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Low income and early cognitive development in the U.K.

A Report for the Sutton Trust
By Jane Waldfogel and Elizabeth Washbrook

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1. Policy background

Raising the educational performance of children born into low-income families has been a key priority of the Labour government since 1997, and looks set to remain a priority following next year's General Election. The three main political parties in the UK all recognise this as a key issue for public policy. This shared commitment reflects a fundamental belief in equality of opportunity – the idea that circumstances at birth should not determine an individual's success in life. It is further motivated by the concern that the unfulfilled potential of those from disadvantaged backgrounds imposes a burden on economic productivity and state expenditures (The Strategy Unit, Cabinet Office 2008).

It is well known that parental income in childhood is a stronger predictor of an individual's later life outcomes in the UK than in most other developed countries (Blanden, Gregg and Machin 2005). It is likely that this strong association between parental income and child outcomes results from the accumulation of disadvantage (or advantage) over the course of an individual's lifetime: from endowments inherited at birth to experiences in the family through schooling and educational achievement in childhood and the teenage years, on to employment and financial success in the labour market in adulthood (Blanden, Gregg and Macmillan 2007).

The development of cognitive and psychosocial abilities among disadvantaged children in the early childhood period has received attention for several reasons. Numerous studies have documented that low-income children perform more poorly than better off children on a variety of tests as young as age 2 (Duncan and Brooks-Gunn 1997; Feinstein 2003). And these early test score gaps are quantitatively large when compared with ultimate differences in educational achievement and earnings (Jencks and Phillips, 1998). Neuroscientists have argued for the existence of 'sensitive' and 'critical' periods in the development of brain function, such that early insults to development may be difficult or impossible to reverse at later ages (Shonkoff and Phillips, 2000). This literature has been taken up by economists such as Nobel Laureate James Heckman, who argue that interventions targeted early in life are potentially much more cost-effective than interventions targeted to under-performing adolescents or adults (Heckman and Masterov 2007; Carneiro and Heckman 2003). Finally, there is rigorous evidence from randomised controlled trials

that early intervention programmes can have beneficial effects on the outcomes of disadvantaged children that extend into adulthood (Karoly et al. 1998; 2005; Carneiro and Heckman 2003).

The Labour government's policy around early childhood disadvantage has followed two lines of attack. The first has focused on tackling poverty itself, that is, by raising the incomes of the poorest parents via a massive programme of tax credits, employment-promotion schemes and unconditional cash transfers. The government has achieved success in this regard with, for example, absolute poverty rates (i.e. the proportion of children in families below some fixed level of income) falling from 26% to 13% between 1998/99 and 2007/08 (Waldfogel, in press). There is evidence that these income transfers have increased spending in low-income families in ways likely to benefit children: on children's clothes, toys and books and fruit and vegetables, as well as on cars, holidays and leisure activities that broaden the horizons of the whole family (Gregg, Waldfogel and Washbrook 2006).

The second line of attack has focused on improving the environments and experiences of low-income children directly, rather than simply relying on the effects of higher parental incomes. Sure Start centres providing an integrated range of services for young children were established in the most disadvantaged areas, and after some teething troubles, there is now evidence that these have been effective in improving a range of child and family outcomes (NESS, 2008; Waldfogel, in press). Universal free half-day nursery places for 3- and 4-year olds ensure that cost is no longer a barrier to the receipt of preschool education.

Despite these successes, the developmental outcomes of low-income children continue to lag behind those of better off children at the time of entry to the school system. The evidence on the potential gains to narrowing this gap for, for example, inequalities in final educational attainment suggests that more should be done in this area. And given the constraints on government spending following the global financial crisis, it is crucial to identify the types of interventions and programmes that will narrow the gaps most effectively.

2. Contribution of this study

Determining the optimal early childhood policy is no easy matter. Low-income children live in environments that potentially hinder their development in a host of different ways: in terms of cognitive stimulation, for example, emotional and social support, and material deprivation. When considering an intervention that targets one particular aspect of the environment, three questions must be asked.

The first is whether the behaviour or factor in question is related to successful development. Low-income children watch more television than the better off, for example, but if television watching is not associated with poorer learning and development, then a policy to discourage it will do nothing to narrow the gaps.

If a factor is related to development, the second question is whether altering the behaviour or factor in question will cause an improvement in developmental outcomes. Clearly if television is not associated with children's outcomes then it is unlikely that limiting television watching will have the desired effect. But even if children who watch a lot of television do perform more poorly, it does not prove that changing the former will affect the latter. Television watching might be correlated with poorer development because of some third factor, rather than because of a direct causal relationship between the two.

If a factor is related to development and that link appears to be causal, the third question is whether policy can effectively change the behaviour or factor in question. Even if television does causally affect children's development, policies to discourage it may be difficult or prohibitively expensive. It may be more cost-effective to target money to behaviours that are less consequential for developmental outcomes but that can be manipulated more easily.

No single study or type of evidence can hope to answer all three questions simultaneously. Indeed, evidence from sources as diverse as statistical analysis, qualitative interviews, programme evaluations, medical and scientific research and practitioners' expertise all have a role to play and should be seen as complementary.

The second and third questions, which concern the nature of the causal relationships between specific interventions, behaviours and developmental outcomes are best tackled with randomized controlled studies. By simulating a controlled laboratory experiment, in which the only factor that differs systematically between

children is the policy with which they are 'treated', the causal effects of the treatment on behaviour and on outcomes can be isolated. This study does not address issues of causality. The evidence accumulated from evaluations of this type is reviewed in Waldfogel and Washbrook (2008) and Karoly et al. (1998 and 2005).

A drawback to rigorous randomized controlled studies, however, is their relatively limited focus. By their nature, they are constrained to establish the effects only of the specific intervention – such as a particular home visiting programme - under consideration. The aim of this study is to address the first question posed above by providing a context against which the importance of more narrowly-focused studies can be understood. We aim to provide a descriptive overview of what low income means in early childhood in Britain today, and give a sense of which aspects of the lives of poor children matter most in predicting their cognitive deficits.

It is important to note that we examine only the relationship between poverty and children's *cognitive* development in this study. Psychosocial development and health are also important determinants of adult social and economic success, particularly when the scope is widened beyond income to consider outcomes like childbearing, divorce, criminal activity, morbidity and mortality. There is evidence that low-income children also fall behind better off peers along these dimensions, and that the factors that are particularly consequential for development in these areas are somewhat different to those that affect cognitive ability. (For example, maternal depression is very strongly linked with children's behaviour problems, but only weakly with cognitive test performance; see Gregg, Propper and Washbrook 2008.) However, it is well known that early cognitive ability is a strong predictor of final educational attainment (Galindo-Rueda and Vignoles 2005), and that inequality in early cognitive outcomes tends to be much greater than in either psychosocial or health outcomes (Waldfogel and Washbrook 2008; Gregg et al. 2008).

One caveat is that our attempt to explain income-related gaps in early childhood cognitive outcomes focuses mainly on the role and behaviour of mothers. This should not be taken to imply that the role of fathers does not matter. As a practical matter, although some information on fathers is available, it is generally much less detailed and partial compared with the information on mothers. Moreover, while our aim is to build a representative picture of income-related differences in early childhood, by the age of 5 23% of children (and 65% of the poorest children) no

longer live with a biological father. Taking the role of fathers more fully into consideration would require separate analyses of single-parent and two-parent families, complicating the analysis and raising questions of comparability between the two sets of findings.

3. Data

Our study makes use of detailed data from the Millennium Cohort Survey (MCS) on a nationally representative sample of 12,644 British children who have been followed since birth and are 5 years old in 2006 and 2007. We explore the relationship between low income (defined as the poorest 20 percent by family income), a child's scores on three cognitive tests at age 5, and a wide range of factors that are potentially consequential for children's development.

We frame our analysis mainly in terms of low- to middle-income gaps, defined as the gap in average outcomes between the poorest 20 percent of children (the bottom income quintile) and the middle 20 percent of children (the middle income quintile). We use the experiences and development of middle income children as a benchmark, as this seems an appropriate target population against which to consider the lowest income families. However, we also provide some information relating to the gap in outcomes between middle income children and the richest 20 percent.

The three child assessments are taken from the British Ability Scales, and are designed to capture different dimensions of cognitive development. (The correlations between the measures are all roughly 0.33.) To focus our discussion, our primary results relate to children's scores on the verbal Naming Vocabulary test because it is on this scale that we find the largest income-related test score gaps. However, we do provide some discussion of how our conclusions differ when we examine tests of nonverbal ability (the Picture Similarities and Pattern Construction tests).

Our interest is explicitly policy-focused. We consider four domains of explanatory factors that have been put forward as relevant for child development and that are or could be the object of policy interventions: parenting and the home environment; material circumstances; maternal and child health; and maternal employment and child care. We contrast the role of each grouping in explaining the low- to middle-income test score gap, and explore in more detail those items within each group that have the greatest predictive power.

4. Conceptual framework

Conceptually we view these four domains of intervening factors as 'proximal', distinct from 'distal' demographic characteristics like ethnicity, parental age and parental education. The proximal/distal distinction is taken from developmental psychology, and captures the notion that the strongest determinants of children's development are the processes and interactions that children experience directly. Distal characteristics such as family income and parental education impact on children only in so far as they shape these proximal processes. If it were possible to measure and account for all proximal influences then, by definition, there should be no remaining association between distal characteristics and the child outcome.

Proximal processes are the factors of interest because they are the direct causes of developmental outcomes, and as such are the mechanisms through which policies that impact on distal factors operate (such as promoting delayed fertility or raising family income). This focus reflects a growing sense that it is likely to be more effective and less costly to target the drivers of children's development directly, rather than relying on more broad-based policies that may or may not end up benefiting children.

Ideally we would like to explain all of the observed income-related test score gaps in terms of measures of proximal processes. Even with the rich MCS data to hand, however, there will be a multitude of factors that we cannot observe or measure. Since many of these will be correlated with factors like parental age and education, we hold constant a set of distal variables when constructing our estimates. According to our conceptual framework, any remaining association between these variables and the outcome reflects the influence of correlated unobserved proximal processes. We do not focus on these estimates, because it is impossible to tell which processes they are capturing. Their inclusion, however, prevents the correlated unobserved factors from contaminating our estimates of the effects of the proximal variables that we do observe.

The terminology of distal and proximal factors may be difficult for some readers to understand intuitively, and for this reason we do not use the terms in the main body of the report, but instead refer to family demographic characteristics and intervening factors.

5. Method

Our methodology is detailed in the Technical Appendix. Intuitively, however, we construct estimates designed to answer the hypothetical question: If the low- to middle-income gap in factor X (duration of breastfeeding say) were eliminated, keeping everything else the same, how much would the low- to middle-income test score gap fall? In essence, our method isolates the independent predictive power of the income-related gap in a particular factor for the overall income-related test score gap.

There are number of reasons (discussed below) why caution is needed in taking these estimates literally. However, the strength of our approach comes from the exceptional richness of our data, and the wide range of potential influences that we are able to consider simultaneously in a simple comparative framework. "Keeping everything else the same" is impossible in any observational study, but our method of statistically netting out the contribution of 157 other variables when calculating the effect of a particular variable is an unusually stringent test.

Even if our estimates cannot be interpreted as causal, the relative ranking of such a wide range of different factors in terms of their importance for the test score gap provides important clues as to where interventions are likely to be most effective. Factors where predictive power is strong are, at the least, candidates for effective policy levers and suggest areas in which randomized control trials to establish causality should be a priority. Factors with little predictive power, however, are unlikely to be the drivers of inequality in early childhood outcomes.

The reasons we cannot be sure that eliminating the income-related gap in a factor would actually have the effect we estimate it would have on test scores are the possibilities of reverse causation (in which the child's developmental level influences the behaviour or factor), and of unobserved third influences that affect both development and the factor in question. To illustrate, suppose that breastfeeding is associated with improved cognitive development. If this arises because mothers are less likely to breastfeed babies with health or developmental problems, or because mothers who are good at fostering cognitive skills are more likely to breastfeed, then changing breastfeeding behaviour itself will have no effect.

A further point to note is that in order to treat all possible influences on child development equally, our method is by necessity very simplified. In particular, we assume that the effect of a factor like breastfeeding is the same for all children. If low-income children benefit disproportionately from certain positive behaviours then we will underestimate the potential influence of policies targeted to the poor. And if there are synergies between combinations of factors, such that a change in one area is more effective when combined with a change in another area, this will be lost in a method that assumes a single constant effect.

As described, our method focuses on the independent predictive power of each factor, holding all else equal. This is a stringent test, but one that rules out the possibility of the knock-on effects of changing one factor on other factors, and again may lead to underestimates. For example, if car ownership impacts on children in part because it allows parents to take them to organized clubs and classes, then this will not show up in the estimated effect of car ownership when the effects of clubs and classes are netted out. Similarly, if breastfeeding improves child development by fostering a warmer mother-child relationship, this will not show up when the effect of the mother-child relationship is controlled.

The richness of the MCS dataset lies in both the range of intervening factors that were measured and in its longitudinal aspect. We observe many factors like parenting behaviours, smoking in the household and indicators of material possessions at two or more points in time. Since the effects of a factor are likely to differ at different points in time (see, e.g. Todd and Wolpin 2003) we make maximum use of the data by including current and lagged measures simultaneously. This is a flexible approach, but one that means care must be taken in interpreting the individual coefficient estimates. Behaviours like parental reading at age 3 and age 5 are likely to be strongly persistent over time, and the effect of each is estimated holding constant the other. To get a meaningful estimate of the effect of parental reading sustained over the preschool period, for example, it is necessary to add together the separate effects, rather than consider them individually. This point also applies to cases where there are highly related measures of a factor measured at a single point in time – such as maternal psychological distress, self esteem and life satisfaction. The main focus of our analysis is on the aggregate contribution of broad domains of factors. We do not

emphasise the individual coefficient estimates, but they are shown in the final sections of the report for completeness.

6. Low-income children in the Millennium Cohort

There are 12,644 children in the Millennium Cohort who completed all the cognitive assessments at the age of 5[1]. We construct a measure of average annual before-tax parental income since the birth of the child using income data from the three survey waves (9 months, 3 years and 5 years after the birth of the child). We divide through by the square root of the number of persons in the household to adjust income for family size and composition. We then split the sample into five equal-sized groups on the basis of this standardized measure[2].

Table 1 shows representative incomes for a family of four in each of the quintile groups. The group that we identify as the lowest-income – Quintile 1 – had average before-tax incomes of £15,100 per year or less. Before-tax incomes of the richest fifth were, on average, about 8 times higher than those of the poorest fifth. This differential falls to 6 times higher when the progressive nature of direct taxes is taken into account.

These income thresholds can be compared to the official poverty line, although the calculations are complicated by the fact that the line – 60% of median income – varies by year and is defined in terms of disposable rather than before-tax income. Our calculations put the average poverty threshold for after-tax income for a family of four during this period at roughly £16,500. According to this measure, just over one quarter of children born in the Millennium Cohort (2000 to 2001) lived in families with incomes below the poverty line. Hence all of the children in Quintile 1 are estimated to be poor by the official definition, plus a further one-third of the children in Quintile 2. These figures are high in part because parents of young children tend to be young relative to parents as a whole, and so have incomes that can be expected to rise as children age.

Table 2 details the demographic composition of families by income quintile, highlighting the lowest (Q1), middle (Q3) and highest (Q5) quintiles, as these are the focus of our subsequent analysis. Some statistics in Table 2 are particularly striking. Only 35% of the poorest children live with both biological parents by the age of 5, compared with 88% in the middle income group. 47% of the poorest children were born to mothers under the age of 25, and a huge 19% to teenage mothers. Young motherhood is much rarer among middle income children, with equivalent figures of

just 13% and 2%. And some 20% of the poorest children are non-white, compared with only 6% of their middle income counterparts. Of these, half are Pakistani or Bangladeshi, groups that are virtually unrepresented in the higher income groups.

One in six of the poorest children were born to an immigrant mother or father, and over a third to parents without a single grade A to C GCSE between them. The parental education gap is stark – only 1 in 12 of the poorest children lived with a degree-educated parent at 9 months, compared with 4 in 5 of the richest children. Despite the relative youth of the poorest mothers, they are much more likely than better off mothers to have three or more children.

7. Cognitive outcomes in the Millennium Cohort

Children in the MCS completed three cognitive assessments at the age of 5 – one verbal and two nonverbal. The tests are designed to measure different aspects of cognitive development, such that the correlations between the three sub-scales are around 0.33. The correlations are positive, which implies that children who do well on one type of test tend also to do well on the other tests. However, they are far from 1, implying that children's abilities tend to be somewhat specialised in one area, rather than identical across all three tests.

British Ability Scales

The *Naming Vocabulary (NV) scale* assesses the spoken English vocabulary of young children. The test items consist of a booklet of coloured pictures of objects which the child is shown one at a time and asked to name. The scale measures expressive language ability, and successful performance depends on the child's previous development of a vocabulary of nouns. The items require the child to recall words from long-term memory rather than to recognise or understand the meaning of words or sentences.

The *Picture Similarities (PS) scale* assesses non-verbal reasoning ability. Each item in the test consists of a set of four pictures which are printed on an easel, and a separate card printed with a fifth picture called the picture response card. For each item, the child is asked to place the separate card underneath the picture in the easel which shares a similar element or concept with the card.

The *Pattern Construction (PC) scale* assesses non-verbal reasoning and spatial visualisation. For each item in the test, a pattern is presented to the child, and the child is asked to replicate the pattern using flat foam squares or solid plastic cubes with black and yellow patterns on each side. The patterns increase in complexity as the assessment progresses. Each item is scored according to the speed and accuracy with which the pattern is constructed.

Since the tests have no natural metric, we calculate the average monthly increase in each score for girls and boys between the ages of 58 and 67 months (91% of children in the sample have ages in this range). We use this number to normalise the scores and centre them on 62 (the modal age in months at assessment), so that the value of the variable can be interpreted as the "developmental age" of a child whose

calendar age is 62 months. A developmental age of 58, for example, indicates a cognitive delay equivalent to 4 months of development relative to the average child in this cohort. A similar technique is used by Jones and Schoon (2008), who caution that age equivalents should only be treated as approximate and note that they become more inaccurate as one moves away from the mean towards the extremes.

Figure 1 shows the mean vocabulary test score of children in each income quintile group. Detailed numbers are provided in Table 3, along with mean scores on the two nonverbal assessments. The average vocabulary test score of a 62-month-old child in the lowest income quintile is that expected of a child aged only 53.6 months – 11.1 months (after rounding) behind the average score of 64.6 months for the average child in the middle income quintile. It is this gap of 11.1 months that we seek to explain via differences in intervening factors between the two income groups.

In contrast the 'advantage' conferred by very high income is much smaller. The mean score in the highest income quintile is 5.2 months ahead of the mean for the middle income reference group. This difference is notable because it suggests that the benefits of higher income diminish strongly after some relatively low threshold. As shown in Table 1, the mean gap in after-tax incomes between the poorest and the middle quintile is around £15,000, while the mean gap between the middle and richest is around £35,000. So although the income gap is 2.3 times greater in the second comparison, the test score gap is less than half as large.

Table 3 provides comparable estimates for the two nonverbal cognitive tests. It is striking that the low- to middle-income gaps on both measures are only just over half the size of those on the verbal Naming Vocabulary test. The high income gap is again much smaller than the low income gap on the Pattern Construction test, although it is of roughly equal magnitude on the Picture Similarities test. While in part the greater gaps on the vocabulary test reflect the fact that low-income children are more likely to be from groups who do not speak English at home and hence have poorer English vocabulary, this difference holds up if we only consider low-income children whose parents are not immigrants and whose families only speak English at home. Dropping the 14% of the sample excluded by this restriction (leaving a sample that is 97% white), we find that the estimated low-income gap in vocabulary scores falls only slightly from 11.1 months to 9.0 months, while the low-income gaps in the non-verbal test scores are unaffected.

These findings raise the important point that certain aspects of cognitive development may be more strongly associated with family background and the early environment than others. When making statements about the extent of inequality in cognitive development, or making comparisons across time and place, it is therefore important to be clear about the concept that is being measured. A focus exclusively on verbal tests of ability may overstate the extent to which disadvantaged children are falling behind in general.

This said, to avoid cluttering our analysis with three full sets of results, we focus on explaining the vocabulary test score gap. Results using the other two tests are available on request, and we note any striking differences in findings in the text. Of course, what we would really like to know is which aspect of cognitive development is most consequential for later outcomes such as final educational attainment. The MCS children are too young for us to know this yet, but evidence from previous cohort studies suggests that both verbal and nonverbal assessments are predictive of later outcomes (Blanden et al. 2007; Carneiro, Crawford and Goodman 2007).

8. The role of intervening factors in explaining the low- to middle-income test score gap

The aim of our multivariate analysis is to understand the factors that give rise to the low- to middle-income gap in vocabulary test scores of 11.1 months of development. We distinguish four broad domains of potential intervening factors, which we then disaggregate into more detailed sub-groupings.

Figure 2 and Table 4 show the results of this analysis. A brief summary of the contents of each domain is provided in Table 4. Many of the concepts are self-explanatory, but full details of all variable definitions can be found in the subsequent sections devoted to each specific domain. As explained in the section on our conceptual framework, we also hold constant a set of demographic characteristics when estimating the effects of the four intervening domains. These characteristics – like parental age, education and ethnic origin - help to absorb the effects of associated but unmeasured factors. Their contribution to the portion of the income-related test score gap unexplained by the four focal domains is shown in the unshaded part of Figure 2 for completeness. However, because of the difference in interpretation, we discuss these estimates separately in Section 9.

An intuitive way to interpret the focal estimates is as the reduction in the low- to middle-income test score gap if the low- to middle-income gap in each domain were eliminated, keeping everything else the same (subject to the caveats discussed in Section 5). The contribution of a factor will depend on the degree to which it varies between low- and middle-income families, and the strength with which it predicts vocabulary outcomes, holding all else constant. If low- and middle-income families differ only slightly in terms of a particular behaviour or factor, then eliminating that difference will be associated with little change in the test score gap, even if the behaviour or factor is very consequential for outcomes. Equally, if the behaviour or factor does not matter for vocabulary, then eliminating even a large difference in that behaviour or factor between low- and middle-income families will have no statistical impact on the test score gap. The numbers in Figure 2 and Table 4 are designed to give a broad overview of our main findings, and as such do not indicate the relative strength of the two components of a factor's contribution. In the sections that follow we focus on each domain separately and look explicitly at that comparison.

Figure 2 shows that we estimate that the equalization, on average, of all measured intervening factors across the low and middle income groups would be associated with a 40% decrease in the poverty test score gap, a reduction from 11.1 months to 6.6 months of development.

The most important single domain is *parenting and the home environment*. The factors in this domain in total explain one fifth, or 2.2 months of the low- to middle-income test score gap. Table 4 shows that this domain is made up of three groups of variables. The home learning environment group is designed to capture the level of cognitively stimulating activities that the child is exposed to from the age of 3 onwards – in terms of parental reading and teaching, in-home activities like TV watching and computer games, and out-of-home activities like trips to the library and places of interest. Cognitive stimulation is clearly strongly associated with both income status and vocabulary skills – the income-related differences in these factors alone predict 11.4% of the total test score gap between low- and middle-income children.

The second group is parenting style, which captures factors relating to rules setting and discipline, and the warmth and sensitivity of parent-child interactions. This grouping is almost as powerful at independently predicting the low to middle-income test score gap as the home learning environment – accounting for 9.3% of the total.

The third group relates to health-related behaviours in the pre- and post-natal period: breast feeding, prenatal care, parental smoking and alcohol consumption. Taken together, these factors have no role at all in predicting the test score gap, and in fact, the negative estimate of -1.1% implies that the behaviours of low-income families are more advantageous than those of middle-income families, such that they contribute to a narrowing, rather than a widening, of the test score gap. This conclusion obscures the fact that there is variation in the contribution of items within the grouping, with differences in breastfeeding that contribute to the gap offset by differences in the other behaviours that work in the opposite direction. These factor-specific results are discussed further below.

The second major domain of *family material circumstances* contributes 13% to the low to middle-income test score gap, or 1.4 months of the total 11.1 month gap.

Of all the domains we consider, this is the one conceptually most strongly linked to income itself, rather than other characteristics that may be more prevalent in low-income families. Of course, the ownership of material possessions, neighbourhood and housing conditions and financial stress reflect not only money, but also parental preferences and decisions about how to allocate the income that they have. Table 4 shows that the bulk of this association reflects the lower ownership of various material possessions, such as internet access, cars, consumer durables and child-related items in low-income families. Poor neighbourhood and housing conditions play only a modest role, holding all else constant, while financial stress is, unexpectedly, associated with better outcomes conditional on other material circumstances (perhaps indicating that mothers who report more financial stress are more concerned with promoting child development).

The income-related differences in the third domain of *maternal and child health conditions* contribute only around 4% of the low- to middle-income test score gap. Child health and maternal psychosocial wellbeing have a small amount of predictive power; maternal physical health has virtually none. It is striking how little health-related factors contribute to the test score gap compared with other domains of parenting and the home environment and material circumstances. However, other research suggests that these factors are much more strongly predictive of children's health and behavioural difficulties than they are of cognitive outcomes (Gregg, Propper and Washbrook 2008).

The fourth domain of *maternal employment and child care* is designed to capture the care environment of the child prior to the start of schooling. Maternal employment can be thought of as a proxy measure that captures time *not* spent with the mother, while other variables capture exposure to formal care settings and early education, rather than care provided by an unpaid relative or friend for example. Income-related differences in care experiences contribute only a small 3.8% to the poverty test score gap in total. This certainly implies that differences in child care settings are not the primary driver of low-income children's cognitive deficits. The interpretation of this finding is discussed more fully in the section devoted to the child care domain, but we note here that this cohort of children represents a group that received universal preschool, introduced by the Labour government after its election in 1997. Only a very small share of children in this cohort did not participate in some

kind of preschool before starting school. In addition, many aspects of child care experience which likely do still vary by income, such as quality and continuity of care, are not captured by our measures. Hence income-related differences in child care likely contribute somewhat to the unexplained portion of the poverty test score gap. In addition, the assertion that current disparities in early education are unlikely to be responsible for the cognitive gaps observed among children today does not imply that intensive, high-quality, targeted programmes cannot help to compensate for disadvantages faced by low-income children.

Although the estimates for the middle- to high-income gap are not our focus here, it is interesting to note whether the domains of factors contribute to them in the same way as they do to the low- to- middle income gap. Differences in the home learning environment and parenting style are important between middle and high income families too, contributing 18% and 9% respectively to the (much smaller) raw gap in their vocabulary scores. Differences in ownership of maternal possessions contribute 9%, a smaller but non-negligible portion when compared with the low- to-middle income vocabulary test score gap.

Inspection of the breakdowns of the low- to- middle income gaps in the nonverbal Picture Similarities and Pattern Construction test scores (available on request), shows that in total the four domains of intervening factors account for similar amounts of developmental deficit as for the verbal test score. Equalization of all measured intervening factors is associated with a reduction in the low- to- middle income gap in Naming Vocabulary of 4.5 months, in Picture Similarities of 5.7 months, and in Pattern Construction of 4.3 months. There are much smaller unexplained components in the income-related gaps on the non-verbal measures, however, such that these predicted deficits account for the entire raw gap in Picture Similarities scores and 70% of the raw gap in Pattern Construction scores, compared with only 40% of the low- to- middle income gap in the Naming Vocabulary measure.

In many respects the role of specific domains in explaining the test score gaps are similar across verbal and non-verbal measures of cognitive ability. The home learning environment and parenting style are strongly predictive of the gaps in all three measures. The role of family material circumstances is somewhat larger in terms of the non-verbal scores relative the role of parenting and the home environment, the reverse of the case for the verbal vocabulary test score. We also find that, for the

Picture Similarities score alone, lack of early maternal employment is independently associated with a sizeable fraction – some 16% - of low income children's deficits.

The numbers in Figure 2 and Table 4 summarize the contribution of a multitude of different factors to the income-related verbal test score gap, and obscure considerable differences in the importance of different items within groups. These are shown fully in the following sections, but in order to give some sense of the role of specific items, we select the 11 individual factors that contribute the most to the vocabulary low-to-middle income test score gap, and present them in Table 5.

Table 5 shows that, of all the indicators included in our estimation, this set of 11 factors alone can account for 35.5% of the low- to- middle income gap in vocabulary test scores. Moreover, they account for even larger proportions of the nonverbal test gaps (although the magnitude of these gaps is much smaller). Hence the handful of items in Table 5 seems a good place to start when searching for possible policy levers.

Lack of internet access and lack of car access stand out overwhelmingly as the key items in the domain of material circumstances. These items are strongly income graded: 62% of the poorest income group have no internet access in the home at age 5, compared with 17% of the middle income group. Lack of access to a car is almost exclusively concentrated among the poorest families: 39% of the lowest income group do not have access to a car compared with 3% of the middle income group. Lack of each factor is associated with a decrease in vocabulary scores of around 1.8 months of development (see Section 11.)

A number of items from the parenting and home environment domain stand out as individually significant: parental reading and trips to plays, museums and libraries from the home learning environment grouping; maternal sensitivity and regular bedtimes from the parenting style grouping; and breast feeding from the health-related behaviours grouping. It is notable that several of the home learning items – reading and outings to plays and concerts – are consistently predictive of verbal test scores but not of non-verbal ability.

Finally, although the contribution of the maternal and child health domain in general is small, low birth weight and child's poor general health at age 5 make significant if modest contributions to all the income-related test score gaps.

The findings in Table 5 are useful because they make clear that the factors that matter for the cognitive test score gaps of poor children are diverse – the 11 items are drawn from five different groups of variables. No single domain of behaviours is responsible for the slower cognitive development of low-income children, and this suggests that interventions that are able to operate on multiple domains simultaneously are likely to be much more effective. The Nurse-Family Partnership programme is a model of this type of intervention, as it is designed to target factors such as birth weight, breast feeding and maternal sensitivity at the same time.

9. The unexplained part of the low- to middle-income test score gap

So far, our analysis has shown that 40% of the gap in vocabulary test scores between low- and middle-income children can be explained by measurable factors that we have termed 'intervening'.. But what of the remaining 60%? There are many candidate factors that are potentially consequential for cognitive development that are not measured, or that are measured poorly, in our data.

Our results show that 20% of the low- to middle-income gap in vocabulary scores can be accounted for by differences in parenting and the home environment. Of this, 4.4% is explained by differences in the interviewer-rated measure of the quality of parent-child interactions. These figures are likely to be substantial underestimates because parental sensitivity is measured poorly by the observations of a person unknown to the family during a single interview. In addition, variation in the measure is limited because many of the 11 binary items are answered positively by the vast majority of the sample. For example, only 0.6% of parents slapped or spanked the child during the visit, 97.2% conversed at least twice with the child, and 96.8% showed physical affection. 58% of the sample scored the maximum of 11 on the aggregate measure.

Prior research on a sample of US preschool-age children suggests that more accurately measured data on sensitivity of parent-child interactions can increase the role of this factor in explaining income-related gaps in vocabulary scores substantially. Waldfogel and Washbrook (2008) attribute 50% of the low- to middle-income gap in vocabulary scores to differences in parenting and the home environment, of which fully 21% is contributed by measures derived from video-taped evidence. These measures are taken from instruments expressly designed to reveal the sensitivity and nurturance of parent-child interactions (the Nursing Child Assessment Teaching Scale and the Two Bags task), they were administered at three separate points in time, coded by assessors trained specifically for the task, and are comprised of continuous scales that discriminate more effectively over the range of the sample.

Two obvious further omissions are detailed data on the role of fathers – their characteristics and the nature of their relationships with the child – and the role of

inherited characteristics that shape both parental income and children's development. It is important to be aware of these omissions, although we cannot quantify their role any further.

What we can explore, however, is the extent to which family demographic characteristics are associated with the unobserved environments and experiences that contribute to the low income test score gap. Figure 3 repeats Figure 2, but switches the shading, such that we focus on the unexplained portion of the raw gap. As a guide to interpretation, 10% of the overall poverty test score gap is explained by factors that differ with parental education, but that are *not* associated with any of the measured intervening factors included in our estimation. Of course, parental education is likely to influence many of the behaviours we have already considered, but the role of these factors is netted out in the final estimates.

Three striking conclusions emerge from Figure 3. Firstly, ethnic minority status and nationality are strongly associated with the unexplained drivers of the low- to middle-income gap. (This grouping contains parental immigration status and language in the home as well as ethnicity, as shown in Table 2.) This conclusion applies only to the vocabulary test score gap, as the role of ethnicity and nationality in the nonverbal poverty test score gaps is negligible (results available on request). This pattern of results suggests that growing up in a non-British, non-English speaking family is linked with slower early verbal development – on an assessment in the English language[3] -- but also suggests that this should not be misinterpreted as an adverse effect on cognitive ability or intelligence more generally. In addition, as mentioned earlier, immigrant background and language in the home by no means explain the lower vocabulary scores of low-income children. Even if we limited our analyses to children of British-born parents who speak only English at home, we would still find a large vocabulary gap between low- and middle-income children.

Secondly, we see a large role for maternal age at birth which explains 9% of the overall test score gap. This entirely reflects the negative outcomes associated with childbearing in the teenage years and the early twenties, rather than an advantage to childbearing after the age of 30. Teenage pregnancy has long been the subject of policy attention, and this finding suggests that the attention is warranted, and that children of young mothers are particularly at risk of cognitive under-development.

Thirdly, differences in family structure and size (combined in the family composition group) contribute almost nothing to the low income gap in verbal test scores, nor to low income gaps in either of the nonverbal test scores. As shown in Table 2, low-income children are massively more likely to live in a single parent household and tend to have more siblings. It is certainly possible that these factors shape the parenting and other behaviours that we have shown matter for explaining the low income gap. But taking these into account, we find no evidence of differences between large and small families, or between single and couple families, that adversely affect children's cognitive development.

The Residual category, which is equal to just over a quarter of the raw low- to-middle income vocabulary test score gap, captures all factors that are correlated with vocabulary and differ across income groups, but that are unrelated to any of the included measures. The implication is that even if all measured differences in parenting, material circumstances, parental education, ethnicity, and so on were equalized between low and middle income families, a gap in average vocabulary scores of 3 months of development is predicted to remain. We have speculated on some of the influences this figure may represent, but can conclude only that there is substantial scope for factors not considered in this analysis to play a role in narrowing the income-related verbal test score gaps.

10. Domains of intervening factors: Parenting and the home environment

This section, along with the three sections that follow, provides details of the individual statistics which we use to construct our breakdown of the low- to- middle income vocabulary test score gap. For each grouping in turn, we show first the (weighted) mean of each explanatory variable across the low-, middle- and high-income groups. The majority of explanatory variables are binary, so the mean is equal to the proportion of children in that income group who possess the characteristic in question. (Where the variable is not binary, an explanation is provided at the foot of the table.) The gap in means between the lowest and middle income quintile groups forms the first component in calculating the overall contribution of that factor to the low- to middle-income test score gap[4]. To give a full picture of the range of children's experiences we also show in the tables the means for the high-income (top quintile)

group, which often differ quite considerably. These numbers do not contribute to our estimates of the break-down of the low- to middle-income gap, which are the focus of the report, but they can be used to gain some sense of the ways in which the most affluent children are advantaged relative to middle-income children.

Second, each table shows the conditional effect of the variable on the vocabulary test score. This effect is the coefficient from a single linear regression that includes all measured factors simultaneously (158 variables, not including the set of binary indicators for missing data). In order to focus attention on the variables with independent predictive power we report only those that are significant at the 10% level.

The product of the difference in means between the low- and middle-income groups and the estimated effect of the variable on vocabulary scores forms the variable's contribution to the raw low- to middle-income gap, shown as percentage of the 11.1 month total in Column 5 of each table[5]. Again, to highlight the important stories we omit the contribution of variables with statistically insignificant effects from the tables (although all the variables were included in our statistical models). The contributions of all factors omitted from the tables do form part of the total contribution of the grouping and are summarized at the bottom of the tables. In general, the role of factors with insignificant effects is very small.

Table 6 provides details of the home learning environment variables. Columns 1 to 3 show that low-income children experience environments that differ from their better-off counterparts in a host of ways. Only 45% of the poorest children are read to every day at age 3, compared with 65% of middle-income children and 78% of the richest children. They are also considerably less likely to visit the library and places of interest like museums, plays and concerts. Only 30% participate in a sporting activity at least once a week at age 5, well below the 63% of middle-income children and the 81% of high-income children who do so. Conversely, low-income children are more likely to spend long hours watching television and playing computer games than better off children.

Column 4 shows that the majority of the home learning environment indicators are independently associated with significant differences in vocabulary test scores. Reading at age 3 and outings to places of cultural interest are particularly

associated with this aspect of development, with for example a child who is read to daily at age 3 predicted to have a test score nearly two months more advanced than an equivalent child who was not read to daily at age 3. The large magnitude of the income-related gaps in these factors combines with the strong estimated effects on verbal development to explain a sizeable fraction of the low- to- middle-income test score gap. Activities with a less obvious cognitive component such as sports, trips to zoos and television watching are generally weaker predictors, and so account for less of the gap, even though they also differ strongly with income.

Table 7 gives details of the parenting style variables, which together account for 9.3% of the total low- to- middle income gap in vocabulary scores, slightly below the 11.4% explained by the home learning environment. Low income children are less likely to have regular routines around bed times and meal times than middle income children, and low income parents tend to impose fewer rules and enforce them less strictly. Of these variables, it is regular bed times that are most strongly associated with the better vocabulary of middle income children.

An interviewer-assessed measure of mother-child interactions at the age 3 interview suggests that middle income mothers are slightly more sensitive and nurturing, at least according to this measure. Even though the income-related differences in this factor are relatively modest, it is very strongly predictive of verbal test score performance, so that these small differences are magnified into a gap in outcomes equal to 4.4% of the overall low- to- middle income test score gap. There is some evidence that these differences relate to beliefs about appropriate parenting style, as low income parents tended to express somewhat less authoritative and nurturing views when the child was 9 months old. It is noticeable, however, that the use of physical discipline (smacking) does not contribute to the test score gap because it is roughly equally common among low- and middle-income families, even though children who were smacked at least once a month at 5 have a one-month developmental delay relative to children who were not smacked.

Table 8 focuses on differences in health-related behaviours across income groups. Low-income children have lower rates of breast feeding and are almost half as likely as middle income children to be breast fed for 6 months – the period recommended by the World Health Organization for the promotion of maternal and infant health. Our results show that children who are never breast fed have a one-

month delay in vocabulary development relative to those who are breast fed for 6 months or more, a factor that makes a modest contribution to the overall low- to-middle income test score gap at age 5.

Low-income children are much likely to be exposed to cigarette smoke, both in the womb and later on in the home, and their mothers were less likely to have received prenatal care in the first trimester of pregnancy. We find no evidence that these factors are independently associated with vocabulary, however, when all other influences are taken into consideration. Low income mothers report that they drink alcohol much less frequently than middle- and high- income mothers, although when the measure concerns problem drinking specifically the relationship is less clear-cut. There is some weak evidence that alcohol consumption at 3 is negatively associated with children's vocabulary scores, so that the higher consumption of middle income mothers in fact works to offset the benefits of their longer breast feeding. Low income mothers are more likely to admit to recreational illegal drug use, but this plays no role in the vocabulary test score gap because of an unexpected perverse positive association between drug use and the outcome[6].

In summary, this section has shown that many diverse aspects of parenting behaviour are linked to vocabulary test scores. Low-income children tend to be disadvantaged across all these aspects relative to better off children, although the differences are perhaps largest with respect to learning activities within the home. One point it is worth noting here is that although most beneficial types of parenting and the home environment are more common in middle- and high-income families, the relationship is far from absolute. Large numbers of the poorest children are read to every day, taken to places of interest, have regular bed times and are breast fed by their mothers. These examples of positive behaviours among the lowest income parents give grounds for optimism that such behaviours can be promoted more widely among vulnerable families.

11. Domains of intervening factors: Family material circumstances

The MCS contains a wide range of measures of material possessions within the home, including a set of deprivation indicators that form part of the official government definition of material deprivation. Our detailed picture of income-related differences in the ownership of these items provides a key insight into how the living conditions of low-income children differ from their better off counterparts. It is possible that certain items make a direct contribution to children's learning and development, but together they also act as a measure of access to social and leisure opportunities more broadly.

Table 9 repeats the findings already discussed of the importance of internet access and car ownership in predicting the low- to- middle income gap in vocabulary test scores. It shows that these items are much more likely to be lacking in low-income households, but are almost universal in the highest income families, and that they are associated with large differences in vocabulary performance at age 5.

Very few families, even among the poorest, are without a telephone, fridge, freezer or washing machine in 21st century Britain. Similarly, inability to meet basic clothing needs, nutritional needs (fruit and vegetables) and to participate in social celebrations is very rare. Larger differences, however, are apparent when we consider more discretionary items like microwaves, dishwashers, tumble dryers, new furniture and contents insurance. It is noticeable that low income parents are much more likely to go without adult rather than child-related items. 15% of low income mothers lack two pairs of weatherproof shoes for themselves, compared with only 3-5% lacking shoes for their children. 28% go without a hobby or leisure activity and at least 40% without a small weekly sum of money to spend solely on themselves. Lack of an annual holiday emerges as one of the key distinguishing features of contemporary low-income family life – 57% of the poorest families cannot afford a holiday, compared with only 15-18% of middle-income families and 3% of the richest families. The finding that it is in the area of car ownership, holidays and access to leisure activities more broadly that low-income families suffer the greatest exclusion is supported by Gregg et al. (2006), who show that increases in the incomes of the

poorest families after Labour's welfare reforms were spent disproportionately on these types of item.

With the exception of cars and the internet, ownership of individual material possessions is not positively associated with children's verbal development, and this conclusion remained even if when we combined the measures into aggregate "material deprivation scores". However, the picture of sharp inequalities in access to social and leisure opportunities shown in Table 9 raises concerns for the well-being of adults in low-income families, who may be protecting their children by going without themselves. It is also possible that these inequalities will come to have greater consequences for low-income children as they age and attend school, when their more limited range of experience will come into sharper contrast with that of more affluent children.

A second aspect of material circumstances relates to the local environment beyond the family home. Table 10 shows that, unsurprisingly, lower income children tend to live in more deprived areas than middle- and high-income children. Subjective indicators of local conditions – assessed by both the interviewer and the child's mother – confirm that the neighbourhoods of low income children are more likely to be perceived as unsafe or of poor quality. These factors are not significantly independently associated with children's vocabulary scores, although of course they may shape the family conditions and processes that are already accounted for in the analysis. Residence in a rural or village location is relatively rare for children in this cohort, but it is still twice as likely for the richest children than for the poorest, and is associated with significantly more advanced vocabulary development, holding all else equal.

Table 11 focuses specifically on housing-related aspects of material deprivation. Two-thirds of low-income children lived in council or Housing Association rented accommodation (social housing) at some point before age 5, and 44% were always in social housing from birth onwards. Unconditional differences in vocabulary outcomes between children in social housing and other children are very large (on the order of 10 months of development), but when other measured influences are held constant, these differences become insignificant. This suggests that our measures of the home environment, material circumstances, family health and

child care fully capture the disadvantageous aspects of life in social housing, at least with respect to early language development.

Low-income children are more likely to live in crowded or damp accommodation than other children, are less likely to have access to a garden, and slightly more likely to have a home that is dark, unclean or unsafe. With the exception of one crowding measure, these factors are not independent predictors of slower verbal development, although we would perhaps expect to see a greater association of these factors with health rather than cognitive outcomes.

Table 12 gives details of our final set of variables in the material circumstances domain – those relating to financial management. Three-quarters of the lowest income parents do not save regularly, but neither do 30% of the richest parents, suggesting that savings behaviour reflects more than just income availability. Around a third of the lowest income parents are behind with one or more household bills, and a fifth report that they find it difficult to manage financially in general. Again, these variables do not predict vocabulary scores when we hold constant income quintile, ownership of material possessions and other influences on outcomes. In fact, conditional on all other factors, measures of financial stress are slightly positively associated with children's vocabulary scores, perhaps because families with higher aspirations for their own and their children's living conditions struggle more on very low incomes.

12. Domains of intervening factors: Maternal and child health

The MCS contains many indicators of the mental and physical well-being of both parents and children. Table 13 focuses on question of whether poor health hampers the cognitive development of low income children. Birth weight is a factor that is known to be strongly predictive of a range of outcomes later in life, and even into adulthood. Children in the lowest income group were, on average, around 150g lighter at birth than those in the middle income quintile. This small difference accounts for 1.3% of the overall test score gap because, as shown in Column 4, an extra kilogramme of birth weight is associated with just under a month of additional vocabulary development, holding all else equal. To some extent lighter birth weight reflects shorter gestation length, and low income children do tend to spend slightly fewer days in the womb (although they are no more likely to be placed in a Special Care Unit at birth). But the very small correction factor of -0.1% associated with shorter gestation shows that our results reflect lighter birth weight in low income children conditional on gestation.

Contemporaneous child health is also associated with vocabulary test scores. Low income mothers tend to report that their children are in poorer general health at age 5 on a five-point scale than middle- and high-income mothers, and an extra point on this scale independently predicts almost half a month of developmental progress in vocabulary.

Table 14 considers the relationship between income group and maternal physical health. As with their assessment of child health shown in Table 13, low income mothers rate their health as worse, on average, than that of better off mothers. 19% report a longstanding illness or disability that limits their activities, compared with 13% of middle income mothers and 8% of the highest income mothers. Neither of these factors, however, independently matters for vocabulary test scores. Overweight/obesity is generally less associated with income than the other health measures, so that even though there is some link between poor maternal health in this area and slower cognitive development (perhaps capturing something about nutrition in the home) it contributes almost nothing to the income-related test score gap.

Table 15 focuses on a broad set of measures of maternal psychological and social, rather than physical, well being. Low income mothers have worse outcomes on all these measures across the board. Fully one-fifth reported symptoms that put them at risk of post-natal depression at 9 months, compared with 11% of middle-income mothers and 7% of the richest mothers. Low income mothers also report considerably higher levels of psychological distress in later years. They perceive themselves to have lower levels of social support than other mothers, and have less of a sense of control over their own lives (as measured by an assessment of locus of control). They also have lower self esteem and are less satisfied with how their lives have worked out in general. Finally 15% of the poorest mothers have problems with basic literacy and numeracy, such as the ability to fill out forms.

None of these variables are significant individual predictors of children's vocabulary test scores when other influences are taken into account. In total, however, they contribute 1.8% of the low- to- middle income vocabulary test score gap, a figure driven largely by the contribution of the lower levels of social support reported by low income mothers. Although their role here is perhaps surprisingly modest, research has shown that these factors in general are much more strongly linked with children's behaviour problems and socio-emotional development than with cognitive development (e.g. Gregg at al. 2008). Hence we should not conclude that maternal psychosocial well-being has few consequences for child development on the basis of an examination of verbal test scores alone, although it is unlikely to be a primary driver of cognitive deficits.

13. Domains of intervening factors: Maternal employment and child care

Table 16 gives the breakdown of our final domain of maternal employment and child care. Low income mothers are much less likely to work than mothers in higher income groups at all points in time, with the exception of the very early post-birth period when even affluent mothers take time out of the labour force. Only 41% of the lowest income mothers worked during pregnancy, compared with 80% or more of mothers in the middle income quintile or higher. The children of mothers who did not work prior to the birth score significantly lower on the vocabulary test at age 5. Pre-birth employment is likely to be associated with a number of factors unmeasured in our study that are potentially consequential for cognitive development, including unobserved aspects of material well-being, maternal social networks and maternal abilities more generally.

After the birth, full-time employment is particularly rare among the lowest income mothers, perhaps by definition as a full-time wage would in many cases lift the family out of the bottom income quintile. Even among the richest mothers, however, only around 30% are working full-time when their child is 5.

We find little evidence that low income children benefit from (or are harmed by) the greater time they spend in the care of their mothers. As discussed previously, this is likely to reflect a number of different influences. This cohort of children represents a group that received universal preschool, a situation clearly illustrated by the fact that two-thirds of the poorest children attended a nursery class or school. In countries without universal provision of free places, such as the U.S., the fraction of low income children attending nursery does not even approach this number. When so few children do not attend any form of preschool, we do not have a counterfactual group that can be used to estimate its effects.

Second, our measures of child care experiences are very broad, and our estimates pool across types of care that vary widely in terms of intensity, continuity and educational quality. Our lack of finding of significant effects on cognitive development may result from the inability to distinguish arrangements with different developmental effects. A similar point applies to the pooling of effects over different

groups of children. If children from disadvantaged home backgrounds benefit disproportionately from preschool education, while those from very advantaged backgrounds benefit more from time spent with their parents, then on average we will see little difference in the outcomes of those who did or did not attend preschool.

14. Concluding remarks and policy recommendations

Taking advantage of the extremely rich data from the MCS on a contemporary cohort of children in the UK, our analysis examines the factors that account for gaps in cognitive development at age 5 between children from the lowest-income families and those from middle-income families. We focus in particular on those factors that intervene between family economic resources and children's outcomes and that might potentially be amenable to policy intervention.

Our results provide grounds for optimism as well as concern.

On the down side, the fact that low-income children lag their middle-income counterparts at school entry by nearly one year in vocabulary, and by smaller but still substantial amounts in other types of cognitive development, is certainly cause for concern. While schools can do a great deal to equalize achievement among children who start at different levels, their job would be a great deal easier if children started school on a more equal footing. In addition, school-age children are aware of their standing relative to their peers, and such early gaps may affect low-income children's attitudes towards school and their aspirations for school attainment.

On the up side, our results point to a host of policy-relevant factors that are important contributors to income-related gaps in cognitive development and that therefore could play a role in reducing such gaps. The eleven most important factors – listed in Table 5 – are: two measures of material resources (lack of access to a car and lack of access to the internet); six measures of parenting and the home environment (the sensitivity of the mother- and child- interaction, along with five specific measures of enrichment or parenting activities); and three health related measures (low birthweight, breast-feeding, and overall child health).

If we are to make progress in reducing the income-related gaps in early cognitive development, policies that tackle the disadvantage faced by low-income children on this set of eleven factors would be a prudent starting point. Identifying effective parenting programmes is crucial, given the prominent role that differences in parenting play in explaining cognitive gaps. As discussed by Waldfogel and Washbrook (2008), the evidence base on such policies is now much stronger than it was in the past. In particular, a handful of rigorously evaluated parenting programmes

are over-turning the conventional wisdom that parenting, although very consequential to child development, is hard for policy to effectively alter. There is also clearly a role for programs that addresss health-related inequalities – by reducing low birth weight, increasing breast-feeding, and improving overall child health. And, a more novel implication of our results is that policies to address material deprivation – in particular, lack of access to a car and to the internet -- are also potentially important in mitigating gaps in cognitive development.

Endnotes

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Technical Appendix

We use the median income quintile (Q3) as the omitted reference category when analyzing income-related gaps in cognitive outcome scores. Formally, we estimate Ordinary Least Squares models (weighted for sampling design) of the baseline model

$$C_i = \sum_{q=1,2,4,5} \gamma_q (1 \mid INC\_Q_i = q) + \mu_i \qquad (1)$$

C_i is the *i*th child's outcome score expressed in months of development, $(1 \mid INC\_Q_i = q)$ is an indicator variable equal to 1 if family income is in the *q*th quintile, and μ_i is an orthogonal error term. Without controls, the γ coefficients in Model 1 are simply the gap in mean outcome scores between children in the *q*th quintile and those in the omitted middle income quintile.

When controls are added to Model 1, the γ coefficients are the income-related outcome gaps holding constant the included covariates – what can be thought of as 'within-group' income differences. The essence of our approach is to try to 'explain' the raw γ coefficients by the inclusion of various sets of controls. If we can drive them to zero, then the income-related outcome gaps can be fully accounted for by differences in observed factors. To explore this we employ a two-step method that allows us to partial up the reduction in the income coefficient into the contribution of particular factors. In the first step we add all the control variables to the baseline Model 1.

$$C_i = \sum_{q=1,2,4,5} \gamma_q (1 \mid INC\_Q_i = q) + \sum_j X_{ij} \beta_j + \mu_i \qquad (2)$$

X_{ij} is the value of the *j*th variable for child *i*, and β_j is the predicted difference in the outcome associated with that characteristic, holding all else constant.

In the second step, each covariate is regressed individually on the set of income quintile dummies

$$X_{ij} = \sum_{q=1,2,4,5} \lambda_{qj} (1 \mid INC\_Q_i = q) + \nu_{ij} \qquad (3)$$

The coefficient λ_{qj} gives the income-related gap in the value of the *j*th covariate between children in quintile *q* and those in the omitted quintile 3. Substituting (3) into (2) gives

$$C_i = \sum_{q=1,2,4,5} \left\{ \left(\sum_j \lambda_{qj} \beta_j \right) + \gamma_q \right| (1 \mid INC\_Q_i = q) + \left\{ \left(\sum_j \beta_j \nu_{ij} \right) + \mu_i \right| \qquad (4)$$

Equation 4 is simply a regression of C_i on the income quintile dummies, and hence equivalent to Equation 1. The first term in curly brackets shows that the raw income coefficient on quintile *q* can be broken down into a sum of terms. The term $\lambda_{qj}\beta_j$ reflects both the degree of income grading in X_{ij} (λ_{qj}) and the extent to which X_{ij} 'matters' for the outcome in question (β_j). A factor will make a contribution to the income-related gap only if *both* of these are non-zero. The residual unexplained component (γ_q) is the remaining income coefficient in (2).

Table 1. The distribution of household incomes in the MCS sample

	Quintile 1 (Lowest)	Quintile 2	Quintile 3 (Middle)	Quintile 4	Quintile 5 (Highest)
Quintile points (before-tax income)		*15,100*	*25,100*	*35,600*	*52,200*
Mean before-tax income	10,300	20,200	30,200	42,900	79,500
Mean after-tax income	9,800	17,600	25,000	34,000	59,300
Approx % below poverty line	100%	35%	0%	0%	0%

All numbers are in March 2005 British pounds, rounded to the nearest hundred. Numbers are representative figures for the average annual income of a family of two adults and two children over the 5 years following the birth of the study child in 2001. In this framework, the poverty line is approximately equivalent to an income of 16,500 after tax. Calculated from data on 12,644 children.

Table 2. Demographic composition of the MCS sample, by income quintile

Characteristic	**Income Q1**	Income Q2	**Income Q3**	Income Q4	**Income Q5**
White	**79%**	91%	**94%**	95%	**93%**
Pakistani/Bangladeshi	**10%**	2%	**1%**	1%	**0%**
Indian	**2%**	2%	**1%**	1%	**2%**
Black or Black British	**4%**	1%	**2%**	1%	**1%**
Mixed race/ethnicity	**5%**	2%	**2%**	1%	**3%**
Other race/ethnicity	**1%**	1%	**1%**	0%	**1%**
Mother or father born outside UK	**17%**	11%	**9%**	10%	**14%**
Other language spoken in home at 9m	**16%**	8%	**5%**	5%	**6%**
Highest parent's ed: Less than GCSE A-C	**37%**	12%	**3%**	2%	**0%**
Highest parent's education: GCSE A-C	**35%**	36%	**26%**	15%	**6%**
Highest parent's education: A-level	**21%**	33%	**36%**	29%	**15%**
Highest parent's education: Degree	**8%**	19%	**35%**	54%	**79%**
Co-resident married bio parents	**27%**	59%	**75%**	82%	**89%**
Co-resident unmarried bio parents	**8%**	14%	**13%**	11%	**8%**
Resident father at only 1 or 2 waves	**34%**	20%	**10%**	5%	**3%**
No resident father at any wave	**28%**	3%	**1%**	0%	**0%**
Other family type	**3%**	4%	**2%**	1%	**1%**
Mother less than 20 at birth	**19%**	6%	**2%**	1%	**0%**
Mother 20-24 at birth	**28%**	21%	**11%**	6%	**2%**
Mother 25-29 at birth	**24%**	31%	**33%**	29%	**20%**
Mother 30-34 at birth	**18%**	27%	**36%**	44%	**46%**
Mother 35 or more at birth	**11%**	15%	**17%**	21%	**32%**
0 younger children in home at 5	**61%**	61%	**61%**	58%	**56%**
1 younger child in home at 5	**30%**	34%	**34%**	37%	**38%**
2+ younger children in home at 5	**9%**	6%	**5%**	5%	**6%**
0 older children in home at 5	**39%**	36%	**41%**	49%	**53%**
1 older child in home at 5	**34%**	40%	**42%**	39%	**37%**
2 older children in home at 5	**18%**	18%	**13%**	11%	**8%**
3+ older children in home at 5	**9%**	6%	**3%**	2%	**2%**
Child is twin or triplet	**2%**	3%	**4%**	3%	**2%**
Child is female	**50%**	49%	**50%**	48%	**49%**
England	**81%**	81%	**83%**	83%	**85%**
Wales	**6%**	6%	**4%**	5%	**4%**
Scotland	**9%**	9%	**9%**	9%	**9%**
Northern Ireland	**4%**	4%	**3%**	3%	**2%**

Weighted proportions. Income Q1 indicates income quintile 1 (the lowest) and so on. Observations: 3378, 2777, 2309, 2208, 1972 in each income quintile group respectively.

Figure 1. Mean developmental ages for 62-month old children on the BAS Naming Vocabulary test, by income quintile

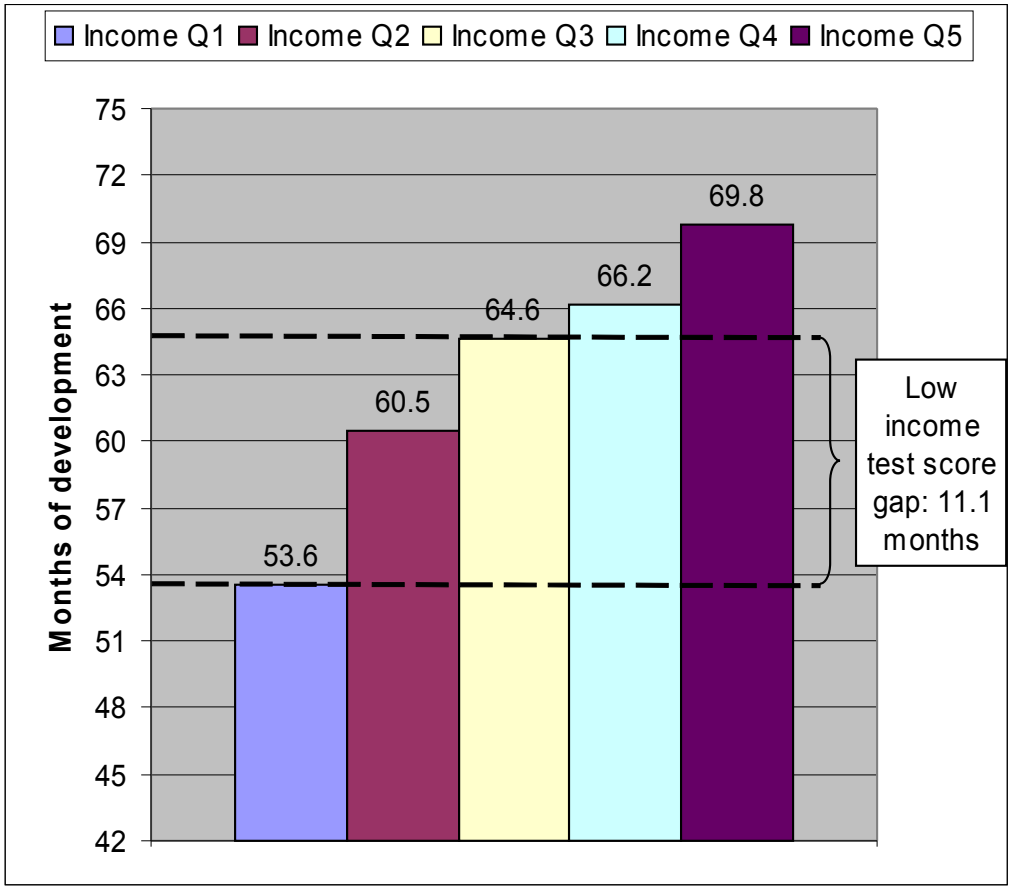
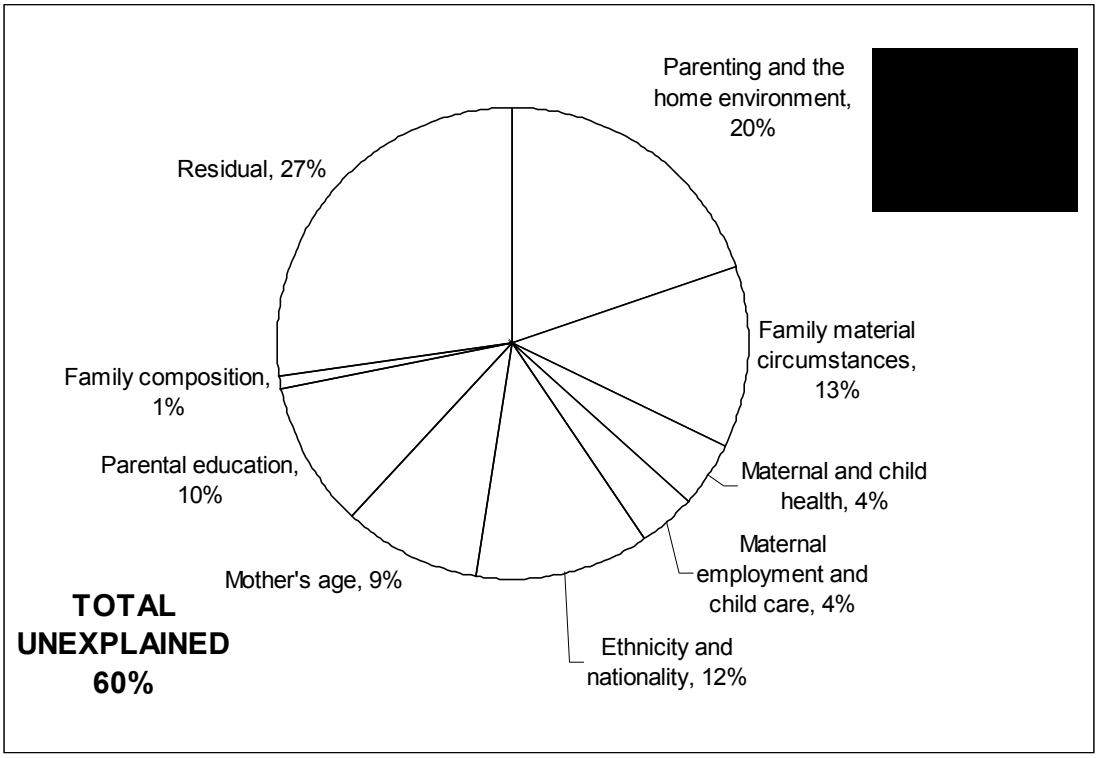


Table 3. Mean cognitive developmental ages, by income quintile

	Naming Vocabulary		Picture Similarities		Pattern Construction	
Income group	Mean	[95% CI]	Mean	[95% CI]	Mean	[95% CI]
Quintile 1	53.6	[52.5, 54.7]	56.9	[55.4, 58.4]	57.4	[56.6, 58.3]
Quintile 2	60.5	[59.7, 61.3]	61.3	[60.2, 62.5]	61.3	[60.5, 62.1]
Quintile 3	64.6	[63.8, 65.5]	62.5	[61.4, 63.7]	63.5	[62.8, 64.3]
Quintile 4	66.2	[65.3, 67.0]	63.5	[62.3, 64.7]	64.3	[63.4, 65.1]
Quintile 5	69.8	[68.8, 70.8]	68.3	[67.1, 69.5]	66.3	[65.5, 67.2]
Low income gap (Q3-Q1)	11.1		5.6		6.1	
High income gap (Q5-Q3)	5.2		5.8		2.8	

Figure 2. Share of the low-to-middle income gap in vocabulary scores explained by intervening factors



Percentages are shares of the total low- to middle-income vocabulary test score gap of 11.1 months (see Figure 1).

Table 4. The contribution of intervening factors to the low-to-middle income gap in vocabulary test scores

Sub-group	Example items	Contribution to test score gap
Parenting and the home environment		**19.7%**
i. Home learning environment	Child read to daily; Child taught alphabet/ numbers/songs; Child taken to library; Child taken to plays/concerts; museums/galleries; zoo; Hours of TV and computer games	11.4%
ii. Parenting style	Interviewer rating of sensitivity of mother-child interactions; Regular bedtimes and mealtimes; Enforcement of rules; Smacking	9.3%
iii. Health-related behaviours	Breast feeding; prenatal care; smoking; alcohol	-1.1%
Material circumstances		**12.6%**
i. Material possessions	Internet in home; car access; ownership of durables (e.g. washing machine, video, dishwasher); Unable to afford key items (e.g. coat and shoes for child; fruit/veg; holidays)	12.2%
ii. Neighbourhood conditions	Index of Multiple Deprivation; Rural location; Interviewer rating of local area, Mother's satisfaction with local area	3.2%
iii. Housing conditions	Social housing; Damp; Crowding; Access to garden; Home is clean/uncluttered/light/safe	1.8%
iv. Financial stress	Behind with bills; Difficult to manage financially; No regular savings	-4.5%
Maternal and child health		**4.5%**
i. Child health	Birth weight; Gestation; Special Care Unit at birth; Mother's rating of general health	2.3%
ii. Maternal physical health	Self-rated general health; Longstanding limiting illness; Overweight/Obese	0.3%
iii. Maternal psychosocial wellbeing	Post-natal depression; Psychological distress; Social support; Self esteem; Locus of control; Life satisfaction	1.8%
Maternal employment and child care		**3.8%**
	Employed part-time/full-time; Childminder/ day nursery at 9 mos; Type of early education centre attended	3.8%

Percentages are shares of the total poverty vocabulary test score gap of 11.1 months (see Figure 1).

Table 5. Largest single predictors of the low-to-middle income gap in vocabulary test scores

Item (Domain)	Contribution to low-to-middle income test score gap		
	Naming Vocabulary	Picture Similarities	Pattern Construction
No internet in home (Material circumstances)	7.2%	13.1%	5.4%
No access to car/van (Material circumstances)	6.2%	13.4%	10.6%
Interviewer rating of sensitivity of mother-child interactions (Parenting and the home environment)	4.4%	9.4%	8.1%
Taken to museum/gallery in last year (Parenting and the home environment)	3.7%	3.5%	1.6%
Child read to daily (Parenting and the home environment)	3.3%	0.2%	0.6%
Regular bedtimes (Parenting and the home environment)	2.5%	6.1%	3.2%
Taken to library at least once a month (Parenting and the home environment)	2.4%	3.7%	2.2%
Taken to play/concert in last year (Parenting and the home environment)	2.0%	-0.8%	1.4%
Birth weight (Maternal and child health)	1.3%	3.8%	3.8%
Breast feeding (Parenting and the home environment)	1.3%	9.3%	2.2%
Mother's rating of child's general health (Maternal and child health)	1.2%	4.0%	4.6%
Total contribution of items to the test score gap	35.5%	65.7%	43.7%
Overall low- to middle-income test score gap	11.1 mths	5.6 mths	6.1 mths

Ranked by contribution to vocabulary test score gap.

Figure 3. Demographic factors associated with the unexplained low- to middle-income gap in vocabulary test scores

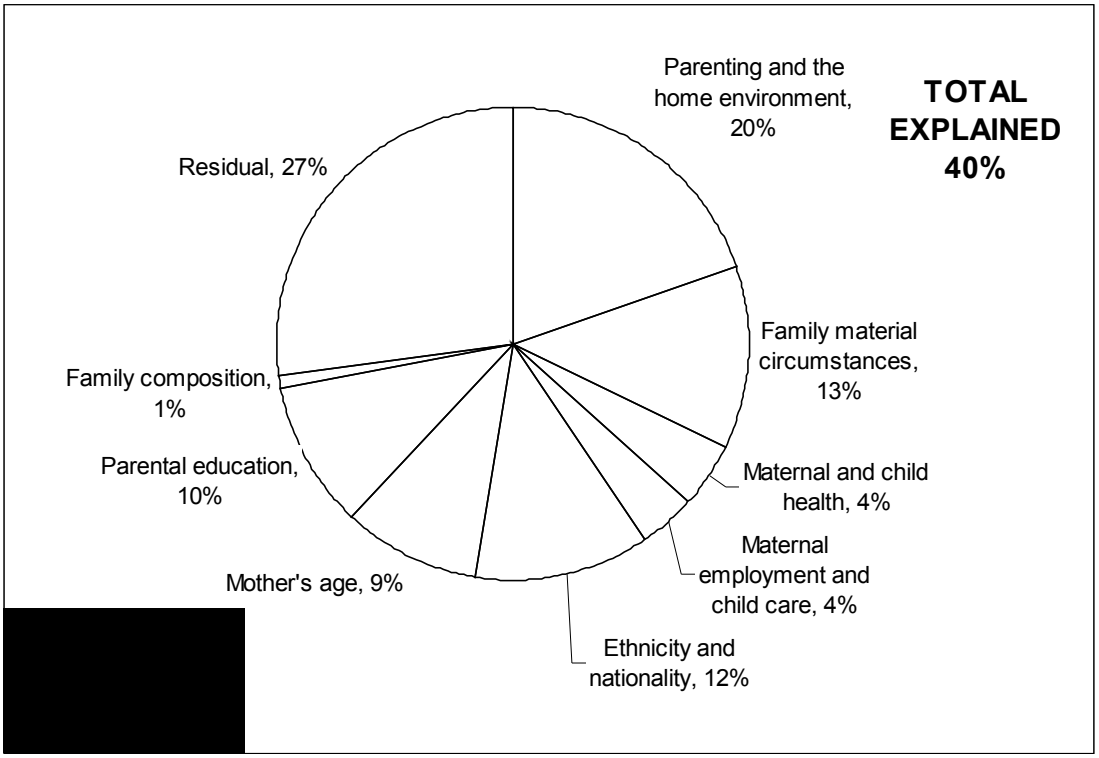


Table 6. Home learning environment, income group and vocabulary test scores at 5

	Mean of variable				
	(1) Low income group	(2) Middle income group	(3) High income group	(4) Effect on test score age	(5) Contribution to test score gap
Child read to daily at 3	45%	65%	78%	1.92	3.4%
Child read to daily at 5	45%	52%	63%	n.s.	-
Teaching of letters/numbers/songs score at 3	12.74	13.26	13.58	0.13	0.6%
Taken to library at least once a month at 3	24%	38%	45%	1.39	1.8%
Taken to library at least once a month at 5	30%	36%	41%	1.14	0.6%
Taken to play/concert in last year at 5	33%	51%	72%	0.96	2.0%
Taken to museum/gallery in last year at 5	57%	78%	89%	2.03	3.7%
Taken to zoo in last year at 5	74%	86%	94%	n.s.	-
Sporting activity at least once a week at 5	30%	63%	81%	n.s.	-
More than 3 hrs TV a day at 3	27%	13%	5%	1.20	-1.5%
More than 3 hrs TV a day at 5	22%	12%	8%	n.s.	-
More than 1 hr computer games a day at 5	30%	20%	12%	-0.59	0.5%
Total contributions omitted from table					0.3%
Total test score gap explained by home learning environment					11.4%

Low, middle and high income group indicates membership of the first, third and fifth income quintile groups respectively.

The effect on the test score is the difference in months of vocabulary development associated with a one unit change in the variable, *holding all else equal*. Hence a child who is read to daily at age 3 is predicted to score 1.92 months ahead of an observationally equivalent child who is not read to regularly.

Statistically insignificant effects (at the 10% level) on test scores are omitted from the table (indicated by n.s.), along with the associated contribution to the test score gap. All variables, however, are used in calculating the total contribution of the factor considered in the table.

The contribution of a variable to the test score gap combines the degree of income-grading (shown in Columns 1 to 3) and the strength of the effect of the outcome (shown in Column 4).

Calculations based on sample of 12,644 children.

Slight discrepancies in sum of rows to total due to rounding.

The Teaching of letters/numbers/songs score takes values from 0 to 21, with a mean of 13.27 and a standard deviation of 5.29. It is derived from three question on how often someone at home tries to teach the child: the ABC or the alphabet; numbers or counting; and songs, poems or nursery rhymes. There are 8 possible responses for each item, scored from 0 (never) to 7 (every day), which are summed to generate the total score.

Table 7. Parenting style, income group and vocabulary test scores at 5

	Mean of variable				
	(1) Low income group	(2) Middle income group	(3) High income group	(4) Effect on test score	(5) Contribution to test score gap
Sensitivity of mother-child interactions score at 3	9.70	10.38	10.56	0.87	4.4%
Regular bedtimes at 3	70%	84%	91%	0.94	1.2%
Regular bedtimes at 5	85%	94%	95%	1.63	1.3%
Regular mealtimes at 3	85%	94%	97%	n.s.	-
Regular mealtimes at 5	88%	96%	97%	n.s.	-
Lots of rules at 3	27%	31%	35%	n.s.	-
Strictly enforced rules at 3	42%	51%	57%	0.59	0.5%
Requests enforced at least half the time at 5	77%	86%	90%	n.s.	-
Child smacked at least once a month at 3	15%	16%	13%	n.s.	-
Child smacked at least once a month at 5	12%	12%	9%	-1.03	-0.1%
Child put in timeout at least once a month at 3	47%	50%	56%	n.s.	-
Child put in timeout at least once a month at 5	65%	66%	63%	-0.68	-0.3%
Authoritative parenting beliefs score at 9 mos	16.21	16.66	17.03	n.s.	-
Total contributions omitted from table					2.3%
Total test score gap explained by parenting style					9.3%

See notes to Table 6.

The sensitivity of mother-child interactions score takes values from 0 to 11, with mean 10.28 and standard deviation 1.15. It is derived from the sum of 11 binary items completed by the interviewer following the child cognitive assessment: Parents provided toys for child during the visit; Parent kept child in visual range when the child was not cared for by someone else, looked often at him/her; When speaking of or to the child, mother's voice conveys positive feeling; Mother converses with child at least twice during visit (scolding and degrading comments are not counted); Mother answers child's questions or requests verbally; Mother spontaneously praises child's qualities or behaviour twice during the visit; Mother caresses, kisses or cuddles child at least once during the visit; Mother introduces interviewer to the child; Mother scolded (shouted) or made derogatory comments to child more than once during the visit (reversed); Mother used physical restraint, grabbed, or pinched child during the visit (reversed); and Mother slapped or spanked child during visit (reversed).

The authoritative parenting beliefs score takes values from 0 to 20, with mean 16.63 and standard deviation 1.95. It is derived from five items, in which the mother was asked to rate the strength of her agreement with the following statements: Babies should be picked up whenever they cry; It is important to develop a regular pattern on feeding and sleeping with a baby; Babies need to be stimulated if they are to develop well; Talking, even to a young baby, is important; Cuddling a baby is very important. Responses are scored from 0 (Strongly disagree) to 4 (Strongly agree) and summed.

Table 8. Health-related behaviours, income group and vocabulary test scores at 5

	Mean of variable				
	(1) Low income group	(2) Middle income group	(3) High income group	(4) Effect on test score	(5) Contribution to test score gap
Breastfed, but less than 6 months	41%	50%	51%	n.s.	-
Breastfed 6 months or more	14%	26%	38%	1.02	1.1%
No prenatal care in first trimester	28%	15%	12%	n.s.	-
Child exposed to smoke in home at 3	34%	11%	4%	n.s.	-
Child exposed to smoke in home at 5	28%	8%	3%	n.s.	-
# cigarettes smoked per day in pregnancy	4.39	1.59	0.70	n.s.	-
Drank alcohol once a week or more in pregnancy	7%	9%	18%	n.s.	-
Drinks alcohol once a week or more at 3	30%	47%	69%	-0.71	-1.0%
Drinks alcohol once a week or more at 5	31%	47%	70%	n.s.	-
# symptoms of problem drinking at 3	0.19	0.15	0.23	n.s.	-
Used recreational drugs since birth of child	10%	5%	3%	1.10	-0.5%
Total contributions omitted from table					-0.7%
Total test score gap explained by health-related behaviours					-1.1%

See notes to Table 6.

Reference group for breast feeding is Did not breastfeed at all.

possible symptoms of problem drinking is 4: Ever felt you should cut down on your drinking; People annoyed you by criticising your drinking; Felt bad or guilty about drinking; Ever had a drink first thing in the morning to steady your nerves or to get rid of a hangover.

Table 9. Material possessions, income group and vocabulary test scores at 5

	Mean of variable				
	(1) Low income group	(2) Middle income group	(3) High income group	(4) Effect on test score	(5) Contribution to test score gap
No internet in home at 3	72%	32%	15%	-0.82	3.0%
No internet in home at 5	62%	17%	5%	-1.04	4.1%
No fully working phone in home at 3	6%	1%	0%	n.s.	-
No access to car/van at 3	39%	3%	0%	-1.89	6.2%
No fridge at 9 mos	1%	0%	0%	n.s.	-
No washing machine at 9 mos	4%	1%	0%	n.s.	-
No freezer at 9 mos	5%	2%	1%	n.s.	-
No microwave at 9 mos	10%	5%	6%	1.22	-0.5%
No video at 9 mos	11%	3%	2%	n.s.	-
No tumble dryer at 9 mos	48%	31%	26%	0.66	-1.0%
No computer at 9 mos	66%	35%	15%	n.s.	-
No dishwasher at 9 mos	87%	61%	27%	n.s.	-
Can't afford:					
Warm waterproof coat for child at 3	1%	0%	0%	n.s.	-
Warm waterproof coat for child at 5	3%	0%	0%	n.s.	-
New properly fitted shoes for child at 3	2%	1%	0%	n.s.	-
2 pairs of weatherproof shoes for child at 5	5%	1%	0%	n.s.	-
Fresh fruit/veg every day for child at 3	3%	0%	0%	n.s.	-
Celebrations for special occasions at 5	4%	0%	0%	n.s.	-
2 pairs of weatherproof shoes for self at 3	15%	2%	0%	n.s.	-
Hobby/leisure activity at 3	28%	7%	2%	n.s.	-
Small amount of weekly money for self at 3	40%	14%	2%	n.s.	-
Small amount of weekly money for self at 5	44%	17%	3%	n.s.	-
Insurance contents for home at 3	41%	2%	0%	n.s.	-
To replace worn-out furniture at 3	43%	12%	2%	n.s.	-
Holiday once a year at 3	57%	15%	3%	n.s.	-
Holiday once a year at 5	57%	18%	3%	n.s.	-
Total contributions omitted from table					0.4%
Total test score gap explained by material possessions					12.2%

See notes to Table 6.

Table 10. Neighbourhood conditions, income group and vocabulary test scores at 5

	Mean of variable				
	(1) Low income group	(2) Middle income group	(3) High income group	(4) Effect on test score	(5) Contribution to test score gap
Index of Multiple Deprivation decile	3.51	5.97	7.54	n.s.	-
Rural/village location	7%	12%	14%	1.54	0.8%
Local n'hood unsafe/uncomfortable at 3	23%	3%	1%	n.s.	-
Mother's satisfaction with n'hood score at 9 mos	3.84	4.27	4.47	n.s.	-
Total contributions omitted from table					2.4%
Total test score gap explained by neighbourhood conditions					3.2%

See notes to Table 6.

The Index of Multiple Deprivation is a within-country measure that ranks each Lower Super Output Area in terms of a range of indicators of deprivation in 2004 to 2005. Areas with a rank of 1 are the most deprived 10 percent of areas within that country (i.e. within England, Wales, Scotland or Northern Ireland). Areas with a rank of 10 are the least deprived 10 percent. The local deprivation indicator relates to place of residence when the study child was 9 months old.

Local neighbourhood is coded as unsafe/uncomfortable at 3 if the interviewer reported any of the following about family's street: I would be uncomfortable living/working/shopping here; I felt like an outsider, looked on suspiciously; I felt afraid for my personal safety.

Mother's satisfaction with neighbourhood is ranked on a five-point scale from 1 (Very dissatisfied) to 5 (Very satisfied).

Table 11. Housing conditions, income group and vocabulary test scores at 5

	Mean of variable				
	(1) Low income group	(2) Middle income group	(3) High income group	(4) Effect on test score	(5) Contribution to test score gap
In social housing part of time to age 5	23%	7%	0%	n.s.	-
Always in social housing	44%	5%	0%	n.s.	-
More than 1 person per room at 3	17%	3%	1%	n.s.	-
More than 1 person per room at 5	17%	4%	1%	-1.61	1.8%
Damp in home a problem at 3	13%	4%	2%	n.s.	-
Damp in home a problem at 5	14%	5%	2%	n.s.	-
No access to garden at 3	14%	4%	1%	n.s.	-
No access to garden at 5	12%	4%	1%	n.s.	-
Home is clean/light/uncluttered/safe score at 3	3.63	3.88	3.93	n.s.	-
Total contributions omitted from table					0.0%
Total test score gap explained by neighbourhood conditions					1.8%

See notes to Table 6.

The Home is clean/light/uncluttered/safe score is the sum of four binary indictors, relating to interviewer reports of whether the child's in-home play environment was safe; all visible rooms were reasonably clean; all visible rooms were reasonably uncluttered; the interior of the home was not dark or perceptually monotonous.

Table 12. Financial stress, income group and vocabulary test scores at 5

	Mean of variable				
	(1) Low income group	(2) Middle income group	(3) High income group	(4) Effect on test score	(5) Contribution to test score gap
No regular savings at 3	73%	49%	28%	n.s.	-
No regular savings at 5	75%	51%	30%	n.s.	-
Behind with bills at 3	34%	6%	2%	0.99	-2.5%
Behind with bills at 5	34%	6%	2%	n.s.	-
Difficult to manage financially at 3	19%	6%	2%	n.s.	-
Difficult to manage financially at 5	20%	8%	1%	n.s.	-
Total contributions omitted from table					-2.0%
Total test score gap explained by neighbourhood conditions					-4.5%

See notes to Table 6.

Table 13. Child health, income group and vocabulary test scores at 5

	Mean of variable				
	(1) Low income group	(2) Middle income group	(3) High income group	(4) Effect on test score	(5) Contribution to test score gap
Birth weight (kg)	3.24	3.39	3.43	0.92	1.3%
Gestation length (days)	276.4	276.7	277.6	-0.03	-0.1%
Special Care Unit at birth	9%	9%	10%	n.s.	-
Child's general health score at 5	4.11	4.39	4.54	0.46	1.2%
Total contributions omitted from table					-0.1%
Total test score gap explained by child health conditions					2.3%

See notes to Table 6.

Child's general health score is the mother's rating on a scale from 1 (Poor) to 5 (Excellent), with mean 4.35 and standard deviation 0.83.

Table 14. Maternal physical health, income group and vocabulary test scores at 5

	Mean of variable				
	(1) Low income group	(2) Middle income group	(3) High income group	(4) Effect on test score	(5) Contribution to test score gap
Mother's general health score at child age 5	3.27	3.70	3.99	n.s.	-
Longstanding illness limits activity at child age 5	19%	13%	8%	n.s.	-
Mother overweight at child age 3	24%	26%	21%	n.s.	-
Mother obese at child age 3	17%	14%	7%	n.s.	-
Mother overweight at child age 5	26%	26%	21%	-0.85	-0.2%
Mother obese at child age 5	19%	15%	9%	-1.11	0.3%
Total contributions omitted from table					0.2%
Total test score gap explained by maternal physical health					0.3%

See notes to Table 6.

Overweight indicates body mass index (BMI) between 25 and 30, obese a BMI of 30 or more. BMI is calculated as weight in kg divided by height in metres squared. The omitted category is mother is normal or underweight.

Mother’s general health score rated on a scale from 1 (Poor) to 5 (Excellent), with mean 3.65 and standard deviation 1.00.

Table 15. Maternal psychosocial wellbeing, income group and vocabulary test scores at 5

	Mean of variable				
	(1) Low income group	(2) Middle income group	(3) High income group	(4) Effect on test score	(5) Contribution to test score gap
Mother at risk of post-natal depression	20%	11%	7%	n.s.	-
Psychological distress score at 3	4.56	2.84	2.25	n.s.	-
Psychological distress score at 5	4.29	2.74	2.00	n.s.	-
Social support score at 9 mos	8.58	9.66	10.15	n.s.	-
Self esteem score	12.29	12.92	13.37	n.s.	-
Locus of control score	4.53	5.36	5.74	n.s.	-
Life satisfaction score at 3	7.13	8.07	8.41	n.s.	-
Life satisfaction score at 5	6.82	7.68	8.19	n.s.	-
Mother has problems with basic literacy/ numeracy	15%	6%	5%	n.s.	-
Total contributions omitted from table					1.8%
Total test score gap explained maternal psychosocial wellbeing					1.8%

See notes to Table 6.

A mother is classed as at risk of post-natal depression if she reported 4 or more symptoms on the nine-item Malaise Inventory (e.g. Do you often feel miserable or depressed?) at 9 months post-birth.

Psychological distress was measured using the Kessler 6 scale. Respondents reported how often they felt each of six symptoms on a scale on 0 to 4 (e.g. how often they felt hopeless). Items were summed to give a score ranging from 0 to 24 with mean 3.1 and standard deviation 3.5 at age 3, and mean 2.9 and standard deviation 3.6 at age 5.

The social support score is the sum of three items (e.g. There are other parents I can talk to about my experiences), each scored from 0 to 4 depending on the strength of agreement and summed. The total has a mean of 9.5 and a standard deviation of 2.0.

Self esteem was measured using 6 items from the Rosenberg Self Esteem scale (e.g. On the whole, I am happy with myself). Items were scored from 0 to 3, depending on strength of agreement, and summed to give a total with a range of 0 to 18, mean 12.8 and standard deviation 2.7.

The locus of control scale is the sum of three items, each scored 0, 1 or 2 (e.g. Whatever I do has no real effect on what happens to me). The total score has a mean of 5.3 and standard deviation 1.3.

Life satisfaction is measured on a scale of 1 to 10 – the response to the question "How satisfied or dissatisfied are you with the way your life has turned out so far?" Mean 7.9, standard deviation 1.7 at age 3 (7.6 and 1.9 respectively at age 5).

A mother is classed as having problems with basic literacy or numeracy if she has difficulties: reading aloud from a child's storybook; reading and filling out forms; or calculating change in a shop.

Table 16. Maternal employment and child care, income group and vocabulary test scores at 5

	Mean of variable				
	(1) Low income group	(2) Middle income group	(3) High income group	(4) Effect on test score	(5) Contribution to test score gap
Mother worked in pregnancy	41%	81%	87%	0.82	3.0%
Mother worked in first 3 months after birth	8%	17%	9%	-1.07	-0.9%
Mother works part-time at 9 mos	14%	49%	39%	n.s.	-
Mother works full-time at 9 mos	4%	16%	34%	n.s.	-
Mother works part-time at 3	18%	51%	41%	ns	-
Mother works full-time at 3	4%	16%	30%	1.10	1.2%
Mother works part-time at 5	22%	53%	42%	n.s.	-
Mother works full-time at 5	6%	20%	31%	n.s.	-
Childminder at 9 mos	1%	6%	13%	n.s.	-
Day nursery/creche at 9 mos	1%	6%	26%	n.s.	-
Attended nursery class/school by 5	67%	55%	54%	-0.77	0.8%
Attended playgroup by 5	30%	37%	28%	n.s.	-
Attended preschool by 5	15%	32%	31%	n.s.	-
Attended childminder by 5	6%	14%	20%	n.s.	-
Attended day nursery/creche by 5	10%	14%	27%	n.s.	-
Total contributions omitted from table					-0.3%
Total test score gap explained by maternal employment and child care					3.8%

See notes to Table 6.

Part-time work is defined as less than 30 hours of work per week.

[1] To be in this sample, we also require that the child's biological mother participated in interviews (as the main respondent) at the 9 month, 3 and 5 year waves. This restriction led to the exclusion of 2455 children.
[2] We use the survey weights provided with the data to correct for the fact that disadvantaged groups were oversampled, and so approximate as closely as possible quintiles of the national distribution of all children born in the UK in 2001.
[3] The Naming Vocabulary test was offered in English and Welsh versions to children in Wales. 25 children took the Welsh version. The two non-verbal tests were conducted in English only.
[4] In fact, the estimated gap in means between the low- and middle-income groups used in our calculation may differ very slightly from that implied by the tables. This is due to the problem of item non-response. The means shown in Tables 6 to 16 are calculated over non-missing observations of the variable in question. For estimation purposes we use mean-replacement of missing values, and account for differential response patterns across income groups via a set of binary missing indicators. (The coefficients on these indicators then form part of the residual unexplained category shown in Figure 3.) In order to avoid showing two virtually identical sets of variable means, we choose to show only the version derived from all valid cases
[5] Although it is not shown in the tables, the contribution of a variable to the low- to *high*-income gap can be calculated similarly as the product of the estimated effect and the difference in means between the low- and high- income groups.
[6] All information on maternal cigarette, alcohol and drug use is self-reported, and as such may be unreliable if stigma plays a role in reporting behaviour.