

# Poor, Hungry and Stupid: Numeracy and the Impact of High Food Prices in Industrializing Britain, 1780-1850

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**Abstract:** This paper argues that low levels of nutrition impaired cognitive development in industrializing England, and that 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, especially when wheat was dear. Crucially, 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 areas with low income support selected into occupations with lower cognitive requirements.

## I. Introduction

Nutrition in the past was often poor. Countries whose populations today rank amongst the tallest in the world two centuries ago had low average heights. Dutchmen and Norwegians males in the 18th century had a mean height of only 165 cm, below the 10<sup>th</sup> percentile of the US population today, and below the levels attained by the British, Irish and French (Fogel 1994). Social differences in heights were also marked. Boys from the London slums were up to 9 inches (23 cm) shorter than those attending the Royal Military Academy at Sandhurst (Floud et al. 1990).<sup>1</sup> 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. Because the genetic composition has changed little in many European countries over the last two centuries, historic heights reflect just how severe chronic malnutrition must have been in the more distant past.

In this paper, we argue that scarce nutrition may have harmed cognitive development of earlier generations as much as it stunted heights. In modern studies, wages are more strongly correlated with intelligence than with education (Murnane, Willett and Levy 1995).<sup>2</sup> Recent work has also shown that heights are strongly correlated with IQ measures, and have considerable explanatory power for wage outcomes (Persico, Postlewaite and Silverman 2004; Case and Paxson 2006). The indicator of cognitive skill we use is numeracy. It has been

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<sup>1</sup> The same is true of children from single-parent families (Horrell, Humphries and Voth 2001). The average difference reported is from recalculations of the Sandhurst and Marine Society data (Komlos 2005).

<sup>2</sup> Komlos (1989) argues that nutrition mattered at the opposite end of the skill spectrum as well. He observed that many innovators of the Industrial Revolution in the UK were born during the good times of the 1730s, when food prices were low.

shown to have high predictive power for wages and other desirable labor market outcomes, such as employment.<sup>3</sup>

Data on IQ or math test scores are not available for the more distant past. Instead, we focus on age heaping. As is well-known (Mokyr 1983, Myers 1976), self-reported age data often show a tendency for people to “round off” to the nearest multiple of 5 or 10. Roman tombstones, for example, show high rates of age heaping (Duncan-Jones 1990). Age heaping is widely regarded as a good indicator of numerical skill. Gradual changes in heaping over longer periods can reflect a number of factors, such as schooling, bureaucratization, and evolving cultural norms. We contend that these factors are unlikely to explain abrupt changes over short periods. These short, sharp shocks to numeracy will mainly reflect environmental factors. In historical data, numeracy, as measured by less age heaping, is positively correlated with stature. We therefore argue that the numeracy in the past captures a dimension of cognitive ability, and reflects the influence of a nutritional component. The paper concludes that negative shocks to the availability of nutrition during the Napoleonic Wars resulted in much higher age heaping in industrializing Britain.

Using a new dataset derived from the 1851 and 1881 censuses, we compile measures of age heaping for those born from the 1780s onwards. Next, we demonstrate that numeracy fell precipitously in England between 1790 and the early 1800s as grain prices surged during the Revolutionary and Napoleonic Wars. The price of wheat more than doubled; the number of erroneously reported ages at multiples of five increased from 4 to 8 percent. Cross-sectional evidence supports our hypothesis. 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). As the nutritional crisis caused by high food prices unfolded, English regions that offered substantive

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<sup>3</sup> Rivera-Batiz 1992.

support to their poor saw much smaller declines in numeracy. 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. Britain was one of the first states to offer income supplements for able-bodied adults in need of support (outside a workhouse).

Moreover, the system was comparatively generous. Its cost was high, consuming 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, relief expenditures per recipient ranged from 7 to 19 shillings (Boyer 1986). Generosity was determined at the parish level, by the overseers of the poor. Funding was also raised locally, through property taxes. Economic factors explain part of the differences in generosity. 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 control for these factors separately. Overall, we argue that generosity of poor relief largely reflected idiosyncratic differences towards supporting the poor.

Related literature also includes the extensive work on nutrition and cognitive development. It argues that there is growing evidence for nutrition affecting intelligence directly. We review this literature in more detail in Section II. Our results also relate to recent anthropometric research that has sought to measure nutrition in the past, mainly based on heights (Steckel 1995, Komlos 1994, Fogel 1994). Other related literature includes work on human capital formation in industrializing Britain (Mitch 1998, Schofield 1973). Finally, our findings have a bearing on research into the origins of accelerating growth after 1850. One class of unified growth models (Galor and Weil 2000, Sunde and Cervellati 2005) has 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 nutrition constrained a key dimension of pre-modern human capital – numeracy.

Section II reviews the literature on the link between IQ, malnutrition, and labor market performance. 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 section V. We show evidence from difference-in-difference estimation that nutritional availability in industrializing Britain influenced numerical ability. We also document that Englishmen born in the hungry decades of the 1790s and 1800s sorted into jobs with lower skill requirements – especially those from areas with limited poor law support. Section VI concludes.

## **II. Nutrition, cognitive ability and occupational outcomes**

In this section, we review the literature linking nutrition to cognitive ability and nutritional outcomes. There is strong medical evidence from experiments 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 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 predict 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). Studies on mammals suggest

that both pre- and post-natal nutrition have a strong impact on brain development (Winick and Rosso 1975). Sensitivity is probably greatest in utero and in early childhood. Low birthweight in humans in particular predicts lower cognitive scores (Richards et al. 2002). Malnutrition between 1 and 16 months also is a strong predictor of poor cognitive outcomes (Lloyd-Still 1976). 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.

Nutrition during the second decade of life also appears to have strong effects. The positive correlation of heights and cognitive scores points in this direction. The heights of individuals are in part determined by parental genes. The same is probably true of intelligence. In populations, however, the gene pool stays approximately constant over time. Changes in average heights primarily reflect the influence of environmental factors (Steckel 1995). Intelligence is likely to be affected in the same way. Richards et al. (2002) used data on IQ scores and height at various ages for a large British post-war sample, and find 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, and not better education (Hiscock 2007; Lynn and Vanhanen 2002). Genetic factors play a role, but do not dominate. While results vary, studies of Scandinavian twins reason that genetic influences cannot explain the correlation between heights and cognitive ability (Magnusson, Rasmussen, and Gyllensten 2006).<sup>4</sup> Earlier studies of malnourished children and their (better fed) siblings also suggested that nutrition, in addition

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<sup>4</sup> Sunder et al.(2005) argue that height and intelligence may be jointly determined by parental genes, and argue that this accounts for approximately 30% of the observed comovement.

to parental IQ scores, is a prime determinant of cognitive performance (Craviato and deLicardie 1975).

There also appears to be little 'catch-up' in cognitive scores, except in the case of very brief shocks. Different studies have tracked the effects of a disadvantageous early environment into late middle age and beyond retirement. Abbott et al. (1998) conclude that men in their 70s show lower cognitive ability if they were shorter. Richards et al (2002) and Richards and Wadsworth (2004) conclude that the negative effects of a deprived childhood can be found in IQ scores measured at all ages up to 53. The one exception appears to be the the Dutch hunger winter in 1944-45, where retreating German forces left part of the population starving for 5-6 months. Children exposed to the famine in utero or immediately afterwards showed no systematic sign of lower cognitive development in later life, despite reductions in birth weight (Stein and Susser 1976). This suggests that for shocks to have long-term effects, they have to last for an extended period.

Cognitive ability also has a clear effect on labor market outcomes. Zax and Rees (2002) show that intelligent members of the workforce earn substantially more. Heckman (1995) also finds IQ to be one important predictor of wages. 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). In related work, Lynn and Vanhanen (2002) offer a broad-ranging survey and argue that intelligence is a prime determinant of the wealth of nations. Jones and Schneider (2006, 2007) 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.

### 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 educated 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 2007, A'Hearn, Baten and Crayen 2006).

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

$$W = 100 \frac{\sum (n_{25} + n_{30} + n_{35} \dots n_{60})}{\frac{1}{5} \sum_{i=23}^{62} n_i} \quad (1)$$

The range of ages has to be chosen so as to include the same number of ages for each 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 0 (500) implies no (only) ages ending in multiples of 5. At 100, it would imply that exactly 20% of the population report ages ending in multiples of 5 .

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<sup>5</sup> For an overview of different indicators, cf. A'Hearn, Baten, and Crayen (2006).

It could be argued that the ability to recall one's age correctly is indicative of schooling, the bureaucratization of life, and changing cultural norms rather than of cognitive development. Where it varies considerably over short periods, it is unlikely to be a result of cultural norms and administrative procedures. 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 19<sup>th</sup> 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.

#### **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 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.<sup>6</sup> 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

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<sup>6</sup> A total of 735 returns came from Southern parishes. Boyer selected the most complete ones.

income of agricultural laborers. We do not have access to all necessary 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 benefit that it allows for a more accurate calculation of Whipple indices.

The age heaping data is derived from self-reported data on ages as they emerge from the 1851 and 1881 censuses. The collection methodology in each case was similar. The aim was to collect information on all individuals who spent the night of 30 March 1851 in a particular home. Information on the age of household members was self-reported. The Census samples were taken and coded from the original returns by Michael Anderson (1987). Occupations were initially classified according to the scheme devised by Armstrong (1972). We later adapt this scheme to more modern standards.<sup>7</sup> In addition to the reported age, we use information on gender, the county of birth, and occupational information.

That age reporting was not fully accurate in the censuses has been known for some time.<sup>8</sup> The General Report for the 1891 census argued that ‘a very large proportion of persons, not improbably the greater number of adults, do not know their precise ages and only report it approximately’.<sup>9</sup> Thomson (1980) traced individuals’ self-reported ages across the 1861, 1871, and 1881 censuses. He found that for both men and women, the correct age (found by adding 10 or 20 to the earlier reported age) was only given by 38-64 percent of respondents aged 60 and over. Up to 30 percent gave answers that were wrong by more than two years.<sup>10</sup> Various other studies checked age recording between two or several 19<sup>th</sup> century British

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<sup>7</sup> They are available at <http://www.data-archive.ac.uk/>.

<sup>8</sup> Apart from the heading of the appropriate column in the household schedule which said “Age [last birthday]”, no general instruction was given to households how to report their age.

<sup>9</sup> 1891 Census, p. 27.

<sup>10</sup> We find markedly lower rates of age heaping.

censuses and found that between 52 and 65% of all men and women reported their ages consistently, while 2-11 percent were inconsistent by more than two years (Anderson 1972, Higgs 1989, Robin 1995, Tillot 1972). Adjustments, on the whole, were as likely to be up as down, suggesting that genuine mistakes – and not a desire to appear older or younger – were to blame. As late as 1951, only 94 percent of men and 64 percent of women reported their ages correctly.<sup>11</sup>

We use the snapshot data from the 1851 and 1881 censuses to compile information on age heaping by birth decade. Our earliest birth decade is the 1780s; the latest, 1850. In order to include a sensible number of multiples of five, we use the period 1779-1788 for the 1780s, 1789-1798 for the 1790s, etc. Whipple indices range from 85 (indicating underreporting of ages ending in a multiple of five) to 175.3, with an average of 117. These scores indicate that the Englishmen in our sample are not from a population with particularly low literacy, by historical standards. On average, about 4-8 percent of respondents misreported their age.

Age heaping in the 1851 and 1881 census varied considerably between the different counties in our sample. Figure 1 shows the differences in age heaping between the average Whipple by individual county, over the entire sample period 1780-1850. 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 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' ability to remember their age correctly.<sup>12</sup> If age alone leads to a deterioration of numeracy, we should find that, say, the 60-year-olds in the 1881 sample have

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<sup>11</sup> 1951 Census, p. 36.

<sup>12</sup> In the main empirical section, we will use a fixed-effects approach to bypass some of the underlying difficulties.

higher Whipple scores than the 30-year-olds in the 1851 sample. Table 1 shows Whipple scores for the same birth cohorts 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. In particular, the larger differences between the two datasets indicate lower age heaping in the later sample, when respondents were older. If anything, greater age should have made it more difficult for people to recall their ages. We conclude that here is no simple mapping from age to age heaping, and that the use of the 1881 census for our purposes is unproblematic.

The grain price data was collected by Liam Brunt and Edmund Cannon from contemporary prize gazettes.<sup>13</sup> Acts of Parliament ordered the collection of grain price data during the period 1770 to 1863.<sup>14</sup> In most years, between 140 and 290 towns reported prices. While information on a number of different grains was recorded, we focus on the price of wheat. It was the main staple of eighteenth and nineteenth century British diets. As Figure 2 illustrates, wheat flour alone accounted for 27% of working class expenditure on food.<sup>15</sup> 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.

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

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<sup>13</sup> 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).

<sup>14</sup> 10 George III, 31 George III, 1 and 2 George IV, 9 George IV, and 5 Victoria

<sup>15</sup> The figure is from Voth 2003, and is based on data from Feinstein 1998.

been in the 1780s. It was the pressure produced by these food prices that inspired Frederic Eden and David Davies to undertake their surveys of working class families on which the budget data cited earlier is based.<sup>16</sup>

Economic historians do not agree on the factors responsible for the price surges apparent in Figure 3. Britain had become a net food importer in the 1760s. In years with poor harvests, her import needs were substantial. Mancur Olson (1963) described “food...as the weakest link in Britain’s chain of defense”. The Revolutionary and Napoleonic Wars limited the extent to which domestic misharvests could be mitigated by grain from abroad. Insurance rates for shipping to the Baltic were high throughout the war (possibly three times their post-war level), as both sides used privateering to destroy the merchant fleet of their adversary (Jacks 2007; Mokyr and Savin 1976). In a bid to hurt the island’s trade, the Berlin decree of 1806 instituted the Continental System, denying European ports to British ships. Neutral shipping was also severely curtailed. The system was at its peak in the years 1807-12. While the French supplied Britain with grain in 1810, they did so while charging export licensing fees that more than quadrupled the price of grain at source (Jacks 2007).<sup>17</sup> In some years, when price differences were greatest, imports continued to flow into Britain, even from direct military adversaries. However, transactions costs inevitable rose, limiting the extent to which domestic weather shocks could be arbitrated away. Bread riots in 1795, 1800, and 1812 reflect the extent to which the precarious food situation put pressure on vulnerable groups in English society.

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<sup>16</sup> Data in Horrell (1996) show 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.

<sup>17</sup> According to some estimates, the UK imported around 15% of its total food in 1810 (Jacks 2007).

Table 2 contains the data descriptives for our key variables. Since our unit of analysis is birth decade, county, and gender, half of our sample by definition is female. Relief payments vary widely between parishes (Figure 4). Grain prices fluctuate over time and across localities (Figure 3). Grain-growing areas make up 12 percent of our sample. Within our sample, we define crisis years as those that have grain prices above 110 (Figure 5).

## **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. We show that the exogenous component of grain price changes, as driven by weather shocks, was an important determinant of numeracy. Finally, we examine issues of endogeneity, present evidence on the effect that nutrition-related shocks had for labor market outcomes, and discuss some caveats.

The first question concerns the link between nutrition, cognitive ability and numeracy. While the influence of nutrition on cognitive ability appears well-established, the connection between age-heaping 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. In the appendix, we show that in modern data, greater heaping is associated with lower cognitive scores. 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 Table 3, we present data from the US, France, Ireland, and the UK, from the 1660s 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– the difference is small. In other cases, 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. In his analysis of nineteenth century Bavaria conscripts, Schuster (2005) finds that with the shortest also had unusual high rates of incidence for exceptionally low intelligence. 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 4 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 suggest that numeracy declines less after the outbreak of a crisis in those counties that treated their poor generously. Figure 6 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 5 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 employs a continuous 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 7 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 coefficients 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 5 suffers from one important drawback – possible bias from unobserved heterogeneity. To address the issue, we employ panel estimation:

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

where  $W_{i,t}$  is the Whipple index 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 6. 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).

### *Endogeneity*

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 use 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 6), the coefficient on grain prices becomes larger, increasing from 0.1 to 0.16. However, it 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.

### *The Skill Requirements of Occupations*

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 9 plots the intelligence requirement scores of jobs held, according 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.<sup>18</sup> These effects are relatively small. This may reflect the highly aggregated nature of our data.

Nonetheless, the life histories of some groups in the low- and high-relief parishes were very different. We contrast the relative frequency of agricultural and farm laborers who have a relatively low intelligence requirements with the relative frequency of carpenters, who have a relatively high one.<sup>19</sup> As can be seen in Figure 17, a declining share of individuals born in high-relief counties sorted into the low-requirement jobs such as agricultural and farm laborers, between 1780 and 1800. In counties with low poor relief, the opposite occurred. At the same time, in these counties, the share of people completing carpenter apprenticeships

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<sup>18</sup> The regression underlying this estimate is a fixed-effects panel. The t-statistic on grain prices is 1.53, significant at the 13% level.

<sup>19</sup> In the DOT classification, lower intelligence requirements translate into higher numbers. Agricultural and farm laborers are the largest group with a relatively low intelligence score (3.44), while carpenters are the largest group with an intelligence score below 3. We deliberately abstract from professional occupations, since joining them did not only depend on cognitive ability.

increased by a third between 1790 to 1800 in high relief counties; it drops from 16% in counties with low poor relief standards.

*Caveats*

Our analysis assumes that wheat prices are a good proxy for the general price of food. Yet alternative sources of calories were clearly available. Those suffering from high grain prices could have substituted away from relatively dear sources of calories, thus mitigating the impact of dear wheat. A more comprehensive measure of the price of food should also capture that cheaper substitutes such as potatoes. In crisis years, their price also rose dramatically. While wheat prices increased drastically between 1798 and 1800 by 73%, substitution possibilities were limited. Rye prices also increased by 55%, and potato prices were even more volatile, rising by 78 percent. The magnitude of price changes was similar in 1812. When wheat prices increased by 34%, potato prices shot up by 81 percent (compared to the non-crisis level in 1806). In general, the correlation between wheat and potato prices in the difficult period between 1793 and 1817 was 0.57. In short, while many clearly tried to avoid hunger in its most extreme form, by switching from wheat bread to potatoes, this was simply not possible in general equilibrium for everyone. Rapid price increases of foodstuffs least favored meant that the quality and quantity of the diet overall still declined markedly in crisis years. Crucially, little or no money would have been left to purchase food rich in proteins, such as meat, fish, eggs and milk. Since the effect of nutrition on cognitive development probably depends on protein availability, this must have biased downwards the chances for infants to develop their full potential.

The decline in numeracy is concentrated during the Revolutionary and Napoleonic wars. Britain fought a war that required unprecedented military, fiscal, and economic mobilization (Brewer 1990). Alternative mechanisms could have contributed to the rise in age heaping. Wartime dislocation brought about by the absence of fathers could have

led to family instability. Passing on information about the age of children might have been disrupted by large-scale mobilization. We consider this unlikely, for a number of reasons. First, since Britain was still fighting the American War of Independence until 1783, and the Fourth Anglo-Dutch War until 1784, establishment size was not that much smaller in the baseline period of the 1780s compared to the 1790s and 1800s. The actual date range for the decade is 1779-1788, comprising five war years (1779-83). Second, the single best indicator for family instability – illegitimacy rates – showed only a small uptick, increasing from 4.6 percent in 1750-74, 5.9 percent in 1775-1799 and to 6.2 percent in 1800-24 (Wrigley et al. 1997). Even if all of the additional 33,000 illegitimate births could be attributed to the effects of the wars, this would pale in comparison with the total rise in misreporting.<sup>20</sup> Third, the army and Royal Navy did not satisfy their demand for manpower by recruiting bachelors who would otherwise have gone on to found stable families. As George Chalmers (1812) put it, in Britain, “the sword had not been put into *useful* hands.” Press gangs routinely rounded up vagrants and other unproductive elements. Impressment was limited to ‘such able-bodied men as had not any lawful calling or employment’.<sup>21</sup> Also, many men in the armed forces – officers and privates alike – joined in their teens. Average age at marriage in England in 1800 was 25 for men (Wrigley et al. 1997). This means that probably less than half of the men in the armed forces would have been of an age when they would have married onshore – and many did regardless of their profession. Finally, the numbers for total enlistment include foreigners recruited into the British army. The British army in 1813, for example, consisted of up 203,000 British troops and 53,000 foreign ones (Smith 1998; Hall 1992). In earlier years,

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<sup>20</sup> ? Average whipple scores increased by 15 points in our sample between the two periods. This corresponds to 8.1 percent of Englishmen born in the period, and surviving to 1851 or 1881, misreporting their age – an additional 3.7 percent compared with those born 1779-1789. In a population of 21 million, this implies 777,000 extra cases of misremembered information on age.

<sup>21</sup> Cit. acc. to Brewer 1990, p. 49-50.

the proportion foreign was smaller. The larger their role, the more negative effects on family stability were mitigated.

Our results establish a priori that the availability of adequate nutrition was important for numeracy, and that Poor Law provisions helped the most vulnerable parts of the country fight the effects of high grain prices. Nonetheless, we cannot rule out that other factors – to the extent that they are correlated with the generosity of poor relief – were responsible for our results in the cross section. There is no direct evidence on the prosperity of individual counties. The validity of our results hence rests on the plausibility of the mechanism we describe, with no possibility of controlling for other variables that might also have provided a ‘safety cushion’ for the poor.

Access to schooling may have suffered during the Napoleonic wars. Educating children is an investment. If general economic conditions deteriorated during the war, a decline in schooling – rather than a decline in nutritional standards – could be responsible for the lower numeracy attained during these decades. However, information on trends in basic literacy – as proxied by the ability to sign one’s name – do not support this alternative interpretation. Schofield (1973) found that illiteracy rates for men and women thus measured were broadly stable or gradually declining between 1750 and 1840. The general view is that the acquisition of basic skills in England took place outside day schools before the 1870s (Mitch 1992). There is no evidence of a sudden fall in signature rates during the Napoleonic wars. Nicholas and Nicholas (1992) examine convict data, and find that illiteracy by the end of the wars was lower than it was at its outbreak.<sup>22</sup> To the extent that the ability to sign one’s name is a more basic skill than remembering one’s age, it could be argued that our findings

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<sup>22</sup> Subsequently, they document an increase. Their data may suffer from greater problems of representativeness and small sample bias than Schofield’s.

suggest that only the performance of more complex tasks suffered. Alternatively, it could be argued that schooling continued unabated, but that the ability to acquire more advanced skills was limited in many cases. There is no evidence to suggest that a sudden collapse in school attendance could be responsible for our results.

Our empirical analysis uses data on grain prices at the county level. Since the UK had a highly integrated market for grain, it may be doubtful how much information can be contained in county-level differences of grain prices. Adam Smith famously observed that “the prices of bread and butchers’ meat are generally the same, or very roughly the same throughout the greater part of the United Kingdom” (1976, p. 177). To the extent that the definition or composition of grains in each county differed, inducing county-specific differences in prices, our fixed effects estimation should solve the problem.<sup>23</sup> Over time, even in a highly integrated market, price differences should capture differences in scarcity. This is because transport costs were anything but negligible. Areas with a surplus in one period may have become net importers in the next. Market integration implies that no arbitrage opportunities remained, taking transport costs into account, not that prices should have been uniform throughout Britain. Jacks (2007) finds a peak of commodity price dispersion during the Napoleonic Wars, possibly as a result of disruptions to coastal shipping driven in part by privateering.<sup>24</sup>

## **VII. Conclusions**

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

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<sup>23</sup> For example, it is possible that the definition of ‘good’ wheat might differ from county to county.

<sup>24</sup> Cf. Fig. 2, Jacks 2007.

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. In others, the costs of imports were high. Prices for wheat and other staples surged. Market integration within Britain declined as privateers preyed on coastal shipping. We examine the impact of these exogenous shocks to food availability, and show that it lowered average numeracy throughout the country. Subjects 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 factor limiting output in the past. While we offer no 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. Flynn (1984) has shown that cognitive scores underlying IQ tests have been rising for several decades in the 20<sup>th</sup> century. Between 1930 and 1900, average cognitive ability scores rose by the equivalent of 0.6 IQ points per year (Hiscock 2007). The benefits of higher cognitive scores in the labor market today are hard to dispute (Case and Paxson 2006). If cognitive ability was in part 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. This would offer an alternative to Greg Clark’s (2007) recent suggestion that it was inappropriate cultural norms in the European past – and around the globe today – that constrained output. The cause of lower productivity may well have been “within” economic agents, but it may not be culture and socialization that is harming output, but low cognition as a result of poor nutrition.

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## Tables

**Table 1: Whipple scores, by birth decade, census date, and gender**

	birth decade	census 1851	census 1881	difference
males	1810	118.56	112.61	-5.95
	1820	113.74	116.19	2.46
females	1810	123.74	114.54	-9.19
	1820	116.55	116.84	0.30

**Table 2: 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	1
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 3: Stature and Whipple Ratios**

Country/Region	Birth Decade	Average Height		Ratio Height	Whipple Index		Ratio Whipple
		Short	Tall		Short	Tall	
England	1800-1840	62.66	67.11	0.93	133	129	1.03
Ireland	1790-1810	63.65	67.70	0.94	160	131	1.22
US	1800-1830	65.75	69.81	0.94	124	114	1.09
France -Paris	1660-1760	61.80	63.98	0.97	141	102	1.38
France -northeast	1660-1760	61.64	64.17	0.96	125	117	1.07
France -southwest	1660-1760	61.43	63.98	0.96	142	125	1.14
France-total	1660-1760	61.52	64.08	0.96	135	123	1.10

**Table 4: Conditional Means (Medians) of Whipple Index**

Relief	Low	High	Difference
Crisis			
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 5: Regression Analysis: Whipple Scores and Grain Prices**

Dependent variable: Whipple Score

Sample Eq.	Relief payment				
	all 1	all 2	< median 3	≥ median 4	5
Grain price	0.092 (2.1)	0.094 (2.34)	0.147 (2.4)	0.042 (0.67)	0.08 (2.3)
Female	0.73 (0.4)	0.73 (0.4)	-0.34 (2.69)	1.88 (0.66)	0.73 (0.4)
Relief high		-4.1 (2.1)			
Relief lack*					0.37 (1.9)
C	109.25 (23.4)	110.96 (25.9)	106.21 (16.5)	111.64 (16.8)	106.2 (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 6: Fixed Effects Panel Estimation**

	Eq.	1	2	3	4	5
Estimation		OLS	OLS	IV	OLS	IV
Gprice		0.1 (2.4)				
Crisis <sup>+</sup>			4.4 (2.4)			
Gprice-instrum				0.29 (3.4)		
Gprice*[R <sub>max</sub> -R <sub>i</sub> ]					0.01 (2.56)	
Gprice*[R <sub>max</sub> -R <sub>i</sub> ] - instrum						0.029 (3.34)
Female		0.73 (0.4)	0.73 (0.4)	0.73 (0.37)	0.73 (0.38)	0.73 (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<sup>+</sup> is a dummy variable equal to unity if grain prices are above 110, and zero otherwise.

Figures

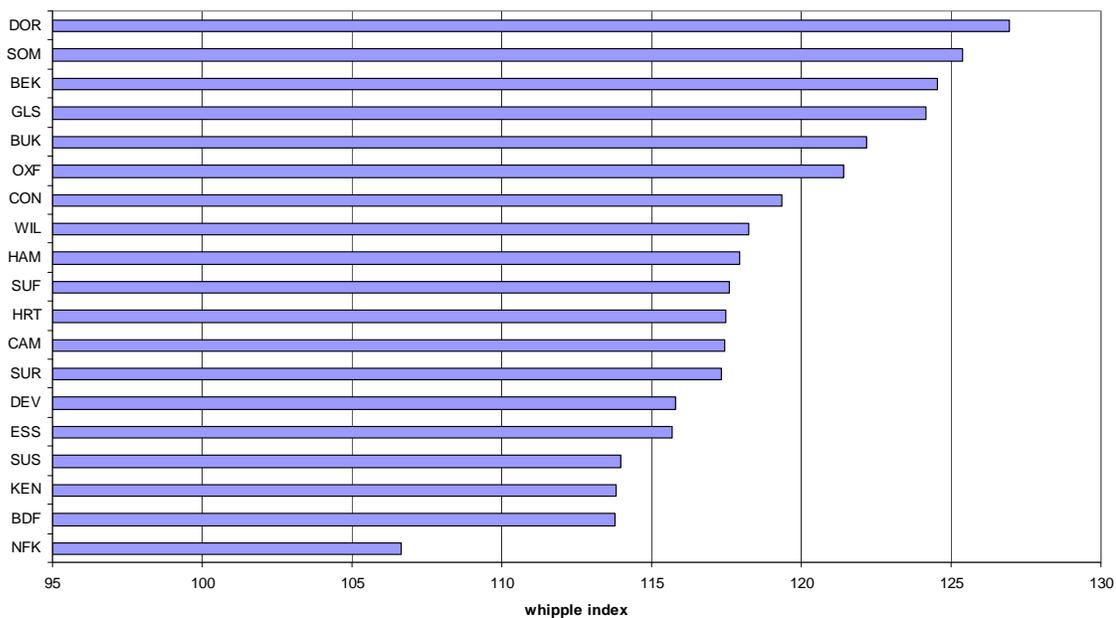


Figure 1: Whipple Indices by County

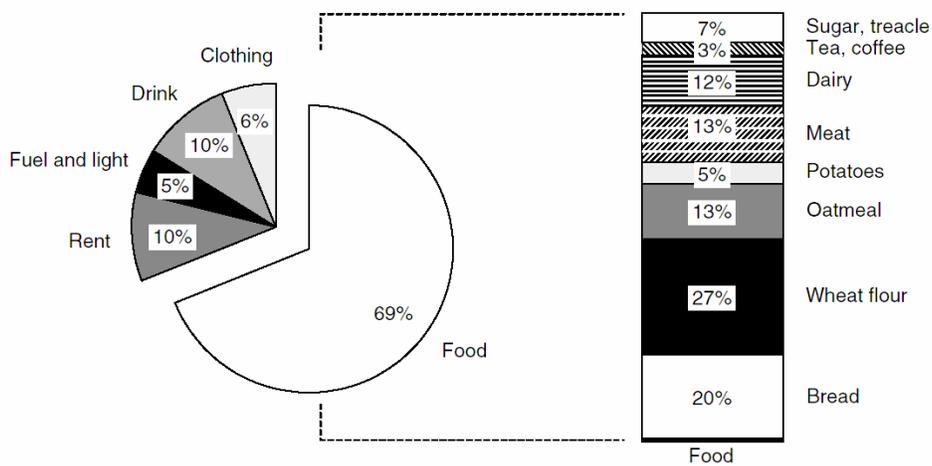
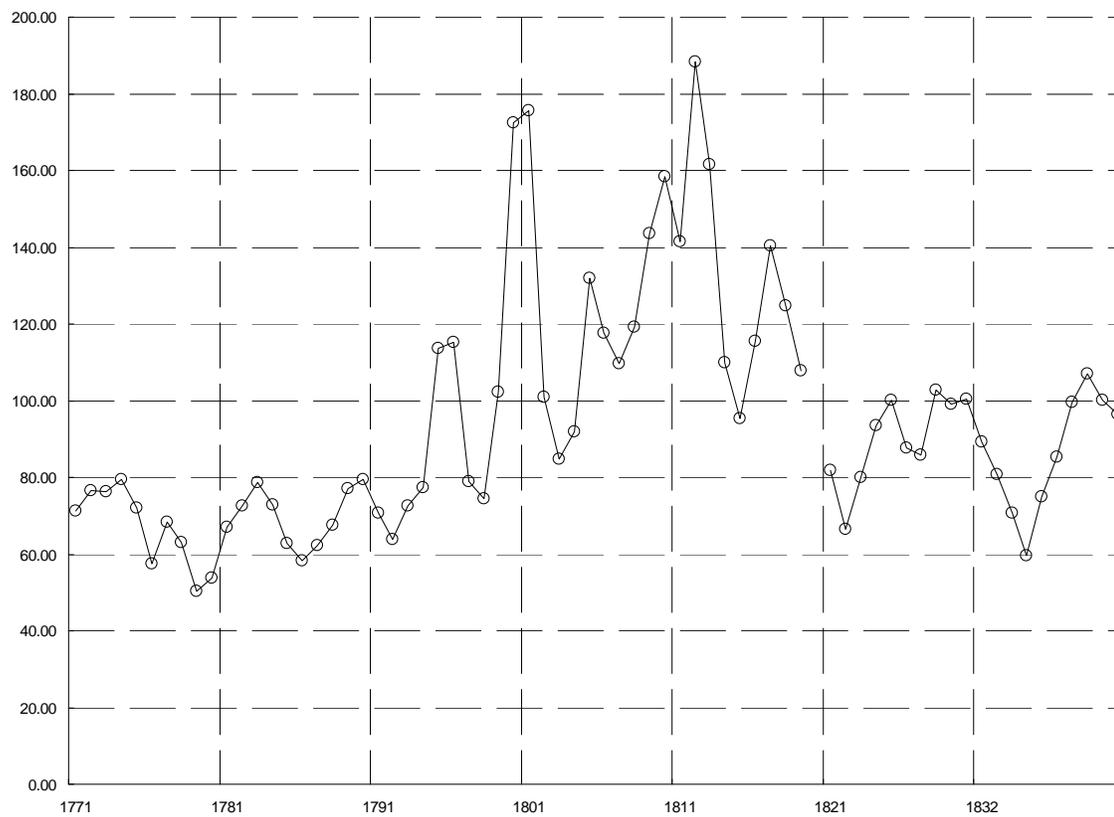
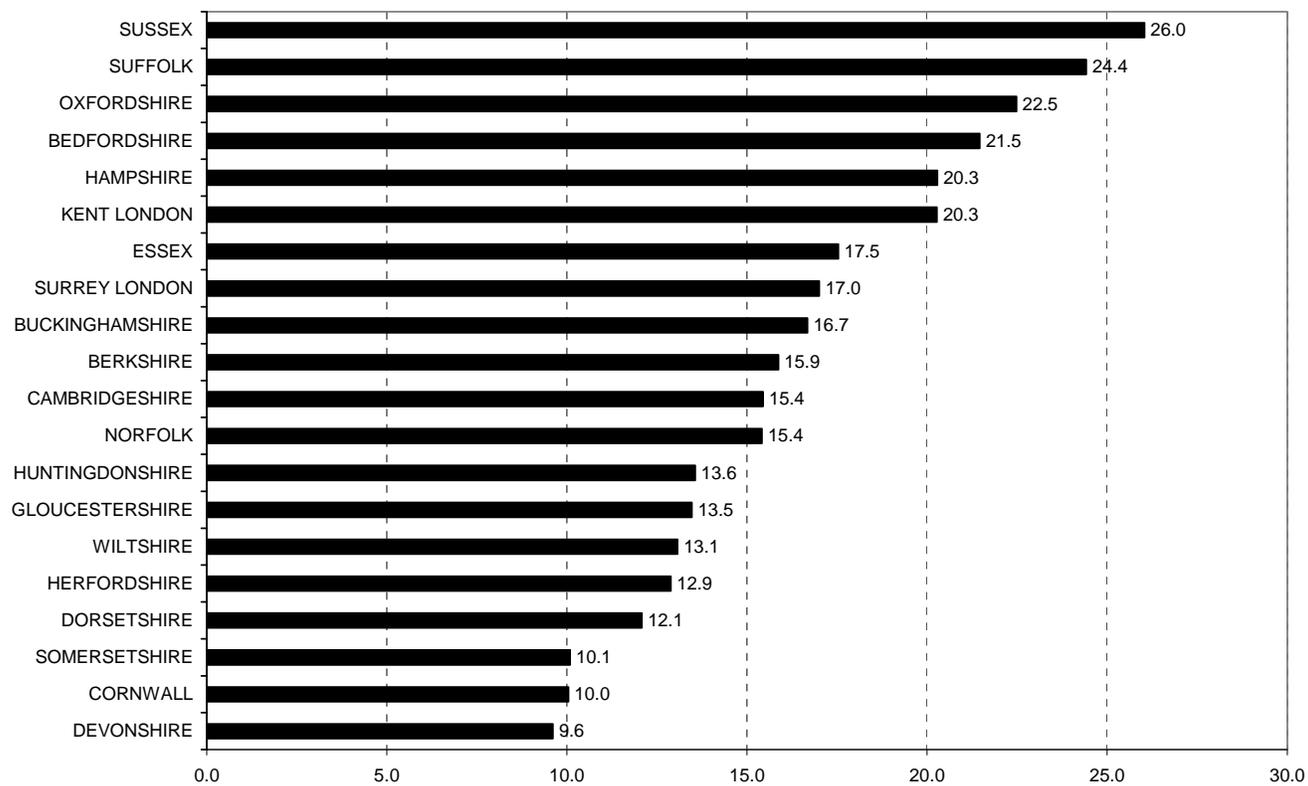


Figure 2: Composition of Working Class Expenditure, 1788-92

Source: Voth (2003)



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



**Figure 4: Poor relief per capita, in shilling**

Source: Boyer 1990.

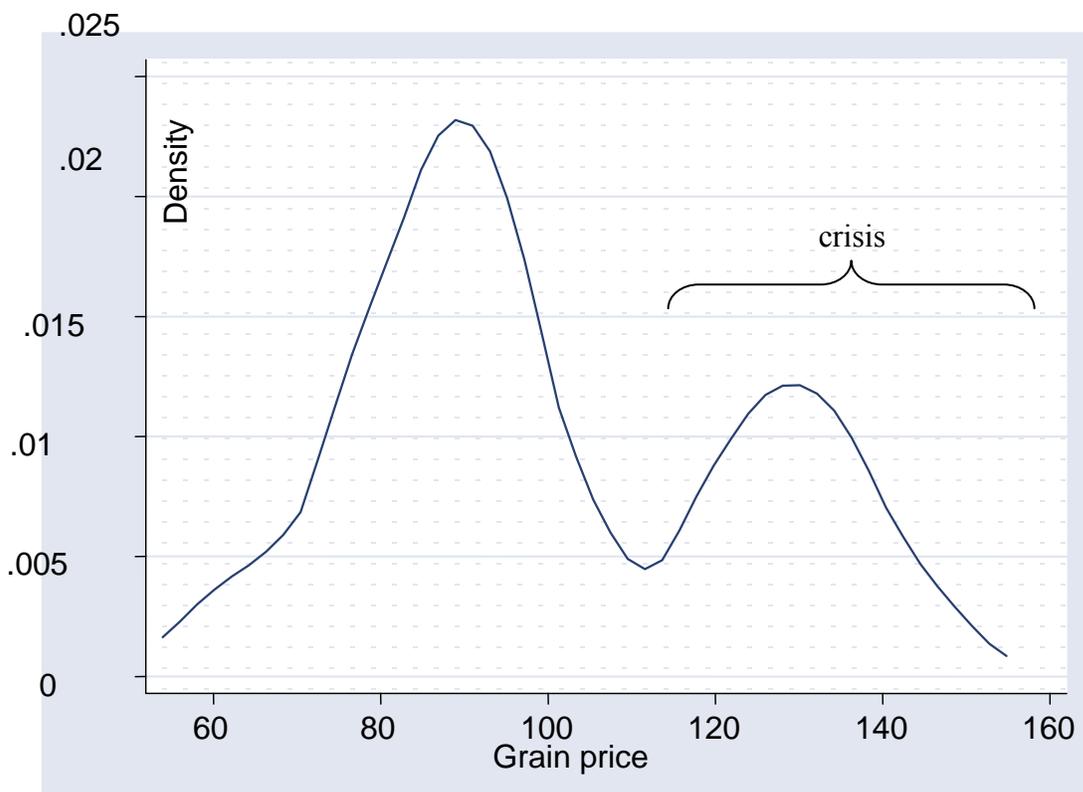
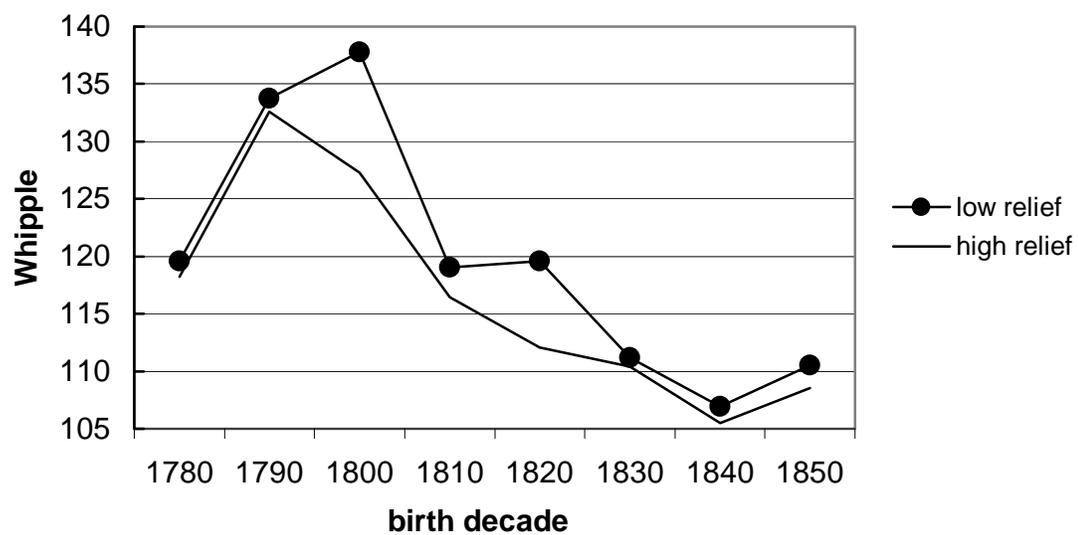
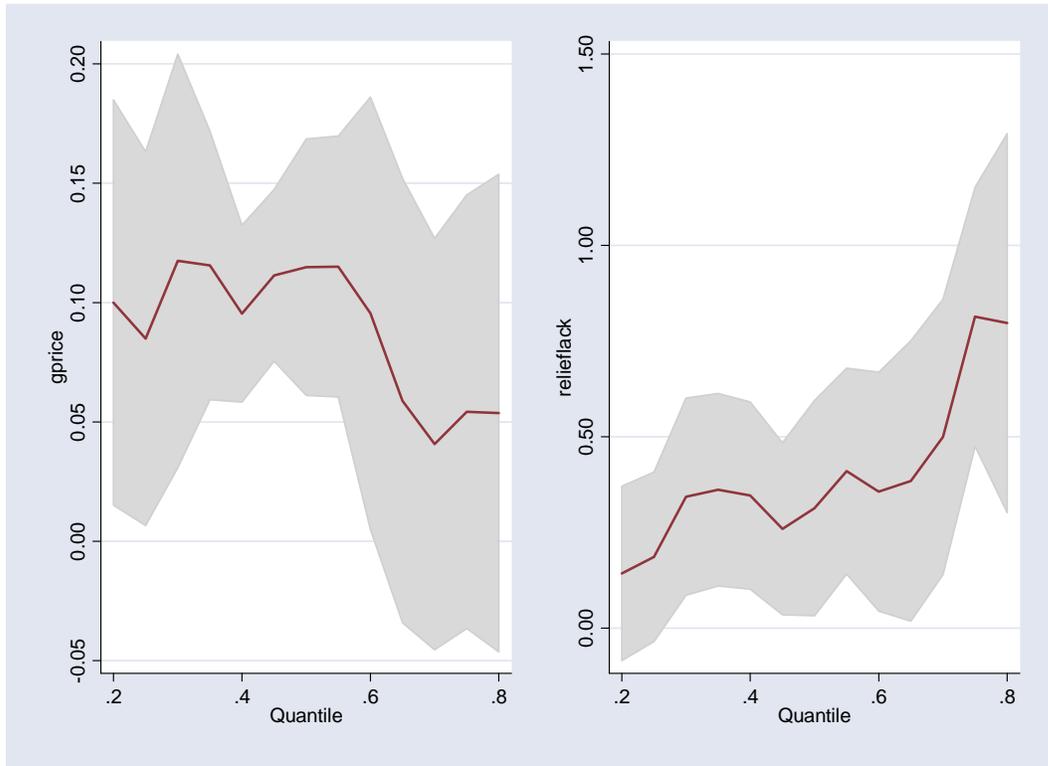


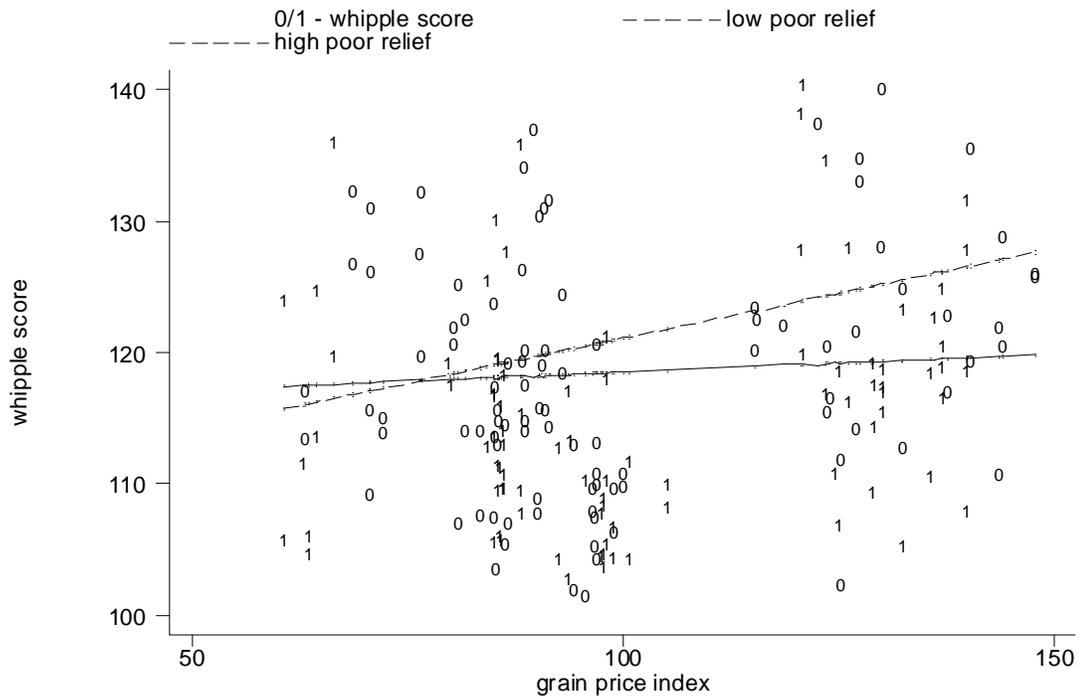
Figure 5: Kernel density estimate of grain prices

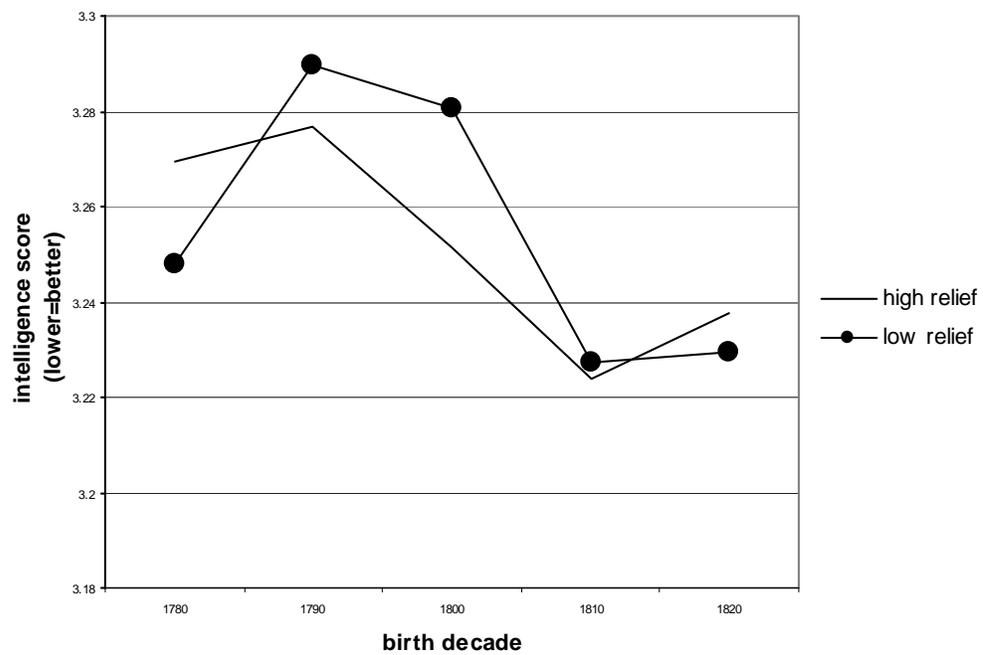


**Figure 6: Whipple Indices over Time, by Generosity of Poor Relief**



**Figure 7: Quantile regression plots, 90% confidence interval**



**Figure 8: Whipple scores and grain prices****Figure 9: Intelligence scores by birth decade**

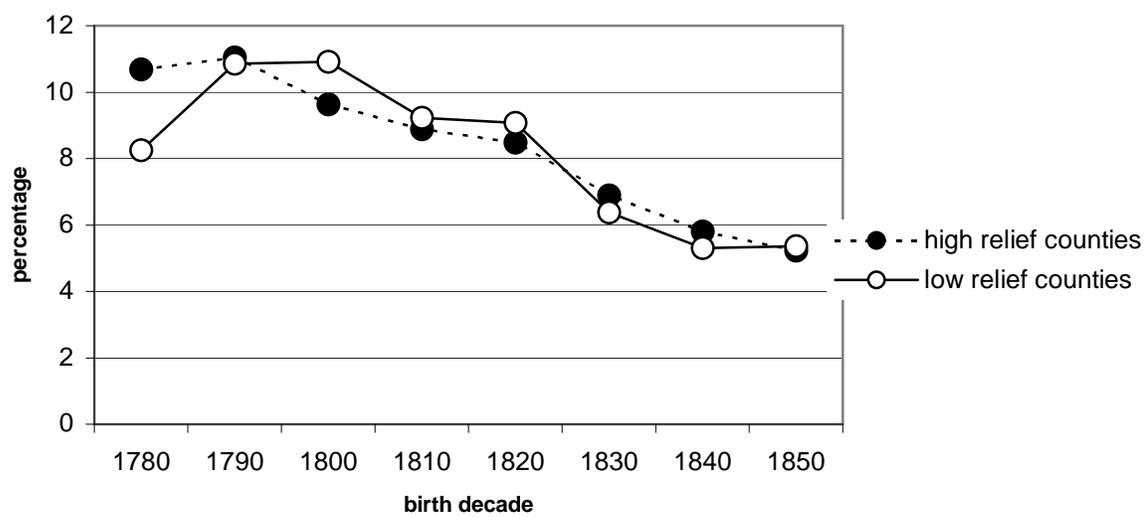


Figure 17: Share of agricultural and farm laborers in all occupations

## Appendix

One crucial assumption underlying our work is that heaping of reported ages is a good proxy for cognitive ability. To test this assumption, we used the 1993 Assets and Health Dynamics Among the Oldest Old (AHEAD) dataset from the Health and Retirement Survey. This contains information on the individual, health, cognitive, and income characteristics of the American elderly. In total, 8222 returns from individuals are available.

There are numerous measures of cognitive ability in the AHEAD survey. One indicator involves asking individuals to count backwards from 100 in steps of 7. This is used as an overall indicator of numerical ability. There are also questions involving word recall (number of words remembered correctly, of a list of 10) and the current day, month, and year. We use all of these as measures of cognitive ability.

Age in the AHEAD survey is not self-reported. However, individuals are questioned about the age of death of their parents. This is not exactly the same as the information we would ideally like to use (self-reported age), but it is similar to measures of age-heaping used in the literature (such as the age given on Roman tombstones, etc.). We find that in a sample of 7317 respondents reporting the age of their father, 2073 provide an answer that is a multiple of five. In a truly random sample, we should expect no more than 1463 responses naming a multiple of five. This corresponds to a Whipple index of 142.

If age heaping are indicators of cognitive (and numerical) ability, we should expect that the HRS measures of are correlated with reported ages of death of the father at multiples of five. As Table A1 shows, those *not* reporting the age of their father as a multiple of five were more likely to remember a large number of words correctly, to know the current year, and to perform a series of subtraction exercises without error.

Table A1: Heaping in reported ages and cognitive ability

Dependent variable	Number of words remembered correctly	Current year correctly remembered	Number of subtractions correct
<u>Panel A:</u>			
Age of father's death NOT reported as multiple of 5	0.025 (1.96)	0.10 (1.79)	0.044 (2.5)
Estimator	Poisson	Probit	Poisson
(Pseudo)-R <sup>2</sup>	0.0001	0.0011	0.0003
N	7163	7363	7382
<u>Panel B:</u>			
Age of neither parent's death reported as multiple of 5	0.055 (2.71)	0.34 (4.3)	0.11 (3.4)
Estimator	Poisson	Probit	Poisson
(Pseudo)-R <sup>2</sup>	0.03	0.006	0.0005
N			

The vast majority of those reporting the age of their father's death as a multiple of five will remember the right age. To demonstrate the power of age-heaping, we also constructed a second variable that takes the value of 0 if only one or none of the ages of the parent's death are reported as a multiple of five, and 1 otherwise. In our sample, if age of death was random, only 329 individuals should be reporting both parents having died at an age that is a multiple of five. In actual fact, 655 reported that this was the case, suggesting that the rate of mistakes is particularly high. Reporting age of death twice as a multiple of five is the explanatory variable in Panel B of Table A1. As expected, the size and significance of the coefficient rises markedly compared to Panel A, where we only used the age of the father's death. These results establish a strong prior that age-heaping in historical data is related to cognitive ability.