Poor, Hungry and Stupid: Numeracy and the Impact of High Food Prices in Industrializing Britain, 1790-1840

Jörg Baten
Economics Department
Tübingen University

Dorothee Crayen
Economics Department
Tübingen University

Hans-Joachim Voth
Economics Department
Universitat Pompeu Fabra
(visiting Princeton)

Abstract: This paper examines if low levels of nutrition impaired cognitive development in industrializing England, and if welfare transfers mitigated the adverse effects of high food prices. Age-heaping is used as an indicator of numeracy, as derived from census data. For the cohorts from 1780-1850, we analyse the effect of high grain prices during the Napoleonic Wars. We show that numeracy declined markedly for those born during the war years when wheat was particularly dear. Where the Old Poor Law provided for generous relief payments, the adverse impact of high prices for foodstuffs was mitigated. Finally, we show some tentative evidence that Englishmen born in parishes with low income support selected into jobs with lower cognitive requirements.

I. Introduction

Nutrition in the past was often inadequate. Stature is known to be a good indicator of cumulative net nutrient intake during an individual's growing years. While short-term deficits can normally be compensated – a phenomenon known as catch-up growth – sustained shortfalls tend to affect the terminal heights of individuals. Since the genetic composition has changed little in many European countries over the last two centures, historic heights reflect just how severe chronic malnutrition must have been in the more distant past. Countries whose populations today rank amongst the tallest in the world showed average heights two centuries ago that were very low. Average adult male Dutch and Norwegians in the 19th century had a mean height of only 165 cm, below the levels attained by the British, Irish and French. The same effects produced large differences in stature between social classes. Boys from the London slums were much shorter than those who went to Sandhurst (Floud et al. 1990).[1]

In this paper, we argue that cognitive development of earlier generations may have suffered as much stature did because of scarce nutrition. In modern studies, wages are more strongly correlated with intelligence than with education (Murnane, Willett and Levy 1995). The indicator of cognitive skill we use is numeracy. It has particular predictive power for wages and other desirable labor market outcomes, such as employment.[3] Since more detailed data sources such as IQ or math test scores are largely absent, we focus on age heaping. It reflects a tendency in self-reported age data for people to "round off" to the nearest multiple of 5 or 10. It is widely regarded as a good indicator of numerical skill. While it will be

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[1] The same is true of children from single-parent families (Horrell, Humphries and Voth 2001).
[3] Rivera-Batiz 1992.

affected by schooling and cultural norms, short-term variations in particular should mainly be driven by environmental factors.

We first show that numeracy, as measured by age heaping, was positively correlated with stature in the past. In contemporary samples, the tall are on average more intelligent, and attain more qualified jobs (Case and Paxson 2006). We therefore argue that the numeracy in the past captures a dimension of cognitive ability, and reflects the influence of a nutritional component. Using a new dataset based on the 1851 and 1881 census, we compile measures of age heaping from 1790 onwards. Next, we demonstrate that numeracy fell precipitously in England between 1790 and the early 1800s as grain prices surged in response to the Napoleonic Wars. The price of wheat more than doubled; the number of erroneously reported ages at multiples of five grew almost as much.

As the nutritional crisis caused by high food prices unfolded, English regions that offered substantive support to their poor saw much smaller declines in numeracy. Britain was one of the first states to offer income support for able-bodied adults in years of crisis (outside a workhouse). The system's costs were high, costing as much as two percent of GDP (Mokyr 1993). At a time when an agricultural laborer could expect to earn 22-35 shillings a year, per capita relief expenditures ranged from 7 to 19 shillings (Boyer 1986). Crucially, its generosity was determined at the parish level, by the overseers of the poor. Funding was also raised locally, through property taxes. Some regions had much greater incentives to retain a large number of able-bodied poor than others (for example, to retain a workforce of sufficient size to cope with the harvest). We merge our new dataset on numeracy with information on the generosity of poor relief under the so-called Old Poor Law from Boyer (1990). Age-heaping still increased systematically in those parishes that were relatively generous to the poor, but much less so than in those areas with limited support payments.

Related literature includes the extensive work on nutrition and cognitive development, and summarizes why nutrition should affect intelligence directly, which we review in Section II in more detail. Our results are also related to anthropometric research that has sought to establish indicators of nutrition in the past, mainly based on heights (Steckel 1995, Komlos 1994, Fogel 1994). Other related literature includes work on human capital in earlier societies (Mitch 1998, Schofield 1973). Finally, our findings have a bearing on research into the origins of accelerated growth after 1850. Unified growth models (Galor and Weil 2000, Sunde and Cervellati 2005) have aimed to join human-capital based interpretations with models of fertility choice, arguing that more investment in the skill of the workforce was crucial for the transition to self-sustaining growth. While we do not examine these arguments directly, we document how firmly nutrition constrained a key dimension of pre-modern human capital – numeracy.

Our approach could also offer an alternative interpretation of why some countries in the Third World have conspicuously failed to developed. In an influential book,Clark (2007) argues that cultural traits such as patience and diligence have to accumulate in human populations by differential reproductive success before a ‚take-off' can occur. He bases much of his argument on the failure of alternative theories – such as capital-labor substitution, or inappropriate technology – to explain overstaffing and low output in the developing world. Since these alternatives fail to account for, say, excess labor usage in Indian cotton mills, Clark concludes that something within workers needs to change, and he points the finger at culture. Our results suggest that better nutrition at young ages may be superior to waiting for cultural change through selective breeding over hundreds of years.

Section III describes our preferred measure of numeracy based on age-heaping, and Section IV discusses the datasets we use in more detail. Our results are presented in the empirical section V, where we present evidence from difference-in-difference estimation that nutritional availability in industrializing Britain determined numerical ability. Section VI concludes.

II. Nutrition, cognitive ability and occupational outcomes

There is strong medical evidence that nutrition during childhood has important effects on the development of cognitive abilities. In one study of preterm infants, the protein content of the diet was varied on a random basis (Lucas 1998). Those children receiving the less nutrient-rich diets showed markedly lower neurodevelopment (lower mental development scores and psychomotor scores) at the 18 month follow up than the control group. These effects could still be detected as late as at age 7.5, when IQ scores were significantly lower. Since intelligence tests at age 7-8 predicts adult cognitive ability, it is likely that infant nutrition can harm cognitive development in a major way. Other randomized trials of stunted children similarly show that nutritional supplements can produce important gains in intellectual development (Grantham-McGregor 2002). In this study, we follow the literature and consider birth cohorts to capture the most important nutritional effects during the first 10 years of life.

Richards (2002) used data on IQ scores and height for the a large British post-war sample, and finds that the variables are strongly and positively correlated. In particular maximum height gain during early childhood and the timing of the adolescent growth spurt predict cognitive ability. There is also some evidence that rising IQ scores in developed countries may partly reflect improving nutrition (Lynn and Vanhanen 2002). Genetic factors may also play a role, but do not appear do dominate. While results vary, studies of Scandinavian siblings find that genetic influences cannot explain the correlation between heights and cognitive ability (Magnusson, Rasmussen, and Gyllensten.2006).

Based on controlled experiments in today's Third World, Behrman (2006) argues that the correlation between height and wages may largely reflect nutrition's impact on early cognitive development, and not strength or resilience to disease. This is in line with the argument in Case and Paxson (2006)

III. Numeracy

Using age heaping as an indicator of numeracy is not new. Bachi (1951) and Myers (1976) showed that across countries and within them, richer, more educatad populations were less prone to show age-heaping. Historical applications include the work of Herlihy and Klapisch-Zuber (1978) on fourteenth century Florence, Mokyr (1983) on selectivity bias among Irish emigrants, and Duncan-Jones (1990) on the Roman Empire. Over the very long run, numeracy as proxied by age-heaping varies strongly with income, and is highly correlated with literacy (Clark 2001, A'Hearn, Baten and Crayen 2006).

It could be argued that the ability to recall one's age correctly is more indicative of schooling and changing cultural norms than of cognitive development. Where it varies considerably over short periods, it is certainly not a result of cultural factors, and less likely a result of closing down schools. Since the use of age and birthdays to identify individuals, and the prevalence of schooling have generally been on the rise of the last two centuries, there is an asymmetry in how we should interpret short-term fluctuations. Increases could be driven by, say, the introduction of compulsory schooling (in the later 19th century in most European countries). Where numeracy falls sharply, on the other hand – and without a collapse of the school system at the same time – other factors should be at work. This is the logic behind our examination of the sharp falls in numeracy in England around 1800.

The most commonly used indicator of age heaping is the Whipple index.[4] It calculates the number of self-reported ages that are multiples of 5, relative to the number expected with a uniform distribution of ages:

$$W = \frac{\sum (n_{25} + n_{30} + n_{35} ... n_{60})}{\frac{1}{5}\sum_{i=23}^{62} n_i} \quad (1)$$

The range of ages has to be chosen so as to include the same number of ages with the same terminal digit (in this case, 23 to 62). There is substantial evidence that the Whipple index dominates competing estimators like the Bachi measure, in particular in terms of accuracy at low levels of heaping (A'Hearn, Baten and Crayen 2006). The index ranges from 0 to 500.. Accordingly, a Whipple Index of 100 (500) implies no (only) ages ending in multiples of 5. At 0, it would imply that multiples of 5 are consistently avoided.

IV. Data

We combine two main datasets – the Poor Law data collected by Boyer (1990), and the 2% and 5% samples from 1851 and 1881 census, respectively. These are then supplemented by

4 For an overview of different indicators, cf. A'Hearn, Baten, and Crayen (2006).

additional information on grain prices and on historical weather patterns. Boyer compiled information on the generosity of outdoor relief under the Old Poor Law. His data is based on a survey by the Poor Law Commission, conducted in the summer of 1832. Motivated by growing concern about the surging cost of poor law provision, it sent out a questionnaire, called the Rural Queries, to the approximately 11,000 parishes of England. They received answers from ca. 10% of them. Of these, Boyer used a sample of 329 parishes in 21 counties in Southern England.[5] The returns include information on average relief expenditure, summer and winter unemployment, the existence of allotments, the percentage of land used for grain production, and the presence of cottage industry, as well as the annual income of agricultural laborers. We do not have access to his data at the parish level. The data at the county level is publicly available. We therefore aggregated the age data from parishes at county level. This had the additional beneift that it allows for a more accurate calculation of Whipple indices.

The Census samples were taken and coded from the original returns by Michael Anderson (1987). Occupations were coded according to the scheme devised by Armstrong (1972), which we later adapt to more modern standards.[7] We use information on gender, the county of birth, the self-reported age of the respondent, as well as occupational information.

Age heaping in the 1851 and 1881 census varied substantially between the different counties in our sample. Figure 6 shows the differences in age heaping between the average Whipple by individual county, over the entire sample period 1780-1840. The range is substantial. While the least numerate county (Dorset) shows Whipple scores of more than 125, the most numerate one (Norfolk) scores a near-perfect 105. Most counties fall into the range

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[5] A total of 735 returns came from Southern parishes. Boyer selected the most complete ones.
[7] They are available at http://www.data-archive.ac.uk/.

115-120, indicating that multiples of 5 are overreported, with 25 percent higher than if all respondents had remembered their ages perfectly.

One crucial question concerns age-specific changes in the respondents in our samples to remember their age correctly.[8] If age alone leads to a deterioration of numeracy, we should find that the, say, the 60-year-olds in the 1881 sample have much higher Whipple scores than the 30-year-olds in the 1851 sample. Table # shows Whipple scores for the same cohort from the two census samples. While age heaping is never identical, there appears to be no systematic pattern that would undermine belief in the usefulness of the indicator or the samples chosen.

The grain price data was hand-collected from by Liam Brunt and Edmund Cannon from contemporary prize gazettes.[9] Acts of Parliament ordered the collection of grain price data during the period 1770 to 1863.[10] In most years, between 140 and 290 towns reported prices. While information on a number of different grains were recorded, we focus here on the price of wheat. It was the main staple of eighteenth and nineteenth century British diets. As figure 4 illustrates, wheat flour alone accounted for 27% of working class expenditure on food.[11] Bread – largely baked from wheat as well – took up another 20% to the food budget. Together with oatmeal, grain-based food accounted for 60% of the food budget, or 40% of the consumer basket overall. To gauge the importance of wheat in particular, and grain more generally, we also have to add part of the 10% spent on drink. The largest share of this would have been consumed in the form of beer, derived in large part from wheat and barley.

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[8] . In the main empirical section, we will use a fixed-effects approach to bypass some of the underlying difficulties.

[9] The authors kindly made their data available to us as county-year averages. The source is described in more detail in Brunt and Cannon (2005).

[10] 10 George III, 31 George III, 1 and 2 George IV, 9 George IV, and 5 Victoria

[11] The figure is from Voth 2003, and is based on data from Feinstein 1998.

During our sample period, average wheat prices in our sample rose sharply in 1795/96, 1800/1801 and in the late 1810s. At their peak, they were more than twice as high as they had been in the 1780s. It was the pressure produced by these food prices that inspired Frederic Eden and David Davies to undertake the surveys of working class families on which the budget data cited earlier is based.[12]

Table 1 contains the data descriptives for our key variables. Half of our sample is female. Relief payment vary widely between parishes. Grain prices fluctuate over time and across localities. Graingrowing areas make up 12 percent of our sample. Our earliest birth decade is 1770; the latest, 1850. Whipple indices range from 85 (indicating too little heaping) to 175.3, with an average of 117. This scores indicates that the Englishmen in our sample are not from a population with particularly low literacy. Within our sample, we define crisis years as those that have grain prices above 110 (Figure 1).

[12] Data in Horrell (1996) shows a strongly negative own-price elasticity of demand for bread, and a positive (but smaller) one for flour. This suggests that price increases led to sharp falls in bread consumption, and that some substitution to home-baked bread took place.

V. Empirical Results

In this section, we show that across a wide range of samples, from different time periods, countries, and social groups, the well-nourished show greater numeracy. We then document that numeracy fell precipitously in England as grain prices during the Napoleonic Wars surged. Declines in numeracy were particularly pronounced in counties where (i) grain prices were particularly high (ii) income support for the poor was less generous. Finally, we show that the exogenous component of grain price changes, as driven by weather shocks, was an important determinant of numeracy.

The first question we have to answer concerns the links between nutrition, cognitive ability and numeracy. While the influence of nutrition on cognitive ability appears well-established, the connection between our indicator of numeracy and cognitive facilities is less clear-cut. A large number of factors unrelated to cognitive ability – such as schooling, changing cultural norms, and bureaucratization – might influence the extent of age-awareness. To address this issue, we turn to heights as an indicator of cumulative nutritional status since childhood. As is well-known, well-nourished individuals stand a better chance to reach their genetic potential in terms of height. In figure 5, we present data from the US, France, Ireland, and the UK, from the 1650 to the 1840s. The samples are divided into „tall" and „short", according to whether they are above or below the median. We then calculate Whipple indices for both groups. Throughout, the tall are less likely to misreport their age. In some cases – such as the data from Wandsworth prison, and from Union Army – the difference is small. In others, such as the Irish prisoners sent to Australia, and French Army recruits from Paris, the differences are marked, with Whipple indices that are 20-40 percent higher for the shorter group than for the taller one. Since the samples are drawn from relatively homogenous backgrounds, this strengthens the *prima facie* case in favor of a link between nutrition and our indicator of cognitive ability, age heaping. If we believe the existing evidence from modern-day sample documenting the nexus between nutrition and cognition, it also strengthens the belief in the usefulness of age heaping as a measure of numeracy.

Is there reason to think that numeracy was affected by years of high prices? As a first pass at the argument, we use the crisis definition from the preliminary examination of grain prices during our sample period. Table 2 calculates means and medians of the Whipple index, conditional on grain prices being at crisis levels, and on relief payments being above or below the median. We find that crisis years consistently have higher Whipple scores (lower numeracy), and that counties with higher poor relief payments showed less age heaping. Finally, the differences in the means between crisis and non-crisis years appears to suggest that numeracy declined less after the outbreak of a crisis in those counties that treated their poor generously.

Figure 7 illustrates these findings graphically, plotting the Whipple indices over time. After the outbreak of the Napoleonic wars, Whipple indices rise sharply in both generous and less generous counties. However, counties with limited relief show a markedly higher peak. Their Whipple scores stay above those for the generous counties until the 1830s. While not conclusive proof that the poor in parishes with lower income support suffered greater nutritional pressures, with subsequent harm to the cognitive development of their offspring, the pattern is broadly consistent with such an interpretation.

We next examine these patterns more systematically. Table 3 shows OLS regressions, using the Whipple index as the dependent variable. We find that higher grain prices consistently drive up age heaping in our sample. On average, a one standard deviation increase in grain prices pushed up the Whipple index by 2.1 points (eq. 1 and 2). Counties with generous relief lowered their Whipple scores by 4 points (eq. 2). Equation 5 uses a continuos transformation of the poor relief variable to test if numeracy declined consistently in those parishes where relief payments were smaller. Instead of the simple dichotomous variable that codes counties as generous or not, we define $[R_{max}-R_i]$, where R_{max} is the maximum relief payment per capita, and R_i is the relief payment in county i. It expresses the shortfall of relief payments relative to the most generous county (Sussex) in our sample. We find that lack of poor relief consistently and strongly predicts higher Whipple scores, and that the use of this continuous measure does not undermine the size and significance of the grain price variable.

Equation 5 examines the conditional mean of the numeracy indicator. Since we are principally interested in numeracy changing as a result of „life under pressure“, it may also be instructive to examine other parts of the distribution. To this end, we estimate quantile regressions for the whole range of the dependent variable, from the 10th to the 90th percentile. Figure 9 illustrates the results, showing the impact of grain prices and lack of relief payments on the percentiles of the Whipple distribution. The effect of grain prices is positive and large throughout the range, but it becomes insignificant above the 60th percentile. The coefficient on lack of relief, on the other hand, is significant throughout, and rising in magnitude for higher values. Lower support payments appear to have done disproportional damage. This suggests that the underlying causal mechanism exhibits some non-linearity in the mapping from malnutrition to cognitive ability.

Do higher grain prices lower cognitive ability to the same extent in generous and in „mean“ counties? Eq. 3 and 4 split the sample into 2, according to whether parishes are above or below the median for poor relief. We find that in those parishes where support is limited, grain prices have a particularly strong effect on Whipple scores (eq. 3), with a one standard deviation increase pushing up age heaping scores by 3.3 points. In those counties where support payment are generous, however, the effect of higher grain prices is small and not significantly different from zero. Figure 8 illustrates this graphically. We plot Whipple scores by county and birth decade against grain prices (during the birth decade). Observations from counties with above-average poor relief payments are marked 1; less generous counties are marked 0. While there is a lot of variation that our setup cannot account for, the regression line for the more generous counties is very flat, compared with the one for the more restrictive counties. An F-test for the difference of the coefficents confirms that dearer staples only had a significant impact in those parts of the country where the poor were largely left to their own devices.

The evidence in table 3 suffers from one important drawback – possible bias from unobserved heterogeneity. To address the issue, we employ panel estimation:

$$W_{i,t} = a_i + \beta G_{i,t} + \gamma X'_{i,t} + \varepsilon \qquad (2)$$

where W_{it} is the Whipple index for for county i at time t, *a* is a county-specific intercept, $G_{i,t}$ is the grain price in county i at time t, and X' is a vector of controls. Alternatively, we use a dichotomous crisis indicator, based on whether grain prices are above 110. The results are presented in table 4. The estimated coefficient on G is very similar to the OLS results, with a rise of one Whipple point for every 10 additional points of grain prices (eq. 1). In years of crisis, Whipple indices are on average four points higher (eq. 2).

There could be some endogeneity in our setup, with higher grain prices causing the workforce to be less well-fed and energetic. This, in turn, could cause a reduction in a county's grain output. To sidestep potential endogeneity issues, we us an instrumental variable approach. In eq. 3 and 5, we predict the main explanatory variable with the ratio of annual spring rain to its long term average. More rain in the spring was bad for crops, raising prices – the first stage regression has a t-statistic of 8.9 on the spring ratio, and an R^2 of 0.3. The estimated coefficient on the grain price actually rises in size and in significance. This could suggest measurement problems. In our view, this is less likely for grain prices as such. However, grain prices are an imperfect indicator of access to nutrition. It is more likely that the instrumented grain prices capture scarcity of foodstuffs more precisely. Since our indicator of poor relief payments does not vary over time, we cannot add it directly to the panel setup. In equations 4 and 5, in a setup similar to Rajan and Zingales (1998), we replace G with $G*[R_{max}-R_i]$. The idea is to examine if counties offering less poor relief suffering higher grain prices had systematically higher Whipple scores. The coefficient on the interaction term is highly significant. It is also large: a one standard deviation increase raises age heaping scores by 5.6 points. If we include year dummies in the fixed effects estimation (not reported in table 4), the coefficient on grain prices becomes larger, increasng from 0.1 to 0.16. However, is no longer statistically significantly different from zero. If we limit the sample to those cases where Whipple scores are above 110 (and hence there is some indication that we are capturing more than noise in our measure of numeracy), the coefficient grows to 0.53. It is also significant at the 10 percent level.

Did the impact of high food prices matter for occupational outcomes? We re-classify individuals in our sample from the 1851 census to match the coding from the Dictionary of

Occupational Titles (England and Kilbourne 1988). Their study offers scores for the skills required for a wide range of jobs. We recode jobs from the Armstrong classification originally used in the computerized version of the 1851 census. Our main interest is in the cognitive skill requirement of jobs performed by individuals in our sample who suffered from high grain prices and low poor relief payments. In nineteenth century Britain, class and parental income were major determinants of access to higher education. Families that could send children to university were unlikely to suffer from the dear food prices during the Napoleonic wars. We therefore exclude the professions requiring the highest skills (code 1-199 in the England-Kilbourne scheme – basically all professionals such as architects, medical doctors, civil engineers, etc.). For the rest, we find that i. those born in years of high prices selected into occupations that required less intelligence, compared to their peers born in years of plenty ii. Englishmen and women born in high-relief parishes held jobs requiring greater cognitive skills. Figure 10 plots the intelligence scores of jobs held, acc. to the England – Kilbourne classification, over time, for both high and low relief parishes. Lower scores indicate higher cognitive skill requirements. Those with limited support for the poor start off in a better position in 1780, but see a sharp increase during the hungry 1790s and 1800s. Counties with generous poor relief see a mild deterioration, and then a sharp improvement over the period. On average, counties with high relief payments see their intelligence scores fall by 0.015 less (t-statistic 1.79, p-value 0.093). We also find an impact of grain prices on the average intelligence of birth cohorts. A doubling of grain prices, as occurred after 1790, translated into a fall of average intelligence scores for the professions into which people selected of 0.02.[13]

[13] The regression underlying this estimate is a fixed-effects panel. The t-statistic on grain prices is 1.53, significant at the 13% level.

These effects are relatively small. This may be driven by the highly aggregated nature of our data.

VI. Conclusion

This paper has argued that cognitive shortcomings in the past may in part be explained by inadequate nutrition. To demonstrate the importance of this new and previously unexamined factor behind low living standards in the past, we exploit a quasi-natural experiment. When industrializing Britain went to war with France in the 1790s, grain supplies from the continent were cut off in many years. Prices for wheat and other staples surged We examine the impact of this exogenous shock to food availability, and show that it lowered average numeracy throughout the country. Children born in the hungry decades of the 1790s and 1800s were much less likely to remember their age correctly, or to perform the calculation necessary to derive it without errors. Crucially, the effect was particularly pronounced in those areas that did little to help the poor. In areas where poor relief was generous, higher grain prices no longer caused a fall in numeracy. There is also some evidence to suggest that the careers of those affected by high grain prices and low support payments suffered. In particular, and in line with our broader argument, individuals from counties hit by particularly high prices, or without much income support, selected into occupations that were on average less demanding in terms of cognitive skills. This also suggests that the „first welfare state“ offered an effective way to improve living conditions for the poorer groups of society.

In his Nobel address, Robert Fogel (1994) sought to determine the contribution of better nutrition to higher productivity over the last 200 years. Focusing on the increase in life expectancy, and the greater resilience and strength of humans today, Fogel concluded that 20-

30 percent of total output growth could be attributed to improved food intake. In his work, one factor does not feature prominently – greater cognitive ability. One of the potential implications of research is that cognitive ability may have been a key limiting factor amongst populations in the past.

Our results raise the possibility that causality may run the other way, too. Low cognitive ability may have limited output to an important extent. While we offer no direct proof, the findings presented in this paper suggest that the transition to self-sustaining growth in industrializing Europe could owe a great deal to improved nutrition and higher cognitive ability. In related papers, Zax and Rees (2002) and Behrman (2004) show that intelligent members of the workforce earn substantially more. Lynn and Vanhanen (2002) offer a broad-ranging survey and argue that intelligence is a prime determinant of the wealth of nations. Jones (2006) shows that, in a simple Ramsey framework, present-day cross-country differences in IQ can account for a large proportion of the gap in productivity. If intelligence was affected by poor food intake, as our results suggest, we will have to take seriously the hypothesis that life was „nasty, brutish, and short“ in part because the populations’ cognitive development was severely limited.

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Tables

Table 1: Descriptive Statistics

Variable	N	Mean	St.Dev.	Min	Max
Relief	264	16.5	4.98	9.61	26.04
Gender	296	0.5	0.25	0	2
Grain price	230	100.7	22.6	60.8	147.98
Graingrowing	264	12.4	4.3	4.5	19.09
Whipple	286	117.17	14.3	85.4	175.3
Year	296	1817.2	22.6	1770	1850

Table 2: Conditional Means (Medians) of Whipple Index

Crisis	Relief	Low	High	Difference
	0	117.3 (114.4)	114.6 (111.0)	2.7 (3.4)
	1	121.0 (117.22)	117.35 (116.2)	3.65 (1.02)
Difference		3.7 (2.82)	2.75 (5.2)	

Table 3: Regression Analysis: Whipple Scores and Grain Prices
Dependent variable: Whipple Score

			Relief payment		
Sample	all	all	< median	≥ median	
Eq.	1	2	3	4	5
Grain price	0.092	0.094	0.147	0.042	0.08
	(2.1)	(2.34)	(2.4)	(0.67)	(2.3)
Female	0.73	0.73	-0.34	1.88	0.73
	(0.4)	(0.4)	(2.69)	(0.66)	(0.4)
Relief high		-4.1			
		(2.1)			
Relief lack*					0.37
					(1.9)
C	109.25	110.96	106.21	111.64	106.2
	(23.4)	(25.9)	(16.5)	(16.8)	(20.5)
adj. R2	0.01	0.04	0.032	0.009	0.04
N	220	220	114	106	220
Impact of 1 sd					
Grain price	2.08	2.12	3.3	0.95	1.8
Relief lack					1.84
F-test of equality (coefficient on grain price, p-value in parentheses)			2.81 (0.097)		

Note: Standard errors clustered at the county level.
* defined as [R_{max}-R_i], where R_{max} is the maximum relief payment per capita, and R_i is the relief payment in county i.

Table 4: Fixed Effects Panel Estimation

Eq.	1	2	3	4	5
Estimation	OLS	OLS	IV	OLS	IV
Gprice	0.1				
	(2.4)				
Crisis[+]		4.4			
		(2.4)			
Gprice-instrum			0.29		
			(3.4)		
Gprice*[R_{max}-R_i]				0.01	
				(2.56)	
Gprice*[R_{max}-R_i] - instrum					0.029
					(3.34)
Female	0.73	0.73	0.73	0.73	0.73
	(0.4)	(0.4)	(0.37)	(0.38)	(0.36)
adj. R2	0.02	0.02	0.02	0.034	0.034
N	220	220	220	220	220

Note: Instrument used is the ratio of spring rain to its long-term average (R2=0.30)
+ Crisis is a dummy variable equal to unity if grain prices are above 110, and zero otherwise.

Figures

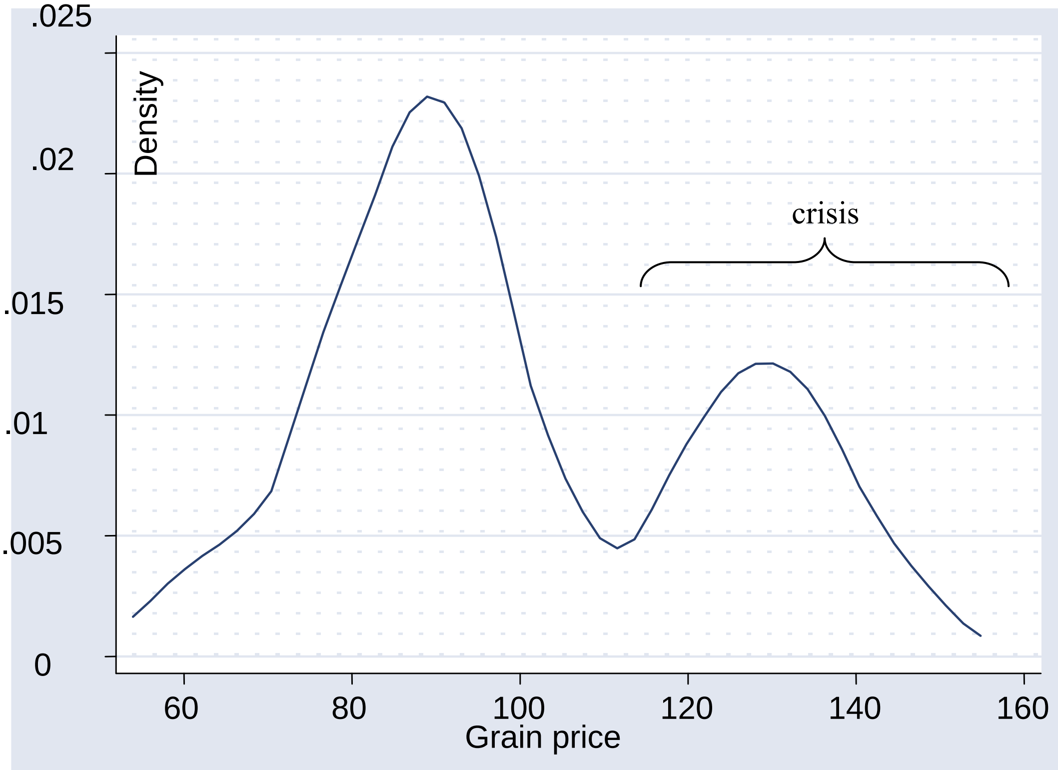

Figure 1: Kernel density estimate of grain prices

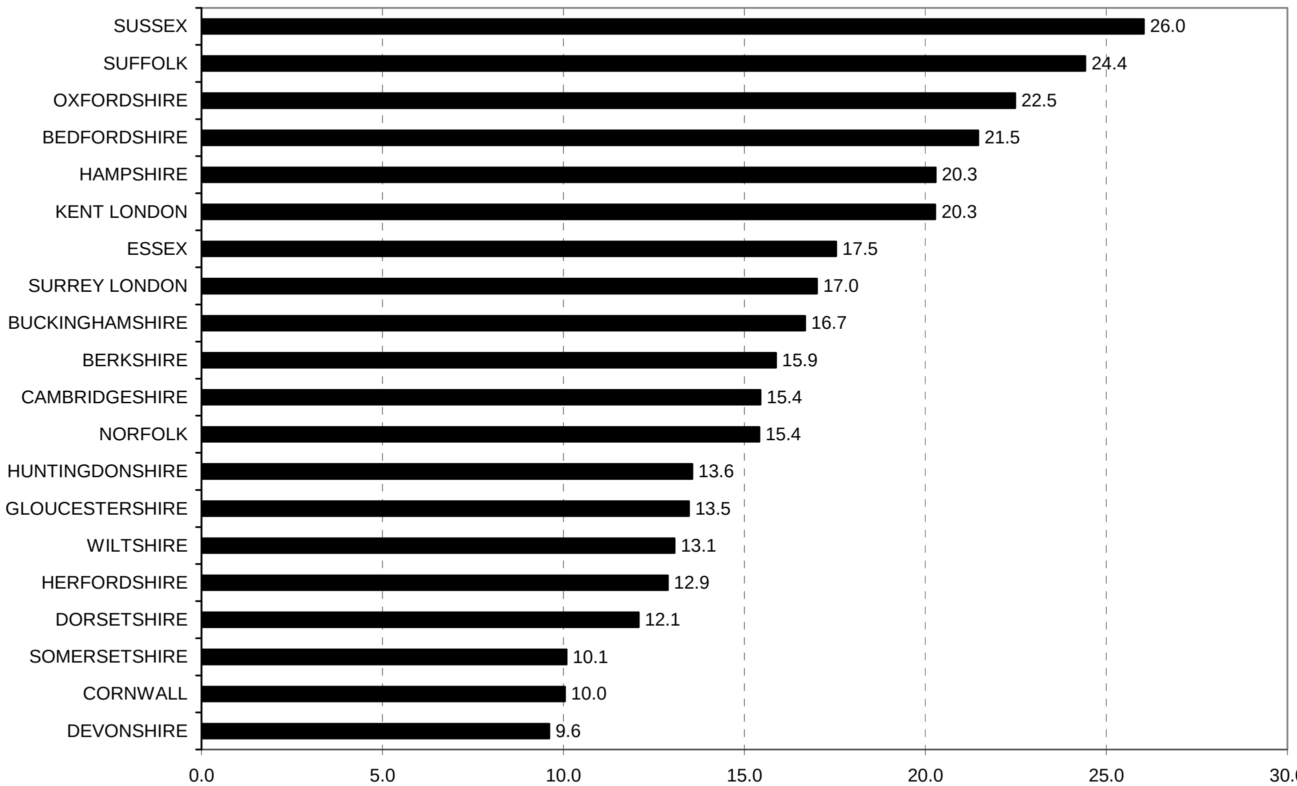

Figure 2: Poor relief per capita, in shilling
Source: Boyer 1990.

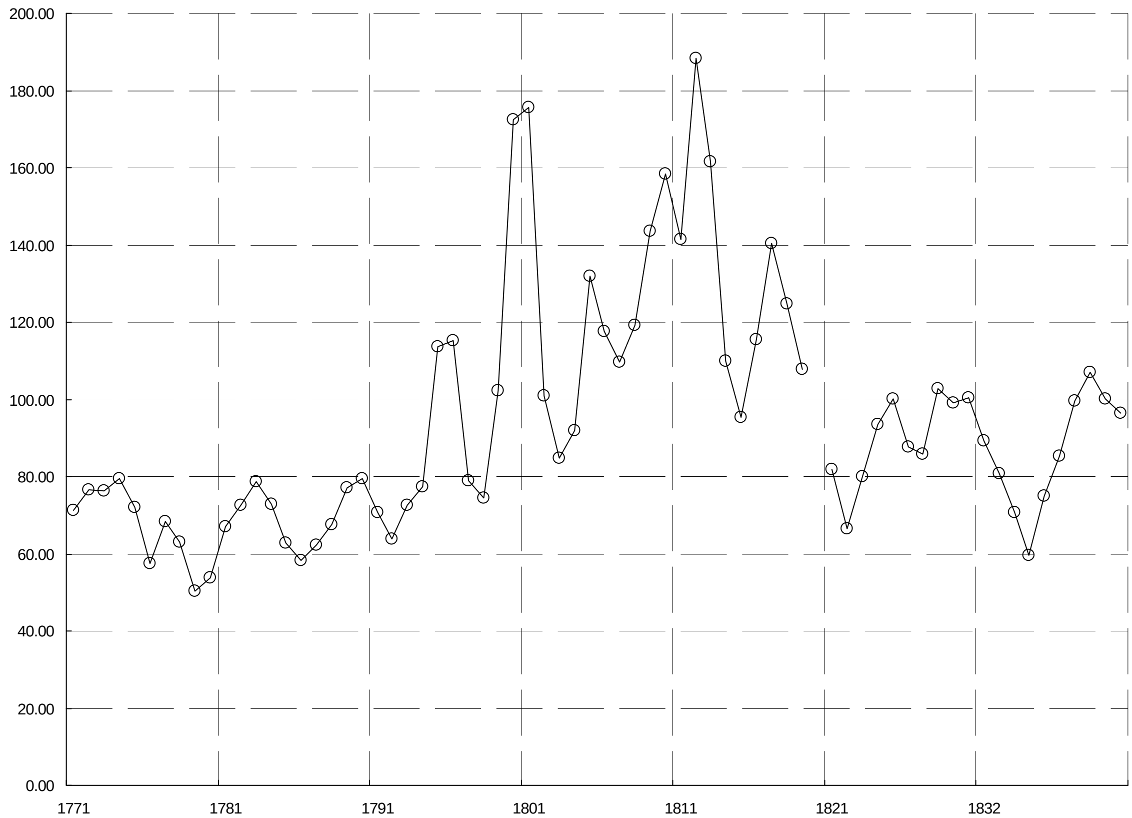

Figure 3: Grain prices in England (1800=100)

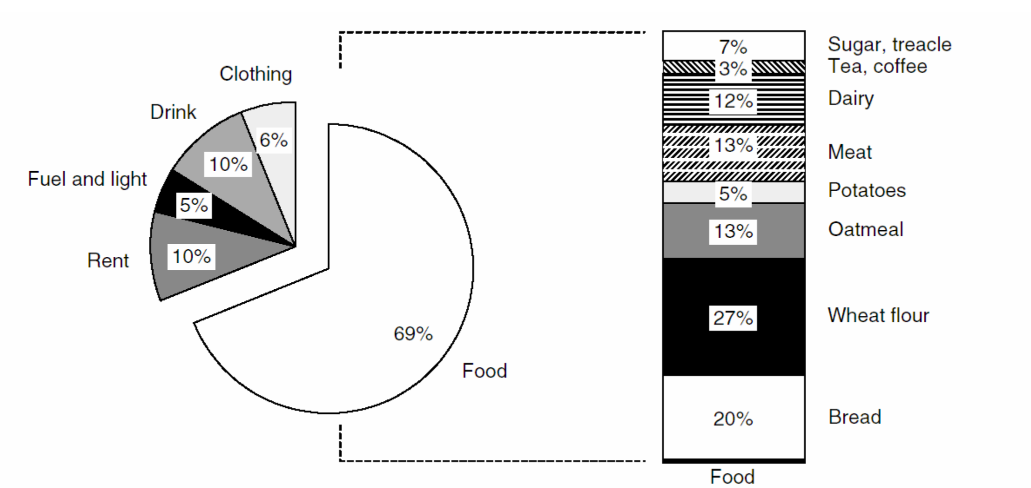

Figure 4: Composition of Working Class Expenditure, 1788-92
Source: Voth 2003

Country/Region	Institution	Birth decades	Whipple index		Ratio
			Short	Tall	
England	Wandsworth prison	1800s-1840s	133	129	1.03
Ireland	NSW convicts	1790s-1810s	160	131	1.22
US (North)	Union army	1800s-1840s	103	101	1.03
Paris	French Army	1650s-1760s	141	102	1.38
France (Northeast)	French Army	1650s-1760s	125	117	1.07
France (Southwest)	French Army	1650s-1760s	142	125	1.14
France (Total)	French Army	1650s-1760s	135	123	1.10

Figure 5: Height and Numeracy

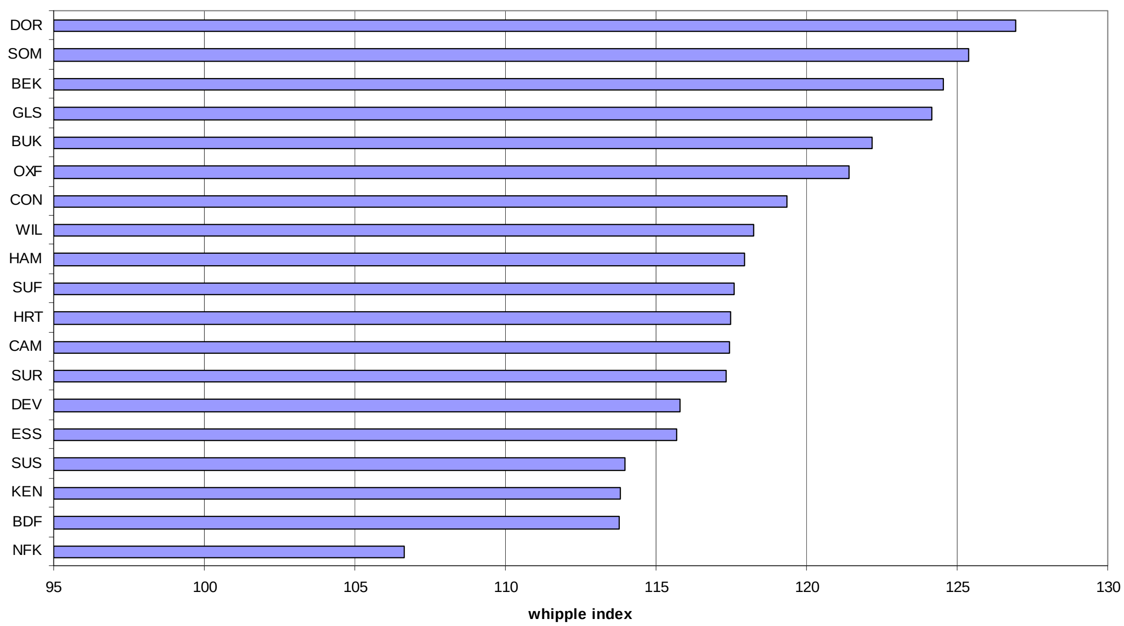

Figure 6: Whipple Indices by County

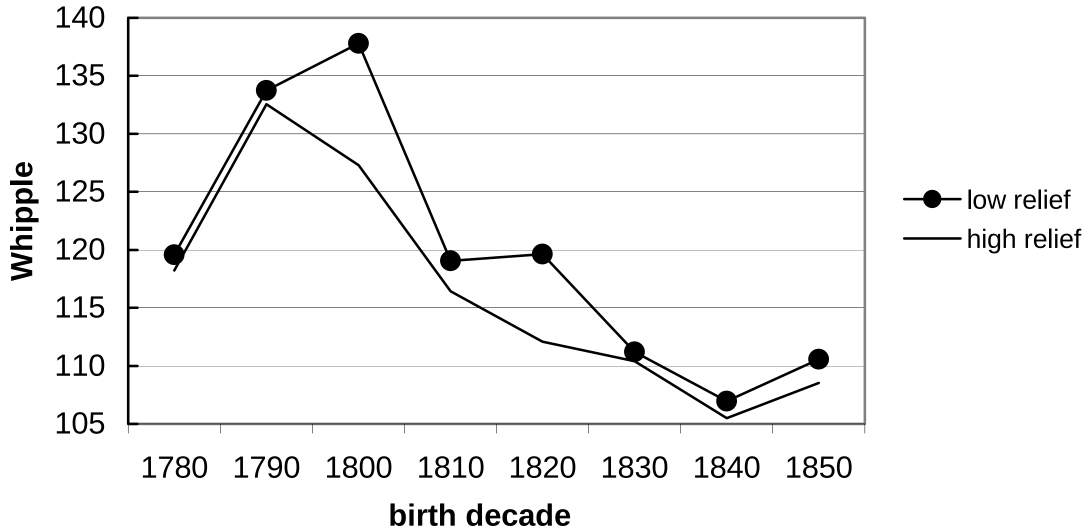

Figure 7: Whipple Indices over Time, by Generosity of Poor Relief

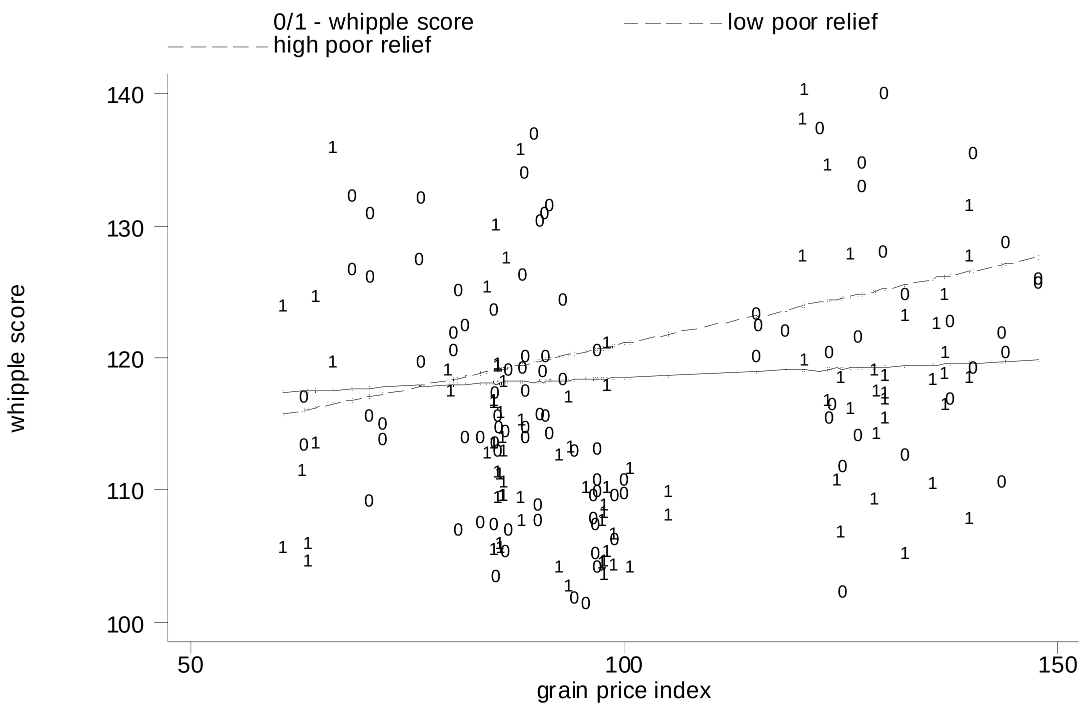

Figure 8: Whipple scores and grain prices

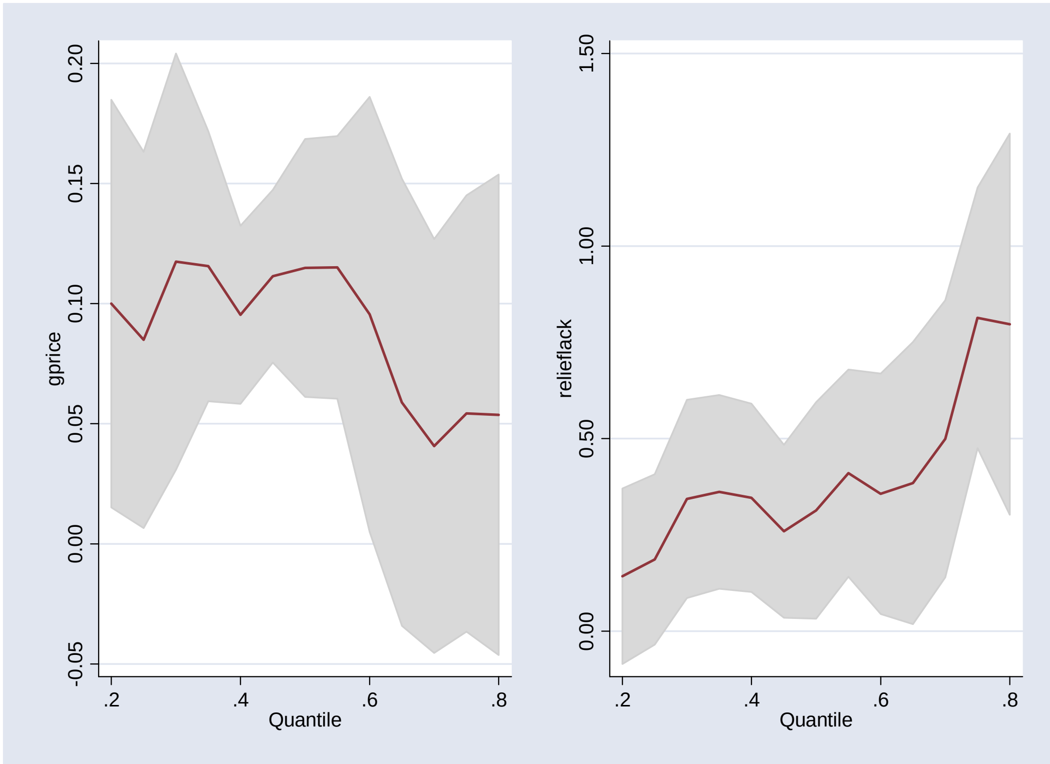

Figure 9: Quantile regression plots, 90% confidence interval

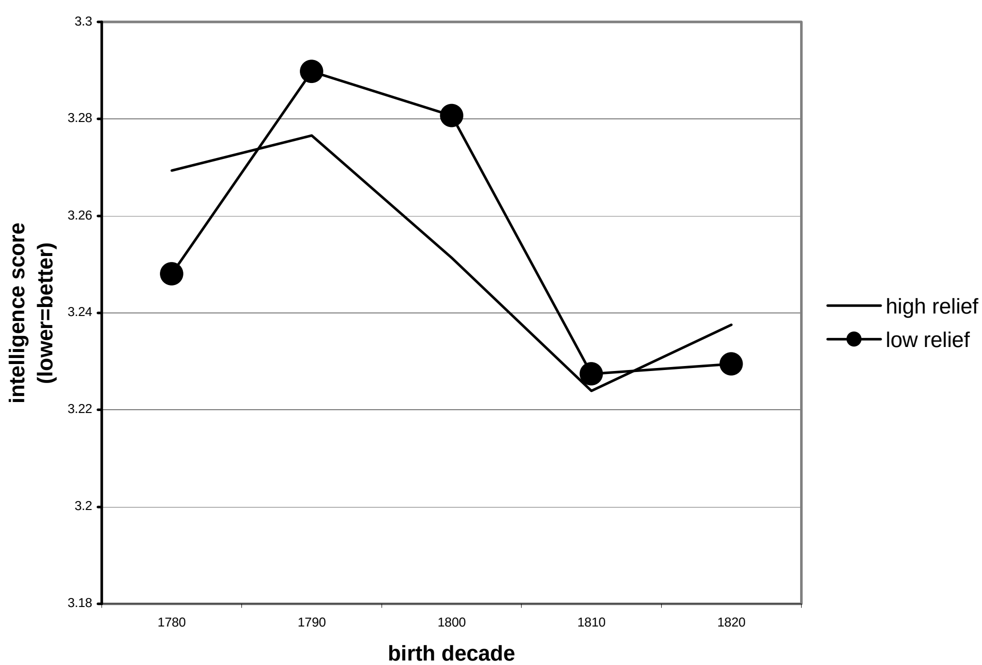

Figure 10: Intelligence scores by birth decade