43.1%	430,081	430,081
	2015	8	41	0.818	17,474	29.9%		
	2016	8	40	0.855	52,834	34.5%		
	2017	8	36	0.843	11,459	23.5%		

The Program of Regional Education Assessment only collected English and Science data on 8th grade students

independent samples, meta-analysis method is used in this study. Some researchers have used the random-effects model to compute homogeneity statistics in recent years (Hedges & Vevea, 1998). Compared to a fixed-effects model, the random-effects model gives a slightly larger error term, but it yields more appropriate estimation of variability across samples (Hunter & Schmidt, 2000). Therefore, the random-effects model was preferred, and Comprehensive Meta-Analysis (CMA) V3 (Borenstein, Hedges, Higgins, & Rothstein, 2012) were used in this study.

In the meta analysis, Cohen's *d* (Cohen, 1988) was used to assess differences in academic achievements between one-only children and children with siblings. $d = (M_O\text{-}M_S)/S_W$, where M_O is the mean for one-only children, M_S is the mean for children with siblings, and *Sw* is the pooled within-group standard deviation. Positive values of d show the advantage of one-only children in test scores, and negative values show the advantage of children with siblings. Absolute values of *d* below 0.2 can be considered small, between 0.2 and 0.5 as medium and above 0.5 as large. In a test of mean effect size, *Z*-value and its corresponding *p* value indicate whether the mean effect size is zero or not. In the heterogeneity test, we used *Q* to reflect the dispersion of all effect sizes about the mean effect size, which can be described as a "Weighed sum of squares". It is computed through squared deviation weighted by the inverse variance $Q = (X\text{-}Y)^2 \times \frac{1}{V}$, with *X* as the observed effect size for each study, *Y* as the mean effect size, and V as the variance of the effect size for the study. The *Q* values across different studies is a chi-squared distribution with the expected value of *Q* equal to *df*. The ratio *(Q-df)/Q* is true/total variance called I^2. By convention, it is multiplied by 100% and shown as a percentage (0% to 100%) (Kelley & Kelley, 2012).

Results

Means, Standard Deviations and Effect Sizes of One-Only Children and Children with Siblings

Table 2 presents the descriptive statistics and effect sizes for one-only children and children with siblings of the 4th grade and the 8th grade across various subjects (Math, Chinese, English, and Science) from 2014 to 2017. Table 3 presents

Table 2 Descriptive statistics, and effect sizes for Math, Chinese, English and Science scores

Subject	Year	Grade	One-Only Children			Children with Siblings			Cohen's d	P Value
			M	SD	N	M	SD	N		
Math	2014	4	559.19	78.31	62,052	526.06	81.47	108,784	0.41	0.000
	2015	4	582.90	104.05	16,641	533.98	108.93	48,916	0.45	0.000
	2016	4	583.95	80.52	43,120	554.39	84.62	115,767	0.35	0.000
	2017	4	580.20	88.63	15,229	543.88	89.01	51,769	0.41	0.000
	2014	8	562.23	102.23	40,426	522.56	99.82	42,997	0.31	0.000
	2015	8	552.06	82.59	73,157	526.58	81.34	96,603	0.36	0.000
	2016	8	585.31	77.42	17,404	557.05	80.42	40,887	0.37	0.000
	2017	8	587.95	76.72	52,776	559.98	75.48	100,227	0.40	0.000
Chinese	2014	4	575.53	86.04	11,435	540.99	86.90	37,211	0.40	0.000
	2015	4	568.86	76.93	62,080	536.20	83.87	109,662	0.48	0.000
	2016	4	583.02	82.42	16,756	540.30	90.88	48,733	0.39	0.000
	2017	4	588.78	79.95	43,092	557.05	83.42	115,755	0.37	0.000
	2014	8	588.10	77.14	15,192	558.82	80.61	51,576	0.22	0.000
	2015	8	544.31	86.16	40,380	522.26	82.91	42,286	0.33	0.000
	2016	8	546.58	85.66	70,002	527.72	83.66	91,565	0.26	0.000
	2017	8	555.44	86.79	17,284	527.99	82.11	40,394	0.41	0.000
English	2014	8	553.81	86.15	51,818	531.89	82.78	98,096	0.31	0.000
	2015	8	551.29	89.27	11,265	514.96	88.73	36,468	0.50	0.000
	2016	8	546.88	97.48	26,896	496.37	90.87	28,598	0.42	0.000
	2017	8	538.82	99.54	54,563	508.81	93.93	78,939	0.50	0.000
Science	2014	8	579.94	108.05	17,289	528.18	101.04	40,580	0.34	0.000
	2015	8	573.94	112.37	34,027	528.63	106.96	75,909	0.38	0.000
	2016	8	595.81	121.59	11,396	537.54	114.81	37,151	0.42	0.000
	2017	8	531.92	101.21	40,503	493.41	95.56	43,243	0.37	0.000

the combined effects of mean differences between one-only children and children with siblings across grades and subjects. The results showed that from 2014 to 2017, the effect sizes of Math score differences between one-only children and children with siblings from the 4th grade are 0.35 to 0.45. The average effect size was $d = 0.41$, $Z = 121.72$, $p = 0.000$. This represents that one-only children from the 4th grade have significantly better scores on Math than children with siblings do. Children from the 8th grade showed a range of effect sizes between 0.31 to 0.40, with an average effect size $d = 0.36$, $Z = 106.80$, $p = 0.000$. This represents that one-only children from the 8th grade also have significantly better scores on Math than children with siblings. The effect sizes of Chinese score differences between one-only children and children with siblings from the 4th grade are 0.37 to 0.48. The average effect size was $d = 0.41$, $Z = 20.62$, $p = 0.000$, which represents that one-only children from the 4th grade have significantly better scores on Chinese than children with siblings. For children from the 8th grade, the range of effect sizes is between 0.22 to 0.41, with an average effect size $d = 0.31$, $Z = 8.00$, $p = 0.000$, also representing that one-only children from the 8th grade have significantly better scores on Chinese than children with siblings. The effect sizes of English score differences between one-only children and children with siblings from the 8th grade are 0.31 to 0.50. The average effect size was $d = 0.43$, $Z = 9.17$, $p = 0.000$, representing that one-only children from the 8th grade have significantly better scores on English than children with siblings. Similarly for Science, children from the 8th grade had the range of effect sizes between 0.34 to 0.42, with an average effect size $d = 0.38$, $Z = 16.83$, $p = 0.000$, representing that one-only children from the 8th grade also have significantly better scores on Science than children with siblings.

Heterogeneity analysis revealed that there was significant diversity present in the distribution of effect sizes across both the 4th and 8th grades and across all subjects. We found that for Math there was no significant difference between the 4th and the 8th grades ($Q(1) = 3.07$, $p = 0.080$). However, for Chinese, the 4th grade has a significantly bigger effect size of differences than the 8th grade ($Q(1) = 6.80$, $p = 0.009$). Across the subjects, there was no significant difference in the effect sizes between Math and Chinese for the 4th grade

Table 3 Scores differences between one-only children and children with siblings across grades and subjects

Subject	Grade	K	Cohen's d	95% Confidence Interval		Test of Null (two-tail)		Heterogeneity		
				Lower Limit	Upper Limit	Z	p	Q	p	I^2
Math	4	4	0.41	0.37	0.45	121.72	0.000	108.19	0.000	97.23
	8	4	0.36	0.34	0.35	106.80	0.000	91.54	0.000	96.72
	Between Groups							3.07	0.080	
Chinese	4	4	0.41	0.37	0.45	20.62	0.000	100.08	0.000	97.00
	8	4	0.31	0.24	0.37	8.88	0.000	293.31	0.000	98.98
	Between Groups							6.80	0.009	
English	8	4	0.43	0.34	0.53	9.17	0.000	461.62	0.000	99.35
Science	8	4	0.38	0.33	0.42	16.83	0.000	127.85	0.000	97.65
Cross Subjects Between Groups	4							0.00	0.964	
	8							5.58	0.134	

($Q(1) = 0.00$, $p = 0.964$). In addition, no significant difference was found among Math, Chinese, English, and Science for the 8th grade ($Q(3) = 5.58$, $p = 0.134$). But the values indicate that there is discrepancy across different subjects With English exhibiting the largest difference, followed by science and math, then Chinese had the smallest difference.

Social Economic Status (SES) Differences on Scores between One-Only Children and Children with Siblings

Table 4 presents the SES differences in scores across subjects for one-only children and children with siblings from the 4th and 8th grades. The results show that for Math and Chinese in the 4th grade, the effect size of one-only children and children with siblings difference is significantly greater in high and medium SES families than in low SES families (Math: $Q(1) = 15.15$, $p = 0.000$; $Q(1) = 4.48$, $p = 0.034$; Chinese: $Q(1) = 10.64$, $p = 0.001$; $Q(1) = 4.27$, $p = 0.039$). For the 8th graders, students from high SES families show a significant larger effect size across all the subjects except Math between one-only children and children with siblings than students from medium SES families (Chinese: $Q(1) = 26.75$, $p = 0.000$; English: $Q(1) = 31.69$, $p = 0.000$; Science: $Q(1) = 23.55$, $p = 0.000$). Meanwhile, students from medium SES families show a significant larger effect size across all the subjects except Math between one-only children and children with siblings than students from low SES families (Chinese: $Q(1) = 5.72$, $p = 0.017$; English: $Q(1) = 4.53$, $p = 0.033$; Science: $Q(1) = 5.96$, $p = 0.015$). For all students from different SES families in the 4th grade, there is no significant difference on the effect sizes in Math and Chinese between one-only children and children with siblings. For students from medium and low SES families in the 8th grade, there is no significant difference on the effect sizes in all subjects between the two different kinds of children. However, for students from high SES families in the 8th grade, there is a significant difference among all of the subjects. The difference is that Math and Chinese have a significantly smaller effect size between the two types of children than in English and Science (Math to English: $Q(1) = 2.37$, $p = 0.124$; Math to Science: $Q(1) = 1.45$, $p = 0.229$; Chinese to English: $Q(1) = 11.34$, $p = 0.001$; Chinese to Science: $Q(1) = 10.00$, $p = 0.002$). There is no significant found between Math and Chinese, or English and Science.

Location Differences on Scores between One-Only Children and Children with Siblings

Table 5 presents location differences in scores across subjects for one-only children and children with siblings from the 4th and 8th grades. The results show that for Math and Chinese in both the 4th and 8th grades, as well as for English and Science in the 8th grade, the effect size of one-only children and children with siblings difference is significantly greater in urban areas than in suburban areas. For the 4th graders in the urban areas, there is no significant difference on the effect sizes of Math and Chinese between the two types of children ($Q(1) = 0.03$, $p = 0.856$). The 4th graders in the suburban areas have similar results ($Q(1) = 1.74$, $p = 0.188$). For the 8th graders in urban areas, significant effects are all found on Math, Chinese, English and Science between the two types of children ($Q(3) = 11.92$, $p = 0.008$). In addition, the effect size difference on Chinese between the two types of children is significantly lower than it on Math ($Q(1) = 4.294$, $p = 0.038$), on English ($Q(1) = 5.84$, $p = 0.016$), and on Science ($Q(1) = 10.67$, $p = 0.001$). For the 8th graders in the suburban areas, no significant effects were found on Math, Chinese, English,

Table 4 Score differences between one-only children and children with siblings across different SES levels

Subject	Grade	SES	K	Cohen's d	95% Confidence Interval		Test of Null (two-tail)		Heterogeneity		
					Lower Limits	Upper Limits	Z	p	Q	p	I^2
Math	4	High	4	0.39	0.31	0.47	9.46	0.000	152.25	0.000	98.03
		Medium	4	0.29	0.23	0.36	8.93	0.000	72.22	0.000	95.85
		Low	4	0.20	0.18	0.25	11.29	0.000	17.65	0.001	83.00
		Between Groups							16.93	0.000	
	8	High	4	0.33	0.21	0.46	5.21	0.000	322.95	0.000	99.07
		Medium	4	0.25	0.22	0.28	16.84	0.000	14.20	0.003	78.87
		Low	4	0.20	0.01	0.39	2.09	0.037	629.95	0.000	99.52
		Between Groups							1.87	0.394	
Chinese	4	High	4	0.37	0.29	0.46	8.86	0.000	162.47	0.000	98.15
		Medium	4	0.29	0.24	0.34	11.36	0.000	43.44	0.000	93.09
		Low	4	0.22	0.18	0.26	11.40	0.000	19.08	0.000	84.28
		Between Groups							12.27	0.002	
	8	High	4	0.34	0.31	0.37	20.59	0.000	23.09	0.000	87.01
		Medium	4	0.20	0.15	0.24	8.80	0.000	30.54	0.000	90.18
		Low	4	0.10	0.03	0.16	2.95	0.003	67.32	0.000	95.54
		Between Groups							54.09	0.000	
English	8	High	4	0.44	0.39	0.48	17.97	0.000	44.57	0.000	93.27
		Medium	4	0.25	0.21	0.30	11.67	0.000	24.56	0.000	87.78
		Low	4	0.14	0.04	0.24	2.85	0.004	106.52	0.000	97.18
		Between Groups							46.06	0.000	
Science	8	High	4	0.41	0.38	0.44	25.50	0.000	22.60	0.000	86.73
		Medium	4	0.28	0.24	0.32	12.80	0.000	31.44	0.000	90.46
		Low	4	0.18	0.12	0.25	5.64	0.000	61.40	0.000	95.11
		Between Groups							50.18	0.000	
Cross Subjects	4	High							0.05	0.827	
		Medium							0.01	0.943	
		Low							0.15	0.698	
	8	High							15.98	0.001	
		Medium							7.73	0.052	
		Low							3.63	0.305	

For SES in this table, high level is defined as the top 1/3 of the rating scale, medium is the middle 1/3 and low is the bottom 1/3 of the scale

and Science between the two types of children ($Q(3) = 6.29$, $p = 0.098$).

Gender Differences on Scores between One-Only Children and Children with Siblings

Table 6 presents gender differences in scores across the different children from 4th to 8th grades. The results show that for Math and Chinese in both the 4th and 8th grades, as well as for English and Science in the 8th grade, there are no significant gender differences on the effect size of difference between the two kinds of children. For the male 4th graders, there is no significant difference on the effect sizes of Math and Chinese. For the male 8th graders, no significant effect is found on Math, Chinese, English and Science between the two types of children. However, the female 8th graders showed a bigger difference with English and Science between the two different children compared to Chinese ($Q(1) = 11.335$, $p = 0.001$; $Q(1) = 9.996$, $p = 0.002$).

Academic Achievement Level Differences on Scores between One-Only Children and Children with Siblings

Table 7 shows the academic achievement level differences in scores across subjects for one-only children and children with

Table 5 Score differences between one-only children and children with siblings across locations

Subject	Grade	Location	K	Cohen's d	95% Confidence Interval		Test of Null (two-tail)		Heterogeneity		
					Lower Limits	Upper Limits	Z	p	Q	p	I^2
Math	4	Urban	3	0.36	0.28	0.44	8.30	0.000	48.44	0.000	95.87
		Suburban	3	0.18	0.11	0.25	5.14	0.000	20.63	0.000	90.31
		Between Groups							10.60	0.001	
	8	Urban	3	0.32	0.28	0.36	14.85	0.000	14.55	0.001	86.25
		Suburban	3	0.12	0.01	0.22	2.23	0.026	56.88	0.000	96.48
		Between Groups							12.35	0.000	
Chinese	4	Urban	3	0.35	0.28	0.42	10.09	0.000	31.57	0.000	93.66
		Suburban	3	0.23	0.20	0.25	17.02	0.000	3.25	0.197	38.40
		Between Groups							10.74	0.001	
	8	Urban	3	0.25	0.21	0.30	11.34	0.000	15.45	0.000	87.05
		Suburban	3	0.08	0.02	0.14	2.66	0.008	16.77	0.000	88.08
		Between Groups							21.50	0.000	
English	8	Urban	3	0.37	0.29	0.45	8.70	0.000	43.88	0.000	95.44
		Suburban	3	−0.04	−0.20	0.12	−0.48	0.63	50.89	0.000	96.07
		Between Groups							19.08	0.000	
Science	8	Urban	3	0.33	0.32	0.34	49.89	0.000	0.10	0.950	0.000
		Suburban	3	0.16	0.09	0.23	4.59	0.000	23.86	0.000	91.62
		Between Groups							22.59	0.000	
Cross Subjects	4	Urban							0.03	0.856	
	4	Suburban							1.74	0.188	
	8	Urban							11.92	0.008	
	8	Suburban							6.29	0.098	

Data in 2014 does not have location indicator

siblings from the 4th and 8th grades. It turns out that for Math and Chinese in the 4th grade, the effect size between the two different children is significantly greater in high academic achievement level and low achievement level than in medium achievement level (Math: $Q(1) = 21.53$, $p = 0.000$; $Q(1) = 7.79$, $p = 0.005$; Chinese: $Q(1) = 5.49$, $p = 0.019$; $Q(1) = 6.93$, $p = 0.008$). For the 8th graders, high academic achievers showed a significantly larger effect size across all the subjects between the different types of children than medium achievers (Math: $Q(1) = 21.10$, $p = 0.000$; Chinese: $Q(1) = 20.67$, $p = 0.000$; English: $Q(1) = 45.97$, $p = 0.000$; Science: $Q(1) = 80.98$, $p = 0.000$) and low achievers (Math: $Q(1) = 37.01$, $p = 0.000$; Chinese: $Q(1) = 33.94$, $p = 0.000$; English: $Q(1) = 47.51$, $p = 0.000$; Science: $Q(1) = 112.82$, $p = 0.000$). Also for the 8th graders, students with a medium academic achievement level showed a significantly larger effect size in Chinese and Science than low academic achievers between one-only children and children with siblings ($Q(1) = 6.58$, $p = 0.010$; $Q(1) = 5.80$, $p = 0.016$). For all students in the 4th grade, there was no significant difference on the effect sizes in Math and Chinese. For students with medium and low academic achievement in the 8th grade, there was no significant difference on the effect sizes in all subjects between one-only children and children with siblings. However, for high academic achievers in the 8th grade, there is a significant difference among all the subjects, which is —— English had significantly larger effect size between the two types of children than Math, Chinese and Science (Math: $Q(1) = 10.22$, $p = 0.001$; Chinese: $Q(1) = 5.74$, $p = 0.017$; Science: $Q(1) = 4.59$, $p = 0.032$).

Discussion

The Comparisons between One-Only Children and Children with Siblings

By using a large Chinese sample with a four-year span from 2014 to 2017, the current study found one-only children tend to perform better in academic achievements than children with siblings. First, the findings of one-only children's advantage are consistent with previous research. Falbo and Poston (1993) and Poston and Falbo (1990a, b) demonstrated in two studies that one-only children outscored children with

Table 6 Score differences between one-only children and children with siblings across genders

Subject	Grade	Gender	K	Cohen's d	95% Confidence Interval		Test of Null (two-tail)		Heterogeneity		
					Lower Limits	Upper Limits	Z	p	Q	p	I^2
Math	4	Male	4	0.41	0.37	0.46	17.27	0.000	81.24	0.000	96.31
		Female	4	0.40	0.37	0.43	25.72	0.000	26.49	0.000	88.67
		Between Groups							0.24	0.628	
	8	Male	4	0.36	0.32	0.40	16.78	0.000	63.39	0.000	95.27
		Female	4	0.37	0.34	0.40	25.99	0.000	22.23	0.000	86.50
		Between Groups							0.15	0.696	
Chinese	4	Male	4	0.44	0.40	0.49	19.10	0.000	76.35	0.000	96.07
		Female	4	0.41	0.37	0.45	20.15	0.000	45.21	0.000	93.37
		Between Groups							1.38	0.241	
	8	Male	4	0.34	0.28	0.41	10.42	0.000	144.37	0.000	97.92
		Female	4	0.35	0.29	0.40	12.52	0.000	85.63	0.000	96.50
		Between Groups							0.01	0.923	
English	8	Male	4	0.49	0.39	0.60	9.32	0.000	314.47	0.000	99.05
		Female	4	0.47	0.40	0.54	13.18	0.000	118.95	0.000	97.48
		Between Groups							0.09	0.771	
Science	8	Male	4	0.36	0.31	0.41	14.58	0.000	85.48	0.000	96.49
		Female	4	0.40	0.36	0.44	18.07	0.000	54.55	0.000	94.50
		Between Groups							1.26	0.262	
Cross Subjects	4	Male	4						0.82	0.364	
		Female	4						0.56	0.453	
	8	Male	4						6.29	0.098	
		Female	4						9.45	0.024	

siblings in academics in China. However, this phenomenon is not particular to China. Numerous studies have been conducted in other countries including Asia, the United States, and Europe which have yielded similar findings to China's study. In comparing one-only children between the United States and China, some researchers commented that "there appear to be more similarities than differences in the patterns, as well as in the predictors, of academic achievement of Chinese and U.S. School students" (Poston & Falbo, 1990a, b, p.450). This finding was also demonstrated in the Netherlands (Veenhoven & Verkuyten, 1989), and Korea (Doh & Falbo, 1999).

According to the resource dilution model (Dowey 2011), parental resources that affect one's educational success are finite and will be diluted by the addition of siblings. The one-only children tend to feel more secure because they receive full attention from their parents. As a result, their intellectual development, confidence and mature behavioral patterns will be enhanced (Falbo, 1987). On the other hand, being the only recipient of family resources provides them more educational opportunities (Falbo & Polit, 1986; Liu, Lin, & Chen, 2010). In addition, one-only children had more positive relationships with their parents including more parent-child communication, and higher parental academic expectations expressed towards the child—both of which have been shown to positively affect child's academic achievement (Zhan, 2006).

Regarding the effect size of difference between one-only children and children with siblings, the values indicate the discrepancy across different subjects in the 8th grade. English had the largest difference, then science and math, and lastly Chinese had the smallest difference. Meanwhile, when the effect size of differences between one-only children and children with siblings across grades was analyzed, we found that, for Math there was no significant difference between the 4th and the 8th grades. However, for Chinese, the 4th grade had a significantly bigger effect size of differences than the 8th grade. The reason for these findings might be, compared to Math, the learning outcome of Chinese is more affected by the resources offered from the child's parents. This is because, based on the resource dilution hypothesis, one-only children enjoy the advantage of getting more family resources, but this advantage can be diminished based on the subject, such as Math, which is less affected by outside resources. For example, Ma (2011) found that students' achievement in Math was most affected by the curriculum

Table 7 Score differences between one-only children and children with siblings across academic achievement levels

Subject	Grade	Academic Achievement Level	K	Cohen's d	95% Confidence Interval		Test of Null (two-tail)		Heterogeneity		
					Lower Limits	Upper Limits	Z	p	Q	p	I^2
Math	4	High	4	0.20	0.17	0.23	13.64	0.000	20.11	0.000	85.08
		Medium	4	0.10	0.07	0.13	6.55	0.000	18.41	0.000	83.70
		Low	4	0.17	0.13	0.22	8.05	0.000	32.30	0.000	90.71
		Between Groups							22.40	0.000	
	8	High	4	0.22	0.18	0.25	12.31	0.000	28.01	0.000	89.29
		Medium	4	0.11	0.08	0.14	6.94	0.000	19.55	0.000	84.66
		Low	4	0.07	0.03	0.10	3.81	0.000	20.96	0.000	85.68
		Between Groups							39.59	0.000	
Chinese	4	High	4	0.17	0.15	0.19	17.12	0.000	10.94	0.012	72.58
		Medium	4	0.11	0.06	0.15	4.84	0.000	35.37	0.000	91.52
		Low	4	0.17	0.14	0.21	9.98	0.000	19.15	0.000	84.33
		Between Groups							7.36	0.025	
	8	High	4	0.24	0.18	0.29	8.11	0.000	76.96	0.000	96.10
		Medium	4	0.09	0.07	0.12	6.89	0.000	12.80	0.005	76.56
		Low	4	0.03	−0.01	0.07	1.33	0.184	31.89	0.000	90.59
		Between Groups							34.06	0.000	
English	8	High	4	0.35	0.28	0.43	9.06	0.000	118.84	0.000	97.48
		Medium	4	0.08	0.07	0.10	12.66	0.000	1.14	0.768	0.00
		Low	4	0.06	0.02	0.09	2.95	0.003	19.58	0.000	84.68
		Between Groups							49.55	0.000	
Science	8	High	4	0.26	0.23	0.29	16.64	0.000	23.98	0.000	87.49
		Medium	4	0.09	0.08	0.11	9.44	0.000	7.64	0.054	60.75
		Low	4	0.06	0.04	0.08	5.39	0.000	7.80	0.050	61.52
		Between Groups							177.90	0.000	
Cross Subjects	4	High							2.18	0.140	
		Medium							0.78	0.781	
		Low							0.00	0.995	
	8	High							11.54	0.009	
		Medium							2.17	0.538	
		Low							2.25	0.523	

In this table, high academic achievement is defined as the top 1/3 of scores in the test of each subject. Median academic achievement level is the middle 1/3, while low level is the bottom 1/3 in the test of each subject

structure. In other words, school involvement is more effective for math achievement than family involvement. For Chinese, since it's students' native language, it can be learned and practiced at anytime anywhere. Students' Chinese abilities, including reading, writing, comprehension, and so on, can be largely affected by environments outside of schools. This is why the difference in effect size of Chinese is the smallest. This proposed reason is consistent with several findings from similar studies. Liu, Chung, and Mcbride (2016) found that the role of Socioeconomic status in learning Chinese and English were different in a Hong Kong sample. More resources for Chinese are available in children's life than English, which makes the resource for English offered by parents very significant. Science is a comprehensive curriculum designed for the eighth grade only. This curriculum includes courses in physics, biology, chemistry which teach both content knowledge and experimental skills. This subject requires higher capability of learning which is partially formed with the support of family resources. So, a more significant difference between one-only children and children with siblings is shown in this subject. The reduction of the effect sizes of Chinese from the 4th graders to the 8th graders is consistent with the result of Polit and Falbo (1988) and Jiao et al. (1996). That is, as children grow older, there are more channels for them to acquire learning

resources through their own abilities. Therefore, the superiority of only children is attenuated by the process of schooling.

Social Economic Status (SES) Differences

It was found that SES and one-only child effect significantly interact with each other. More specifically, SES affects the impact of one-only children advantage in academic performance. Our findings are consistent with Downey and Nerbauer (1998) and partially consistent with Marks (2006). However, this is not consistent with the study of Liu, Chen, Yang, and Hu (2017) which did not find any interaction effect. For the 4th grade, the effect size of one-only children and children with siblings difference is significantly greater in high and medium SES families than in low SES families. For the 8th graders, students from high SES families show a significantly larger effect size across all the subjects except for Math between two types of children than students from medium SES families. Meanwhile, students from medium SES families show a significantly larger effect size across all the subjects except Math between one-only children and children with siblings than students from low SES families. This is probably because compared to low-income families, additional siblings in high-income families have a more considerable negative effect on the resources parents could provide towards the target child's educational future (Downey & Nerbauer, 1998). However, for students from high SES families in the 8th grade, there is a significant difference among all the subjects. Math and Chinese have significantly smaller differences between two types of children than English and Science. This finding is consistent with our previous argument that the learning outcomes of English and Science are more affected by family resources than Math and Chinese.

Location Differences

We also examined the location differences in scores across subjects and grades between one-only children and children with siblings. Significant interaction effect was found between one-only child effect and urbanicity. Our results show that for the 4th and 8th grades, as well as for English and Science in the 8th grade, the difference between the two types of children is significantly greater in urban areas than in suburban areas. More specifically, for the 8th graders in urban areas, significant effects were all found on Math, Chinese, English and Science. In addition, the difference on Chinese between one-only children and children with siblings is significantly lower than that on Math, English and Science. These differences were mainly caused by family financial situations. Typically, students living in urban areas have better family financial situations than those living in suburban or rural areas, which directly determined the amount of educational resources parents are able to provide (Downey & Nerbauer, 1998).

Gender Differences

It is found that for Math and Chinese in both the 4th and 8th grades, as well as for English and Science in the 8th grade, there are no significant gender differences between one-only children and children with siblings. That is probably because no gender differences related to education between single-girl and single-boy families are found regarding Chinese parental expectations and investment (Tsui & Rich, 2002). More specifically, for the male 4th graders, there is no significant difference on the effect size of Math and Chinese between one-only children and children with siblings. For the male 8th graders, no significant effect is found on Math, Chinese, English and Science between the two types of children. However, the trend shows that the effect size differences between one-only children and children with siblings in Chinese and English are larger than Math and Science. For female 8th graders, the effect size difference on English and Science between one-only children and children with siblings is significantly bigger than it on Chinese. This is mainly because one-child parents pressured their children to succeed in school more than parents did with multiple children (Wu, 1996). Also one-child parents are more likely to devote more communication, attention, and have diverse requirements for their children. In addition, parents' expectations for their children include the characteristics of both boys and girls, especially in disciplines they are not good at, in which they expect the children to perform better. For example, there are a large body of previous research found that boys typically do better in quantitative subjects such as Math and Science (Reilly, Neumann, & Andrews, 2015) but worse in language learning (Brozo et al., 2014).

Academic Achievement Level Differences

It was found that for the 4th grade, the difference of the two groups is significantly greater in high academic achievement level and low achievement level than in medium achievement level. For the 8th graders, high academic achievers show a significant larger difference across all the subjects between the two types of children than medium achievers. We believe that this difference is related to the attention received from the environment. Typically, the students from two ends of academic achievement get more attention from parents than those in the middle. The higher achievers are treated as role models and the lower achievers are treated as targets for improvement. This affects the effect size difference between one-only children and children with siblings. However, the impact of parents attention might decrease when students grow older (Guimond & Roussel, 2001). In addition, for high academic

achievers in the 8th grade, there is a significant difference among all the subjects, which is —— English has significantly larger difference between the two groups than Math, Chinese and Science.

Educational Implications

With the implementation of the one-child policy for more than 30 years in China and an increase in the number of one-child families in several Western countries, it would be very beneficial to learn about the strength and weakness of this family structure. The finding that one-only children tend to have better academic achievement might indicate that this family structure may have some benefits to child development. In addition, Deutsch (2006) found that the only-child policy in China had promoted gender equality in this country. However, these findings should not be used as an endorsement of the one-child policy. Any family related policy should be considered carefully because they might have unintended consequences for children. One of the most important implication of this study is to provide people who work with children or parents with more accurate descriptions about the strengths and weaknesses of one-only children and children with siblings, so their stereotypes about two types of children can be reduced. This study also provides insights to schoolteachers and counselors. They should take students' family contexts into consideration while serving them. In addition, this study suggests that help should be offered to families in need. For example, family education workshops should be provided in primary and secondary schools. Parents need the skills to educate a single child in a more scientific way, especially in rural areas. Last but not least, more formal support from the government should be provided for broadbased education, health, and increasing opportunities in both rural and urban communities.

Limitations

This study has limitations too. The first one is related to data collection. Due to the varying times English and Science courses start being offered across different places, as well as the inconsistent learning objectives for the 4th grade, standard tests on English and Science were not offered. As a result, we were not able to get access to the scores of the 4th graders in these two subjects. Therefore, the changing trend of these two subjects could not be detected in this study. Secondly, this is a cross-sectional study, in which the hypotheses regarding the relationship between variables are based on one-only children effect. As reviewed in literature introduction, different conclusions were found based on different theoretical models. For example, if the one-only child effect is partially or wholly mediated, via the differences of academic achievement, with respect to SES and urbanicity, the explanation of the effect will be different from ours. Just as findings by various studies (Downey & Nerbauer, 1998; Liu et al., 2017; Marks, 2006), inconsistent conclusions were found based on different hypotheses. Due to the limitations of this study, more longitudinal studies will be very beneficial in bridging this gap. Third, future research could analyze some other non-cognitive factors such as personality, learning motivation, etc. This will provide a more thorough understanding of why one-only children enjoy advantage in academic achievements. Lastly, the conclusions from this study are solely based on academic performance. In other words, the advantage of being the only child in the family is discussed within the educational background. Our findings are consistent with the majority of literature around the world. However, the one-only child advantage or disadvantage in other non-academic areas needs to be discussed further. For example, Roberts and Blanton (2001) found that the negative stereotype regarding one-only child — they are usually spoiled, selfish, lonely, and maladjusted —is prevalent across cultures (Laybourn, 1990; Doh & Falbo, 1999; Falbo & Poston, 1993). However, a quantitative review of one-only children primarily focused on personality domains and found that compared to peers with siblings, one-only children do not significantly differ in areas of sociability, character and personal control (Polit & Falbo, 1987).

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Data Availability The data that support the findings of this study are available from Collaborative Innovation Center of Assessment toward Basic Education Quality but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of Collaborative Innovation Center of Assessment toward Basic Education Quality.

Compliance with Ethical Standards

Conflict of Interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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