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Evidence of dysgenic fertility in China

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ABSTRACT

The relationship between fertility, intelligence, and education was examined in China using a large sample sourced from the population-representative China Family Panel Studies (CFPS) dataset. For the 1951–1970 birth cohort, the correlation between fertility and gf was −.10. The strength of recent selection against gf in China substantially increased between the 1960s and the mid-1980s. Later (between 1986 and 2000), the speed of decline in gf due to selection stabilized at about .31 points per decade with a slightly downward trend. The total loss from 1971 to 2000 due to dysgenic fertility is estimated to be .75 points. A negative relationship between educational attainment and fertility was additionally found. Both negative relations were stronger for women.

1. Introduction

In modern times, mortality rates have been reduced as a result of improvements in public health, nutrition, and the control of infectious diseases (Lynn, 2011). As a result, selection against deleterious mutations has been relaxed. Additionally, in many societies, individuals with lower levels of intelligence and education have begun to reproduce at higher rates than those with higher levels of these traits. Due to a reversal of selection for socially important traits such as intelligence, genes promoting these traits may decline. This phenomenon is termed dysgenics. Intelligence has been found to influence many outcomes both on the individual and societal levels. For example, individual differences in g are related to educational performance (Deary, Strand, Smith, & Fernandes, 2007; Poropat, 2009), occupational performance (Schmidt & Hunter, 2004), social mobility (Forrest, Hodgson, Parker, & Pearce, 2011; Krzyżanowska & Mascie-Taylor, 2013; Nettle, 2003; Sorjonen, Hemmingsson, Lundin, Falkstedt, & Melin, 2012; Waller, 1982), health (Gottfredson, 2004), and longevity (Calvin et al., 2011). National differences in measured intelligence are related to economic performance (Lynn & Vanhanen, 2002). Regarding this latter association, cross-lagged analysis and other studies suggest that the direction of causality runs largely from the former to the latter (Christainsen, 2013; Rindermann, 2008, 2012). Reconstructed differences in g scores across time also predict temporal variation in both innovation rates and the frequencies of eminent individuals (Woodley, 2012; Woodley & Figueredo, 2013).

Owing to the social importance of intelligence, the issue of population changes in this trait is important. Interest in this issue, which goes back to the 19th and early 20th century (Darwin, 1871; Galton, 1865; Morel, 1857; Pearson, 1901; Spencer, 1873) has recently increased. A recent meta-analysis by Woodley of Menie (2015) summarizing various studies (Burt, 1948; Cattell, 1937; Lentz, 1927; Loehlin, 1997; Lynn, 1999, 2004; Meisenberg, 2010; Reeve, Lyerly, & Peach, 2013; Retherford & Sewell, 1988; Sutherland & Thomson, 1926; Thomson, 1950; Vining, 1995) found that the loss of g due to dysgenic fertility during the 20th century has been about .385 points per decade in the UK and US. Selection against intelligence has also been found in economically developing countries, such as Kuwait, Sudan, and Libya (Abdel-Khalek & Lynn, 2008; Al-Shahomee, Lynn, & Abdalla, 2013; Khaleefa, 2010). Moreover, it has been found that, by the middle of the 20th century, populations in Asian, African, Latin American, and Middle Eastern countries exhibit negative relations between fertility and both social status and educational attainment (Skirbekk, 2008), traits which correlate with intelligence. Seemingly paradoxically, this trend of dysgenic fertility has occurred alongside a secular increase in measured intelligence (Flynn, 1987, 2009).

In light of these findings, Woodley and Figueredo (2013) have proposed the "co-occurrence model". According to this, dysgenesis primarily acts on the more heritable general intelligence factor (from now on: heritable g) whereas the Flynn effect primarily represents an increase in the more environmentally conditioned specific cognitive abilities (from now on: environmental s). On this basis, dysgenesis and the Flynn effect co-occur, with environmental s gains masking the decline in heritable g at the level of phenotypic (i.e., measured) IQ scores. According to the

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model, a historical decline in g can be detected when certain indicators of latent general ability are used, such as ratio-scale measures like simple reaction times, which have been slowing in the UK and US since the 19th century (Woodley, te Nijenhuis, & Murphy, 2014) and backwards digit span, which has been decreasing in the US since the 1920s (Woodley of Menie & Fernandes, 2015), and also knowledge of hard-to-learn words, the use of which has been declining in English language texts since the 1850s (Woodley of Menie, Fernandes, Figueredo & Meisenberg, 2015). Furthermore, performance on measures of IQ that are sensitive to the Flynn effect will begin to decline as a result of a decline in heritable g when the effect of improvements in the environment stall. A decline in phenotypic IQ appears to have already begun in parts of the developed world, including Norway, Denmark, Netherlands, Finland, and France (Dutton & Lynn, 2014, 2015; Sundet, Barlaug, & Torjussen, 2004; Teasdale & Owen, 2008; Woodley of Menie & Dunkel, 2015; Woodley & Meisenberg, 2013b). Consistent with the co-occurrence model, dysgenic fertility and losses on phenotypic IQ scores are more pronounced on subtests with higher g-loadings (Peach, Lyerly, & Reeve, 2014; Woodley & Meisenberg, 2013a, 2013b; Woodley of Menie, Figueredo, Dunkel, & Madison, 2015).

To date, no research has investigated the reproductive ecology of intelligence in China, which contains one-fifth of the world's population. The present study investigates the relationship between intelligence and family size in mainland China using data from the China Family Panel Studies (CFPS) survey.

2. Method

The data come from the China Family Panel Studies (CFPS), a series of longitudinal surveys funded by the 985 Programme of Peking University and carried out by the Institute of Social Science Survey (ISSS) of Peking University. It is planned for these surveys to be carried out biennially on nationally representative samples drawn from 25 provinces in mainland China. Full details of the sampling procedures are given by Xie and Hu (2014). In 2012 the surveys used memory and number-sequence questions to test the participants' fluid intelligence (gf) level. This offered a unique opportunity to examine the relationship between gf and fertility in the population of China.

The STATA script for the analysis is available to download as part of the online supplement material.

The following variables were used in the present study:

2.1. Children

Data on the number of children were based on the participants' answers about their children. Only those children with age information were counted. Because children who died in childhood are of little interest from a reproductive viewpoint, children marked as deceased were dropped.

2.2. Sibship size

Sibship size information for adults came from the CFPS 2010 survey. For the 1951–1970 birth cohort, sibship size for 85% of the sample was available. Sibship size for children was assigned based on the parental reported number of children.

2.3. Intelligence

The cognitive tests used in 2012 were composed of two word memorization tests and a number series test, both of which measure gf. Short term memory ability, in particular, has been found to be moderately to highly correlated with gf (Aben, Stapert, & Blokland, 2012; Martínez et al., 2011; Unsworth & Engle, 2007). With the memory tests, respondents were read a randomly selected list of ten simple nouns (e.g., rice, river, and doctor) and were immediately asked to recall as many of those words as possible. The number of words that the respondents correctly recalled was recorded as their immediate word recall score. After thirty-one questions concerning subjective wellbeing, or approximately 5 min of delay, they were asked to recall the words again. The number of words recalled was recorded as their delayed word recall score. With the number series test, respondents were asked to identify the pattern of missing items in a number series and to fill in the missing numbers. This test had two stages. The difficulty level of the second stage was based on the respondents' performance in the first one. In our analysis, the W-score, which took into account both the selection of and the performance in the second stage, was used. Crystallized intelligence (gc) measures given in the 2010 survey were additionally used. These included verbal and math tests, which included problems drawn from textbooks used in primary and secondary schools. For a more detailed discussion, see Huang, Xie, and Xu (2015). The raw scores were scaled into a normally distributed and standardized score ($M = 100$, $s = 15$) for each age and gender group for samples younger than 81. Older samples were scaled together for each gender. These tests were administered to participants aged 10 and older. While almost all of the samples in this age range in the 2010 survey had verbal and math scores, the participation rate for the gf tests was lower. For the 37,003 participants, who fell in the age range considered, that took the long form of the questionnaire, answer rates were, respectively, 93%, 92%, and 48% for the immediate word recall, delayed word recall, and number series test.

The low response rate for the number series test was due to some respondents demonstrating considerable difficulty in understanding the introductory examples of the test. Those with a younger age, from higher income families and with more education were more likely to complete this test (Xu & Xie, 2015). Their fertility and sibship size was also lower than the total participants'. For the birth cohort 1951–1970, the correlation between fertility and participation in the number series test was −.13. The fertility of participants was lower by 0.13 children. To address the issue of sampling bias both due to selective participation with regards to the gf tests and due to missing data on sibship size, the sampling weight was adjusted with an inverse propensity weighting method using a logit regression model which included the square of age, mean-centred age, years of education, urban or common residence, and gender. With the weight adjustment, the fertility and sibship size of number series test takers became closer to the value of the total participants in the majority of the groups analysed. For the total sample, the difference became 0.02 children. See Supplementary Table S1 for a comparison of results with and without the weight adjustment. Sample sizes are also included in the table.

In this study, we separately analysed the relationship between each subtest indicator and fertility and sibship size. In some analysis, only the weighted average results (with the two memory tests averaged and weighted at 50% and the number series test weighted at 50%) were reported.

2.4. Education

Educational attainment and years of education were analysed. The years of education variable was transformed into a normally distributed and standardized score for each age group and gender, so as to represent the relative level of education within peer groups.

2.5. Hukou type

Hukou (household registration) refers to a socio-economic division between rural (agricultural) and urban (non-agricultural) populations in China. Data on the sample's 3-year-old, 12-year-old, and current *hukou* type were used. Note, some of the people born outside the birth planning quota are unregistered (Greenhalgh, 2003). They have no *hukou* status and were not included in the subgroup analyses.

2.6. Ethnicity

As of 2010, around 8% of the Chinese population is classified as belonging to "ethnic minority" groups, which are non-Han ethnic groups. "Han" and "ethnic minority" classifications were derived from the participants' reported ethnicity.

3. Results

The unweighted correlation matrix for cognitive test scores and years of education for the 1951–1980 birth cohort is shown in Table 1. Missing values were handled using listwise deletion.

As can be seen in the correlation matrix, the duration of education was highly related to gc scores and less so to the gf scores. In contrast, Kaufman, Kaufman, Liu, and Johnson (2009) found that in the 21th century United States, years of education correlates slightly stronger with gf. The higher correlation between gc and education in the CFPS dataset may result from the fact that the gc tests were designed to measure knowledge acquired mainly through basic schooling. In contrast, some studies have shown that gf is unaffected by education (Dahmann, 2015). It's possible that, due to educational inequality in China, gc, as measured by verbal and math tests, is a better index of educational quality than of general intelligence. Given this concern, we concluded that gf is likely a better index of g in the present Chinese population. Hence, in this paper, we mainly use the gf test scores as indicators of g.

When examining if a population is exhibiting dysgenic reproductive patterns, we need to ensure that the sample has completed or has nearly completed fertility to avoid possible distortions that arise due to a correlation between intelligence and child-bearing age. Though it is believed that Chinese women seldom give birth to children after age 35 (Wang, 2008), we chose the older age of 42 as our cut off for completed fertility. Further, to limit the magnitude of bias due to g-dependent mortality, participants born before the year 1951 were excluded. Therefore, only participants born from 1951 to 1970, who were aged 42–61 at the time of the survey, were selected for the analysis.

The correlations between scaled scores and completed fertility are shown in Table 2. To test for a Jensen effect on reproduction, the method of correlated vectors (MCV) (Jensen, 1998) was employed; see Woodley and Meisenberg (2013a) for the rationale. Subtest g-loadings were correlated with the magnitude of the fertility effect for each of the subtests. Unit-weighted g-loadings were calculated by correlating the subtest scores with the subtest score average (Gorsuch, 1983). Missing subtest data were handled using listwise deletion. Jensen effects were calculated for the total sample, for each gender, and for each *hukou* type.

The correlation between gf and completed fertility for the total population was −.10. The fertility effect was more pronounced for females. This is consistent with findings from most other countries (Lynn, 2011) as well as from Taiwan (Chen, Chen, Liao, & Chen, 2013). Despite the small magnitude of the dysgenic fertility in the rural samples and the rural samples constituting over 70% of the total, the negative correlation in the total sample was high, indicating the presence of an interactive effect, one resulting from the urban samples having higher gf scores and lower fertility levels than the rural ones. The weighted average of the urban and rural correlations came out to −.04, which is statistically significant at the .01 level. The results overall demonstrate the presence of dysgenic selection for gf in China. Although the number of subtests was too limited to allow for a robust analysis, we can see that for all groups that exhibited significant dysgenic fertility, the correlations between g-loadings and dysgenic fertility was positive, suggesting a possible Jensen effect on the negative ability-fertility correlations in China. For the same samples, we also computed the Jensen effects using all five subtests. The results are shown in Supplementary Table S2. When the gc tests, which had higher g-loadings and for which the negative relationship tended to be greater, were added the Jensen effects were significantly positive in all cases. This further suggests the existence of a Jensen effect on the negative ability-fertility correlations. It suggests that the negative phenotypic selection in China may act on heritable g.

Table 1
The correlation matrix for subtest scores and years of education for birth cohort 1951–1980.

		1	2	3	4	5
1. Immediate word recall	r1	1				
	r2	1				
2. Delayed word recall	r1	0.64	1			
	r2	0.63	1			
3. Number series	r1	0.19	0.17	1		
	r2	0.18	0.17	1		
4. Verbal test	r1	0.18	0.20	0.28	1	
	r2	0.20	0.22	0.29	1	
5. Math test	r1	0.16	0.16	0.29	0.68	1
	r2	0.20	0.20	0.32	0.60	1
6. Years of education	r1	0.11	0.10	0.20	0.58	0.76
	r2	0.21	0.20	0.27	0.49	0.60

r1 = the correlation coefficient based on raw values.
r2 = the correlation coefficient based on scaled values.
All correlations are significant at the .01 level.

To investigate the relationship between cognitive ability and fertility differences in relation to social status, we used *hukou* status as a proxy for social status. Participants born after 1962 were selected to avoid possible confounding effects due to the Great Chinese Famine (1959–1961), which affected rural populations more (Lin & Yang, 2000). This sample, thus, involves individuals born between 1963 and 1972. Results are shown in Table 3.

For both females and males, those with rural status at age 12 who gained an urban status later in life had higher gf than those who stayed in rural areas. This suggests the occurrence of selective migration, in which rural residents with higher cognitive ability were able to obtain an urban status. Because they had fewer children than those who stayed in rural areas, dysgenic selection is suggested.

While the relation between a cohorts' intelligence and completed fertility indexes the effect on the next generation, the relation between the cohorts' intelligence and their number of siblings indexes the effect of the previous generation. This latter is a potentially biased estimate if the childless of that previous generation heavily deviates from the mean intelligence of that generation because the childless of the previous generation go unrecorded. To get a sense if this is the case, we calculated the gf scores for individuals with different numbers of children for the 1951–1970 birth cohort. The results are shown in supplementary Table S3. While childless urban and rural females performed better than the urban female average, the childless in the 1951–1970 cohort had below-average gf scores. However, the difference is small at 1.24 points. Of note, the childless in the 1951–1970 cohort made up only a small proportion (2.3%) of the total sample. Assuming that this portion and the relation between gf and childlessness was roughly the same for the previous generation, a 1951–1970 cohort sibling analysis should not provide a severely distorted estimate of the fertility trends of the previous generation.

Let us then look at the relation between gf and number of siblings. Correlations between scores and the number of siblings are shown in Table 4.

The overall relation between gf and sibship size was slightly negative. For the total sample, the gf-sibship size correlation was smaller than the gf-fertility correlation. However, for the sample with urban status at 3 years old, the correlation was −.16, which was close to the correlation between gf and completed fertility for the same sample. This implies that the Chinese urban population began to experience a relatively high level of dysgenic selection early on.

To illustrate the relationship between family size and gf, average gf scores were calculated for individuals by the number of siblings. The results are shown in supplementary Table S4. Notably, the gf scores are all around 100 for individuals with 0 to 6 siblings. This is contrary to

Table 2
Correlations between scores and completed fertility (dysgenic fertility), their respective g-loadings, and vector correlations (Jensen effect) for birth cohort 1951–1970, broken down by *hukou* status and gender.

	Immediate word recall		Delayed word recall		Number series		Average	Jensen effect[a]
	Dysgenic fertility	g-loading	Dysgenic fertility	g-loading	Dysgenic fertility	g-loading	Dysgenic fertility	
Total	−.10**	.80	−.13**	.79	−.09**	.66	−.10**	.79
Females	−.16**	.80	−.18**	.79	−.10**	.68	−.14**	.80
Males	−.05**	.80	−.09**	.79	−.08**	.65	−.07**	.68
Total rural	−.01	.78	−.03**	.77	−.03	.65	−.02*	.02
Rural females	−.05**	.78	−.06**	.77	−.01	.67	−.03*	.09
Rural males	.05**	.79	.01	.77	−.04	.63	−.01	−.42
Total urban	−.13**	.80	−.14**	.81	−.04	.65	−.09**	1.00*
Urban females	−.16**	.80	−.19**	.80	−.11**	.65	−.14**	.76
Urban males	−.10**	.79	−.09**	.81	.01	.65	−.04**	.77

* $p < .05$.
** $p < .01$.
[a] A positive Jensen effect normally indicates a positive relation between the magnitude of the effect in question and g-loadings. In this case, the direction of selection is negative and so carries with it a negative sign. For consistency with the broader literature, the signs of the selection effect were reversed so to ensure that a positive correlation between dysgenic selection and g-loadings will exhibit a positive Jensen effect. The significance level shown is based on the number of subtests. When it is based on the aggregate sample size (for rationale and method, see: Woodley of Menie, Figueredo, Dunkel, & Madison, 2015), the Jensen effects for all of the subpopulations, except for the total rural sample, were significant at the .01 level; for the total rural sample, the Jensen effect was significant at the .05 level.

Zajonc's (1983) "confluence" theory, according to which the negative association between cognitive ability and sibling size is due to children in larger families receiving less cognitive stimulation. Were that theory correct, the scores should have followed a consistent downward gradient as the number of siblings increases whereas what was found was that those with two siblings actually had a slightly higher gf than those with fewer siblings. The results suggest that within-family sources of cognitive variance cannot fully account for the association between gf and family size, at least in China.

To present the secular trend of the gf–fertility relationship, we show the selection differentials by year based on both the completed fertility method and the sibship method. With the completed fertility method, selection differentials for a given year represent the gf difference between their own generation and their children's. The gf of the children's generation was estimated by weighting the samples' gf by their fertility, a method which assumes that, on average, children are in the same place in the cognitive ability spectrum as their parents. With the sibship method, selection differentials for a given year represent the difference between the participants' generation and their parents'. The gf difference was calculated by weighting the participants' gf by the inverse of the family size as indicated by the number of siblings, making the same assumption as above. As the sibship method has excluded the childless individuals, we also excluded the childless in the completed fertility method so to examine how this affects the results. To make the results from both methods comparable, we give the results by average birth year (i.e., the children's average year of birth for the completed fertility method and the siblings' plus the participants' average year of birth for the sibship method). The results are shown in Fig. 1.

The selection differential trend calculated by both methods is similar except for around the 1960s. The completed fertility method is based on samples a generation older than those used for the sibship method. g-dependent mortality presumably resulted in larger sampling bias for the completed fertility method in these earlier years. If we adopt results from the sibship method for earlier cohorts and results from the completed fertility method for later cohorts, we can see that the negative selection differential substantially increased between the 1960s and the mid-1980s. After that, the trend line begins to decrease, though with a smaller slope.

Comparing the different results from the completed fertility method, we can see that excluding the childless had a slight effect in more recent samples with the result of increasing the negative selection differential. This is interesting because it suggests that childlessness, in recent years, is associated with a eugenic effect. This childless effect can account for some of the differences between the sibship and the completed fertility method.

Assuming a generational length of 27 years, the selection differentials between 1971 and 2000 estimated using the completed fertility method for immediate word recall, delayed word recall, and number series tests were −.70 points, −.88 points, and −.53 points, respectively. The smaller fertility effect for the number series test scores may be partly due to participation bias with respect to this test although our weight adjustment should have reduced this. The weighted average selection differential for gf came out to −.66 points. Using an adult narrow heritability of .86 (Panizzon et al., 2014), the total gf loss during the period of 30 years, calculated using Breeder's equation (Fisher, 1929), would have been .57 points. This estimate needs to be corrected for the reliability and validity of the cognitive measures. A correction for reliability can be made by dividing the estimate by the square root of .71, the Cronbach's reliability alpha for the three gf indicators for this cohort. A correction for validity can be made by dividing by .9 (Jensen, 1998, p. 383; Woodley of Menie, 2015). Doing so yields a total loss of .75 points over 30 years. The decline calculated based on the 1986 to 2000 fertility cohort was .64 points per generation and .24 points per decade. After corrections were made, the decline is .85 points per generation and .31 points per decade.

Chinese birth planning policy is relaxed in rural areas and for ethnic minorities. To see whether the negative gf–fertility relationship manifests within subpopulations or whether it results from an interaction between subpopulations, we looked at the selection differentials broken down by ethnicity and *hukou* status at different ages. As educational

Table 3
gf and completed fertility in relation to *hukou* mobility for birth cohort 1963–1972, broken down by gender.

Hukou status		Females			Males		
Age 12	Adult	Proportion	gf	Fertility	Proportion	gf	Fertility
Rural	Rural	72%	97.47	1.91	70%	98.43	1.79
Urban	Rural	00%	98.82	1.29	00%	104.06	1.77
Rural	Urban	14%	104.02	1.45	14%	103.70	1.43
Urban	Urban	13%	106.53	1.09	16%	105.38	1.10

Table 4
gf in relation to sibship size for birth cohort 1951–1970, broken down by *hukou* status at age 3.

	Immediate word recall	Delayed word recall	Number series	Average
Total	−.04**	−.04**	−.04**	−.04**
Rural	−.03**	−.03**	−.02	−.03**
Urban	−.15**	−.07	−.20**	−.16**

** $p < .01$.

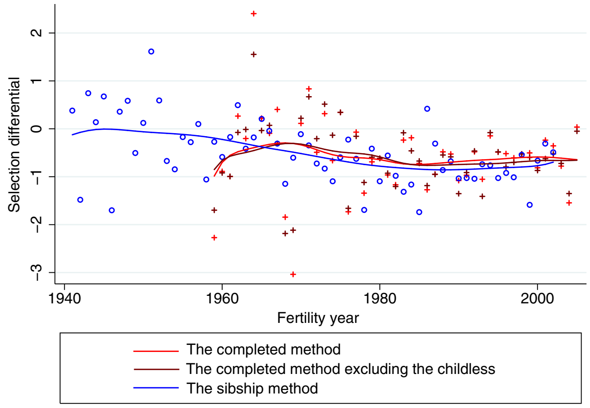

Fig. 1. Selection differentials estimated by the completed fertility and the sibship method.

inequality would be reduced within subgroups, results from gc measures are also shown in Table 5.

As can be seen, many subpopulations exhibited selection against intelligence. It is stronger among urban populations compared with rural populations. The selection was strongest for ethnic Han who transferred their *hukou* status from rural to urban. However, the selection was low for those individuals who had rural status at age 12 and who remained in rural areas. The observation that selection against intelligence manifests within every subpopulation of ethnic Han demonstrates the presence of dysgenesis in China, regardless of the cause of the rural/urban cognitive gap. Results from gc measures provide corroborating evidence. Though only constituting less than a third of the sample, individuals with urban *hukou* status had a selection differential similar to that of the combined sample, suggesting, again, the presence of an interaction between rural–urban status, fertility, and cognitive ability. It should be noted that the results for ethnic minorities are potentially biased because the survey missed some provinces with large percentages of ethnic minorities (e.g., Xinjiang, Tibet, and Inner Mongolia).

Now let's look at the relationship between educational attainment and fertility. The results for females and males are shown in Figs. 2 and 3. The mean number of children in relation to educational completion are presented as the columns and, to give an overview of secular changes, the average educational attainment of the population is presented as the stacked area in the background. Scaled years of education were correlated with the number of children; the coefficients are shown in the figures.

Fertility for recent cohorts became much lower because these cohorts had not completed their fertility as of the 2012 survey. Results for these cohorts should be viewed cautiously.

It is notable that the relationship between fertility and education level becomes stable after 1950. For cohorts born between 1950 and 1980, females who completed tertiary education had about one-half the number of children on average as those who did not complete primary school. Nonetheless, the overall negative correlation between years of education and completed fertility rose across decades. This probably reflects an increased opportunity for receiving education, an opportunity which is illustrated in the background of the figures above. For males, fertility rates generally decreased in all educational groups, and the negative correlation between years of education and completed fertility rose, though to a smaller degree than for females.

It should be noted that, between the time when the Communist Party came into power and the end of the Cultural Revolution, the opportunity for lower class individuals to attend secondary and tertiary school was unprecedented. Admission quotas were established for the lower class. In 1952, the Ministry of Education set the target proportions of middle school students with an agricultural or labourer family background at 60% to 70% in regions initially controlled by the Communist Party and at 30% to 50% in other regions. The proportion of students with an agricultural or labourer family background reached 21%, 55%, and 71% in 1952, 1958, and 1965, respectively (Yang, 2006). In a society with an egalitarian educational policy, variance in educational attainment is more likely to be conditioned by genetic rather than family background factors as variance owing to family background will be reduced (Heath, Berg, Eaves, & Solaas, 1985). Therefore, the negative correlation between family size and secondary and tertiary education in China may represent a dysgenic trend. However, the opportunity for basic education was still lacking in China, and it was less available in rural areas (Hannum, 1999). Thus, the relation between fertility and basic educational attainment could largely arise from the rural/urban divide in educational opportunity, in which case genetic selection cannot be inferred.

Given the above concern, we conducted an alternative analysis, one which could provide better evidence for dysgenic fertility related to educational attainment. The University Entrance Examination (*Gaokao*) system in China resumed in 1977 after the end of the Cultural Revolution. This provided a social ladder for those who were apt but had a poor family background. Before 1992, tertiary education was not only entirely free for state-planned students (in addition, there was a small proportion of self-supporting and commissioned training students from the late 1980s), students also were provided meal stipends and free accommodation (Agelasto & Adamson, 1998). Moreover, all graduates were assigned jobs with state-run firms or government bureaus before 1985. Thus, going to college was an appealing option that was affordable to everyone. Whether a (state-planned) student could get in only depended on his/her *Gaokao* performance. This situation allowed for another test for dysgenic fertility: after controlling for the opportunity to attend general-type high schools, we compared the fertilities of those who managed to enter a college and those who did not. The results are shown in Table 6.

For both females and males, the college graduates had fewer children than the high school graduates for each comparable class. Note, rural–urban college graduates had a completed fertility of 1.04 and 1.19 for females and males, respectively, whereas the rural–rural high school graduates had a completed fertility of 1.71 and 1.91 for females and males, respectively. The results suggest that the rural residents who were selected based on their *Gaokao* performance and who

Table 5
Selection differentials per generation in relation to *hukou* status and ethnicity for the fertility cohort 1986–2000.

Hukou status		Han			Minorities			Combined		
Age 12	Adult	Proportion	Selection differential		Proportion	Selection differential		Proportion	Selection differential	
			gf	gc		gf	gc		gf	gc
Rural	Rural	60%	−.17	−.65	08%	.06	−1.37	67%	−.17	−.95
Combined	Rural	63%	−.17	−.66	08%	.07	−1.38	71%	−.18	−.96
Rural	Urban	13%	−.48	−1.14	01%	.51	−.05	13%	−.40	−1.05
Urban	Urban	14%	−.27	−.64	00%	−1.28	−1.53	14%	−.34	−.68
Combined	Urban	27%	−.55	−1.03	01%	.06	−.61	29%	−.52	−1.00
Combined	Combined	90%	−.74	−1.67	09%	−.33	−2.39	100%	−.74	−1.99

Note: The proportion is calculated based on the 2012 dataset. It would have been slightly different if calculated based on the 2010 dataset. The urban–rural results were not shown because of these samples' small sizes.

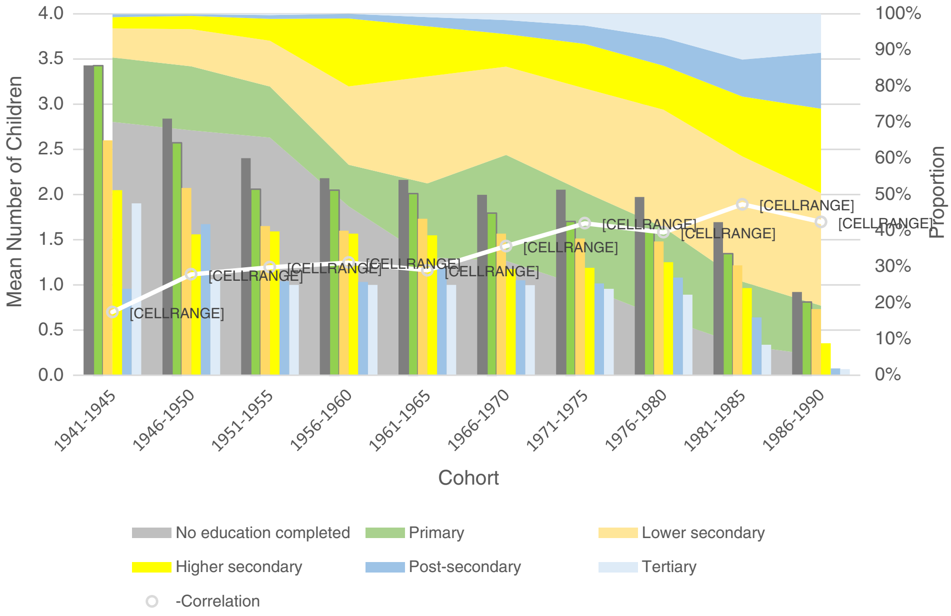

Fig. 2. Relations between education attainment and fertility, females. All correlations are significant at the .01 level.

obtained an urban *hukou* status had fewer children than their classmates who were not selected. Enrolment in China's universities at this time was much lower than it is today, entailing that it was very difficult for students to get in. The national enrolment was 483 thousand per year on average in the 1980s, compared with 6.85 million in 2012 (Ministry of Education, 2013). It should be noted that success on the examination requires both intelligence and conscientiousness (Chen, 2014). Regarding intelligence, Dai (1988) found a correlation between *Gaokao* grades and full-scale IQ of .52, which is modest. The results above therefore support the presence of dysgenesis for intelligence in China. Because conscientiousness is also heritable (Bouchard & McGue, 2003), these results suggest that there may also be a dysgenic effect on this trait.

4. Discussion

We estimate the total decline due to selection to be −.91 points between 1971 and 2000. The decadal decline between 1986 and 2000 due to selection is estimated to be .38 points. Despite this, measured gf in China recently has been rising at a rate of about 2 points per decade (Liu & Lynn, 2013; Liu, Yang, Li, Chen, & Lynn, 2012). Given this rise, it might behove us to be cautious when it comes to drawing conclusions based on the present results.

Some of this selection resulted from an interaction between rural and urban status, fertility, and cognitive ability. In general, urban residents, who have higher cognitive scores (Table 4) have fewer children. As IQ has been rising in China, one explanation for the rural/urban

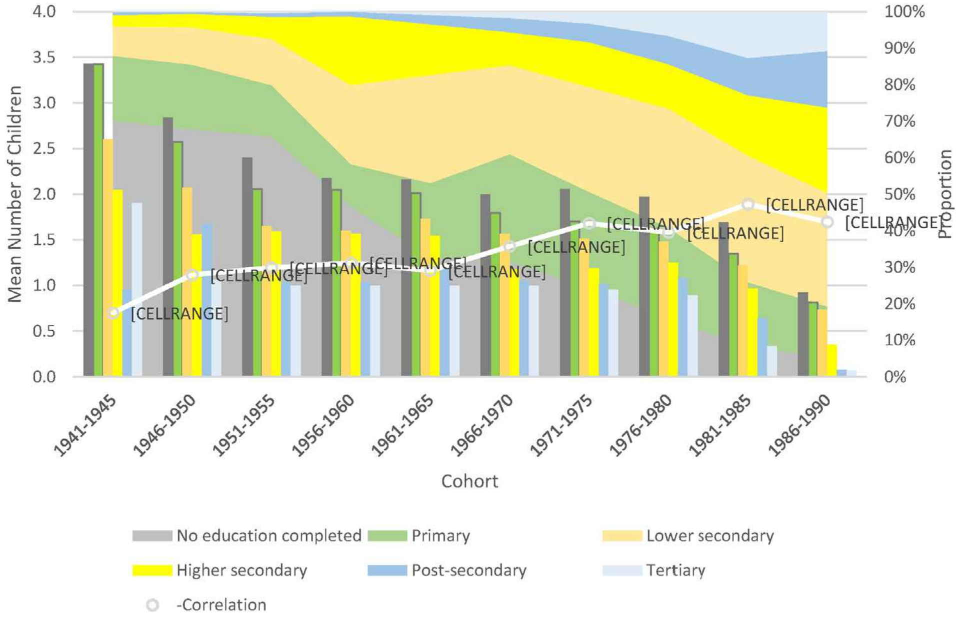

Fig. 3. Relations between education attainment and fertility, males. All correlations above .10 are significant at the .01 level. The correlation for the 1946–1950 cohort is significant at the .05 level.

Table 6
Completed fertility of college graduates in comparison with general-type high school graduates and *hukou* mobility for birth cohort 1963–1972, broken down by gender.

Education	*Hukou* status		Completed fertility					
	12 years old	Adult	Female			Male		
			n	*M*	*s*	*n*	*M*	*s*
College	Rural	Urban	25	1.04	.37	48	1.19	.40
	Urban	Urban	25	.92	.28	35	1.01	.15
High school	Rural	Rural	97	1.71	.66	166	1.91	.81
	Rural	Urban	40	1.33	.63	69	1.61	.63
	Urban	Urban	105	1.05	.28	86	1.13	.42

differences in cognitive ability is that the rural areas have been experiencing a lagging Flynn effect relative to the urban ones, owing to slower socioeconomic improvement. If this is the case, we likely overestimated the heritable g decline for the total population. That said, available evidence suggests that the types of gf measures we used in this study are not strongly affected by the factors that underlie the Flynn effect. The Flynn effect is small on number series tests as compared to other typical gf subtests (Teasdale & Owen, 2000). For verbal learning and recall tests, the scores of which are more negatively correlated with fertility in this sample than are the number series ones, there seems to be little Flynn effect for the majority of age ranges tested (Baxendale, 2010).

One of the biggest contributors to the recent Flynn effect in China might be Iodine supplementation, which greatly reduced the prevalence of Iodine deficiency (ID) (Ministry of Health, 2003; Qian et al., 2005). Wang et al. (1998) looked at the scores of Chinese rural and urban children from both non-ID and mild ID areas in Hunan. The rural and the urban children have shown similar improvements compared with, respectively, the rural and urban norms, ones which were standardized before the launch of the anti-ID campaign and which were created separately because of the rural/urban cognitive gap. These results suggest that the effect of ID on IQ is similar in rural and urban areas and cannot account for the rural/urban cognitive gap.

An alternative explanation of the rural/urban cognitive difference is selective emigration. One's *hukou* status doesn't change automatically when one moves or changes occupation. While urban *hukou* status can be gained through policy means (e.g., displacement due to state-initiated land expropriation), it can also be gained through selective means (e.g., enrolment in an institution of higher education or promotion to administrative positions) (Chan & Zhang, 1999). According to a study by Zheng and Wu (2013), 80% of participants (unweighted) gained urban *hukou* through various selective means. As shown in Table 3, the average gf score is higher for those who obtained an urban status later in life, consistent with a selection model. This selection could have also occurred at earlier periods in Chinese history. In imperial China, the Imperial Examination provided an opportunity for those from poor backgrounds to gain positions as officials (Ho, 1964), where even poor families in rural areas would identify and support talented children to go to school and take the exam (Li, 2015), resulting in a selective emigration to historic urban areas.

In addition to being affected by selective participation in the number series test, the estimated g decline might underestimate the actual decline in heritable g in the Chinese population as it does not take into account the effects of g-reproduction age relations, mutation accumulation, and selective emigration. Lower g individuals not only have a higher fertility but also tend to start their fertility ahead of those with higher g; thus, the proportion of offspring of lower g individuals will increase in the population as a result of a shorter generation length in addition to a higher fertility. Dysgenesis can also occur as a result of mutation accumulation. A male's spermatogonia undergo 23 meiotic events per year after puberty and accumulates *de novo* mutations with age. In theory, this could impair offsprings' g. The deleterious effect of mutation accumulation on g has been estimated to be about .05 points per decade based on an analysis of secular increases in fluctuating asymmetry in the US (Woodley of Menie & Fernandes, 2016). Selective emigration to foreign nations may further contribute to a dysgenic effect. 133 thousand Chinese individuals managed to obtain permanent resident rights in United States, Canada, and Australia in 2013 (Wang, 2015). 28.2% of those who migrated to the United States in 2013 did so for employment-based reasons (United States Department of Homeland Security, 2014).

Why was there a negative relationship between fertility and intelligence in China?

Miller (2013) speculated that China's population policies reduced dysgenic fertility. We believe instead that these policies may have increased it. Chinese fertility policy programmes were tailored differently for rural and urban residents. The nationwide programme promoting late marriage and childbearing, birth spacing, and limited fertility started in 1973 and allowed rural residents to marry earlier and to have more children than urban ones (Wang, 2012). In 1979, the policy was strengthened to limit fertility to one child per family without any rural/urban difference. In April 1984 and May 1986, the one-child policy was relaxed in rural areas, allowing rural residents to bear a second child if they had a girl. In 1988, the policy began to require an interval (4–6 years) for rural residents. Finally, as of 2016, the policy allows urban couples to have two children.

Chinese policies make it more difficult for individuals with higher status to give birth to more children. For those who have extra children, a fine called a “social fostering fee” is charged. The fee is related to the family's or to the average regional income (Kang, 2005), making it more expensive for richer families to afford extra children. There are cases where poor families who cannot afford the fine, continue to give birth to more children. For example, a man who lives on the basic living allowance and believes that “it would be better to give birth to more children than saving money” gave birth to 11 children (Liu & Zhang, 2015). Furthermore, the Communist Party regulates its members more strictly. According to the 1997 version of “Regulations on Disciplinary Punishment,” party members are to be punished for exceeding their birth quotas, although this policy was not specifically mentioned in the 2015 version (Central Committee of the Communist Party of China, 1997, 2015). Because individuals who gain party membership tend to have higher cognitive ability (Huang et al., 2015), this policy may contribute to dysgenesis in China.

However, such policy explanations cannot explain why dysgenesis also takes place in Taiwan, where there is no mandatory birth planning policy. Chen et al. (2013) estimated the decline in Taiwan to be about 1 point per generation, an amount which is larger than our unadjusted mainland China estimate. The study seems to not have standardized scores within age groups, a method which may have led to an overestimation of the magnitude of dysgenic fertility. Nevertheless, the results remind us to look at factors other than a nation's idiosyncratic policies. This point is reinforced by the observation that the dysgenic fertility was already relatively high among urban populations before the birth planning policy was initiated. We've seen, in Table 4, that urban populations in China exhibited a relatively high dysgenic fertility trend in the 1951–1970 birth cohort. For this same cohort, the trend was much smaller in the rural populations. It suggests that dysgenic selection is related to urbanity. This supports Pan's (1923) observation that “modern urbanization has had so many dysgenic effects upon the race.”

We also need to take a look at Chinese culture. Under Chinese culture, parents have a strong expectation for their children to become successful and to “glorify their ancestors”. Upward social mobility is an indicator of success and is correlated with the correspondence between an individual's g and the social class into which they were born (Waller, 1982). Recombination affects the variance of fitness-enhancing traits among children, on which selection operates (Weismann, 1889, 1904; discussed by A. Burt, 2000). The average difference in g between DZ twins is 10 points, compared with 6 points for MZ twins and for the same individual tested twice (Plomin & DeFries, 1980). Poorer parents in China may realize that by having more children the probability that some will be well endowed and able to move up the social ladder will be increased. In contrast, higher class individuals in China may be less concerned with the ability of their children to climb socially because they may believe that their children can at least environmentally inherit some of their statuses.

Further, in contrast to the West, where adult children are likely to receive support from parents, intergenerational exchange in Chinese families usually takes place in the opposite direction (Lin & Yi, 2011). It is possible that people may regard giving birth to children, especially sons, as an investment in the future. Disadvantaged parents may therefore attempt to secure their future by giving birth to more children.

Still, these China-specific explanations cannot also explain why dysgenesis is a universal phenomenon in the modern world. A more generalizable model needs to take into account insights from an evolutionary perspective. Humans are designed by evolution to reproduce. However, more intelligent individuals can more easily acquire and espouse evolutionarily novel preferences and values and thus deviate from evolutionarily optimal behaviour (Kanazawa, 2012). Many of these preferences and values are maladaptive in the sense that they decrease individuals' fitness and make intelligent people “evolutionarily stupid”. These intelligent people are more likely to abandon traditional values, some of which can be seen as culturally evolved memes that can enhance individuals' fitness (e.g., the Chinese proverb “the more children / sons, the more blessings”), in favour of more liberal ideas.

According to the model put forward by Woodley and Figueredo (2013), eugenic selection is favoured under conditions of ecological harshness and group conflict while dysgenic selection is favoured in the absence of group conflict and in the presence of relative prosperity. The latter situation is characteristic of most of the modern world, including China in recent decades. Improvements in the environment have gradually eliminated infant and child mortality, and longer work hours coupled with prolonged periods of education have encouraged high-IQ individuals (especially women) to delay childbirth in order to maximize their economic competitiveness. These recent changes in the social environment are likely to explain the presence of the dysgenic phenomenon.

4.1. Strengths, limitations, and suggestions for future research

This was the first attempt to explore the presence of dysgenic fertility in China. We used a large dataset to explore the relation between intelligence and fertility. We found that the negative relationship between intelligence and fertility is not only strong for the total population but is also strong for the urban population. Using college attainment as a proxy for intelligence, we provided supporting evidence for the above finding.

However, a number of issues remain to be explored. When we estimated the heritable g decline based on the fertility effect, we assumed a substantially genetic aetiology to the gf score differences between rural and urban populations. While we feel that this assumption is defensible, we recognize that it needs to be tested. This can be done by analysing the effect that internal migration (e.g., rural to urban) has on scores controlling for self-selection. If the assumption made is incorrect then the estimated heritable g decline for the total population is overestimated. Further research is needed to explore the origin of the rural/urban gap.

While we found evidence for Jensen effects on the negative ability-fertility correlations in China, this can only be taken as tentative because results were based on only three or five subtests, with two of them being measures of memory ability, and another two of them being measures highly dependent on educational opportunity. Also, the response rate for the number series subtest was low, introducing bias into the analysis. Thus, the apparent Jensen effect might have appeared by chance. Nonetheless, the findings here were consistent with findings in the United States (Peach et al., 2014; Woodley & Meisenberg, 2013a; Woodley of Menie, Figueredo, Dunkel, & Madison, 2015). Future studies are needed to ascertain if the negative ability-fertility correlations in China are more pronounced on higher g-loaded ability tests.

In the future, it may be possible to conduct a more direct test for selection on heritable g by looking at polygenic scores for intelligence (Piffer, 2015). Such an analysis would involve looking at the polygenic scores of different birth cohorts and fertility groups to see if there were differences in allele frequencies.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.intell.2016.04.001.

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