2010

Impact of the Home Learning Environment on child cognitive development: Secondary analysis of data from 'Growing Up in Scotland'

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Abstract

This study aims to investigate whether interview-based measures of children's activities are associated with cognitive ability at age 34 months, and whether they have independent effects once socio-demographic factors have been taken into account.

Keywords

child, cognitive, secondary, impact, development, analysis, home, data, growing, up, learning, scotland, environment

Disciplines

Education | Social and Behavioral Sciences

Publication Details

Melhuish, E. (2010). Impact of the Home Learning Environment on child cognitive development: Secondary analysis of data from 'Growing Up in Scotland'. Edinburgh, United Kingdom: The Scottish Government.

The Scottish Government

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Education

IMPACT OF THE HOME LEARNING ENVIRONMENT ON CHILD COGNITIVE DEVELOPMENT: SECONDARY ANALYSIS OF DATA FROM 'GROWING UP IN SCOTLAND'

Edward Melhuish

Scottish Government Social Research
2010

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EXECUTIVE SUMMARY

Background

1. Researchers in both the UK and the US have noted a gap in 'school readiness', i.e. how well prepared children are to start school, between children from less advantaged and more advantaged backgrounds. However, various research studies have also found that parenting and children's activities in the early years can make a difference to children's outcomes.

2. A composite measure of a child's home learning environment has been developed in the Effective Provision of Pre-school Education (EPPE) project, the National Evaluation of Sure Start (NESS) and the Millennium Cohort Study (MCS). This composite measure of the Home Learning Environment was then found to be very effective in predicting future development for the EPPE, NESS and MCS longitudinal studies.

Aim and objectives

3. This study aims to investigate whether interview-based measures of children's activities are associated with cognitive ability at age 34 months, and whether they have independent effects once socio-demographic factors have been taken into account.

4. The objectives of this report are:

   - to replicate, using GUS data, methods previously used with EPPE data to determine which variables should be included in a composite Home Learning Environment index
   - to calculate the index, using the variables identified
   - to examine the ability of the index to independently predict cognitive outcomes at age 34 months

Data

5. Growing Up in Scotland is a longitudinal study aimed at tracking the lives of a cohort of Scottish children, from the early years through to childhood and beyond. In 2005, data were collected on a cohort of 5,217 children aged approximately 10 months, and they have been followed up annually since then.

6. In this report, eight activity measures from the Year 1 interview, 18 from the Year 2 interview and 25 from the Year 3 interview (i.e. 51 activities in total) were considered for their relationship with cognitive development. A small number of these measures had been examined in the original EPPE work on this topic (Melhuish et al., 2001; 2008), but the majority had not been tested in this way in previous research.

7. Cognitive and language ability in the birth cohort was measured at the 3 year contact by two assessments: the naming vocabulary and picture similarities subtests of the British Ability Scales (BAS).

Statistical analysis

8. Firstly, multilevel models were constructed for each of the cognitive outcomes (BAS naming vocabulary and picture similarities at age 3 years), with the following tested as predictors: age, child gender, birth weight, number of siblings, respondent and partner (parental) education, household socio-economic status, lone parent status, child developmental status in the first year, child health status in the first, second and third years, amount of centre-based care/education, and home area characteristics (deprivation and urban/rural).

9. From the baseline demographic multilevel models for naming vocabulary and picture similarities measures of relative over- and under-achievement were calculated for each outcome. Three categories of relative achievement (performance) were used (unexpected over-achievers, average i.e. as expected, and unexpected under-achievers) for both child outcomes.

10. Each of 51 home activity items derived from the GUS interviews were analysed separately with a multinomial logistic regression for any significant association with the individual categorical variables of over- or underachievement. On the basis of these results activities were selected for inclusion in a Home Learning Environment index.

11. From consideration of the analyses of over- and under-achievement and analyses of internal consistency, nine activity items were chosen to form a Home Learning Environment index.

12. The correlations of this HLE index with Household socio-economic status was 0.22, with respondent's (mother's) education was 0.20, and with partner's (father's) education was 0.10. This indicates that this measure of learning opportunities provided in the home is only slightly associated with parental socio-economic and educational status and that it can be regarded as a measure that is relatively independent of family demographics.

13. To further examine the effects of HLE on the prediction of achievement over that provided by family and background characteristics for children, new multilevel models for Naming Vocabulary and Picture Similarities were created that added the HLE (see Table 2). Comparison of models indicates a significant contribution of the HLE to children's attainment. Adding the HLE to the demographic model, the child level variance explained increased by 30% for Naming Vocabulary and 21% for Picture Similarities.

Discussion and conclusions

14. In the analyses presented in this report, it is clear that a measure of the Home Learning Environment (HLE) added to the understanding of the influences that might affect a child's cognitive development. The influence of the HLE was over

and above that of standard measures of family socio-demographic factors such as parental education, socio-economic status and income.

15. Of the nine activity measures selected in the this report for inclusion in the Home Learning Environment measure, eight are similar to those identified in the original EPPE research in England (Melhuish et al., 2001; 2008a) and the ninth item (number of children's books in home) is similar to an item (number of books in home) identified in several previous studies (e.g. Kirsch et al., 2002) as being related to children's cognitive development or educational achievement. Hence, the findings in this report are supported by research on other populations. It is interesting to note that none of the other items in the 51 tested added further to a measure of the Home Learning Environment.

16. Research findings such as those reported here suggest that policies that encourage active parenting strategies (including for disadvantaged parents) can help to promote young children's cognitive development and educational achievement both early and later in development.

1 INTRODUCTION

Policy background

1.1 One of the Scottish Government's five strategic objectives is a 'Smarter Scotland' - to expand opportunities for people in Scotland to succeed, from nurture through to life long learning, ensuring higher and more widely shared achievements. A smarter Scotland is critical to delivering the Government's overarching purpose of achieving sustainable economic growth (Scottish Government, 2007).

1.2 The Scottish Government aims to deliver a Smarter Scotland through all 15 of its national outcomes, but with a particular focus on the following four outcomes:

- We are better educated, more skilled and more successful, renowned for our research and innovation.
- Our young people are successful learners, confident individuals, effective contributors and responsible citizens.
- Our children have the best start in life and are ready to succeed.
- We have improved the life chances for children, young people and families at risk.

1.3 The Scottish Government recognises that the early years (including pre-birth) play an important part in setting the pattern for our future adult life. The Early Years Framework (Scottish Government, 2008) seeks to provide the opportunities for children to get the best start in life and to provide a platform for future success.

Research background

Importance of cognitive development

1.4 Cognitive development refers to changes in reasoning, thinking, problem-solving, language acquisition and processes of acquiring, storing, remembering and using information about the environment. It also includes learning about the world. These developmental achievements are highly interdependent; many of the cognitive functions children acquire depend on a certain degree of maturation within the growing brain before they can be performed adequately.

1.5 Several previous longitudinal studies have established that early cognitive ability influences later outcomes. For example, Feinstein (2003) used data from the 1970 Birth Cohort Study (BCS) to show that assessments of ability at 22 and 42 months predicted educational outcomes at age 26 years. Feinstein also demonstrated that low scoring children from high socio-demographic status families were more likely to have progressed and improved their position in later years than similarly scoring children from more disadvantaged backgrounds who tend to stay at the bottom end of the distribution. Other

research confirms that early poor cognitive ability is likely to have a negative impact on several aspects of development in the realms of education, employment, health and social development (Duncan and Brooks-Gunn, 1997; Essen and Wedge, 1978; Rutter and Madge, 1976).

Factors influencing cognitive development

Socio-economic status

1.6 Many research studies document the relationship of socio-economic status (SES) to cognitive development and academic achievement (e.g. Bloom 1964, Feinstein, 2003). The extent and persistence of deficits in academic achievement associated with low SES (and minority ethnic status) led to policy initiatives in the USA such as the *Elementary and Secondary Education Act* of 1965 and the recent *No Child Left Behind Act* of 2001. Similar thinking also applies to policies in other countries, such as Sure Start in the UK, aiming to improve schooling outcomes for disadvantaged children.

1.7 However, studies indicate that the relationship between SES and cognitive development is present at preschool age (e.g. Denton, West & Walston, 2003) and, indeed, is even present in infancy (McCall 1981). Such evidence suggests that the causes of poor academic achievement may partly lie in experiences and development during the early years. For example, Heckman and Wax (2004) recently proclaimed, “Like it or not, the most important mental and behavioral patterns, once established, are difficult to change once children enter school”. This may be overstated, but the importance of the early years is clear.

Home learning environment

1.8 Substantial research evidence indicates that parenting and children’s activities in the early years have a powerful influence on cognitive ability (e.g., Lugo-Gill and Tamis-LeMonda, 2008; Melhuish et al, 2001; 2008a, b). Parenting practices such as reading to children, using complex language, responsiveness, and warmth in interactions, are all associated with better developmental outcomes (Bradley 2002). Stimulating activities may help children with specific skills (e.g. linking letters to sounds) but also, and perhaps most importantly, by developing the child’s ability and motivation concerned with learning generally. This partly explains links between SES and developmental outcomes, in that higher SES parents use more developmentally enhancing activities (Hess et al., 1982). The strong interrelationships between parenting, activities and socio-demographic factors – for example parents’ willingness to read to their children and their own educational background – means that any analysis that attempts to explore the impact of activities needs to take account of these wider influences.

Composite measures of the home learning environment

1.9 The most successful research measures in the field of child development, in terms of explaining child outcomes, have often been composite measures. The

advantages of composite measures over individual measures as predictor variables include the following:

- They are generally more reliable (because an error on an individual component does not cause the whole measurement to go wrong).
- There is generally greater variability in respondents' scores (allowing greater discrimination amongst individuals).
- They can be used to address the issue of multicollinearity (i.e. when two or more explanatory variables in a multiple regression model are highly correlated).
- They can be theoretically based upon existing knowledge of what is important.
- They can integrate across items that initially appear separate but are functionally similar.

1.10 A composite measure of a child's home learning environment has been developed in the Effective Provision of Pre-school Education (EPPE) project and the National Evaluation of Sure Start (NESS). In the case of the EPPE project, multilevel modelling was used to determine which of a variety of measures available should be combined together in the composite (Melhuish et al., 2008a).

Aim and objectives

1.11 This study aims to investigate whether interview-based measures of children's activities are associated with cognitive ability at age 34 months, and whether they have independent effects once socio-demographic factors have been taken into account.

1.12 The specific objectives are:

- to replicate, using GUS data, methods previously used with EPPE data to determine which variables should be included in a composite Home Learning Environment index
- to calculate the index, using the variables identified
- to examine the ability of the index to independently predict cognitive outcomes at age 34 months.

2. DATA

The Growing up in Scotland (GUS) study

2.1 Growing Up in Scotland (GUS) is a longitudinal study aimed at tracking the lives of a cohort of Scottish children, from the early years through childhood and beyond. Focusing initially on a cohort of 5,217 children aged approximately 10 months at the time of first interview (the birth cohort) and a cohort of 2,859 children aged approximately 34 months at the time of first interview, the first wave of fieldwork began in April 2005. Annual data collection from both cohorts has been undertaken since that time. The analysis in this report concerns children in the birth cohort only.

GUS sample design

2.2 The GUS sample is geographically clustered, to facilitate obtaining a representative random sample of children which could be accessed efficiently by the interviewers from the study The area-level sampling frame was created by aggregating Data Zones. Data Zones are small geographical output areas created for the Scottish Government and used to release small area statistics. The Data Zone geography covers the whole of Scotland. The geography is hierarchical, with Data Zones nested within Local Authority boundaries. Each data zone contains between 500 and 1,000 household residents. More information can be found on the Scottish Neighbourhood Statistics website: http://www.sns.gov.uk.

2.3 The Data Zones were aggregated to give an average of 57 births per area per year (based on the average number of births in each Data Zone for the preceding 3 years). It was estimated that this number per area would provide the required sample size. Once the merging task was complete, the list of aggregated areas was sorted by Local Authority and then by the Scottish Index of Multiple Deprivation Score, and 130 areas were then selected at random. These were the Primary Sampling Units (PSUs), and the Department of Work and Pensions sampled children from these 130 sample points.

2.4 Within each sample point, the Child Benefit records were used to identify all babies and three-fifths of toddlers who met the date of birth criterion (June 2004 to May 2005 for the birth cohort and June 2002 to May 2003 for the child cohort). The sampling of children was carried out on a month-by-month basis in order to ensure that the sample was as complete and accurate as possible at time of interview. In cases where there was more than one eligible child in the selected household, one child was selected at random.

Data collection

2.5 The data were collected by a study interviewer in face-to-face interviews with the child's main carer using computer assisted personal interviewing (CAPI). To ensure that respondents were interviewed when their children were approximately the same age, each case was assigned a 'target interview date'. Interviewers were allotted a four-week period based on this date (two weeks either side) in which to secure the interview.

Cognitive development

2.6 Cognitive ability was measured in the GUS birth cohort at age 34 months via two assessments: the naming vocabulary and picture similarities subtests of the British Ability Scales Second Edition (BAS II). These two assessments measure, respectively, language development and problem solving skills. Each subtest is part of a cognitive assessment battery designed for children aged between 2 years and 6 months and 17 years and 11 months. The assessments are individually administered.

2.7 Numerous tests of cognitive ability and intelligence exist but the BAS is particularly suitable for administration in a social survey like GUS. Hill (2005) provides a useful and succinct history of the development of the BAS and its strengths relative to other measures of intelligence. These strengths include:

- its development in Britain using a domestic reference population
- the fact it is comprised of a number of stand-alone components
- its theoretical grounding
- its explicit concern to measure ability rather than intelligence
- versions of the scale can be administered up to the age of 17 years and 11 months, but each age-specific version is specifically designed for the relevant age group.

2.8 The scales are designed to form a composite measure known as General Conceptual Ability (GCA). For the age range 2 years and 6 months to 3 years and 5 months (the age range within which the GUS birth cohort fell at the point of testing), four individual scales contribute directly to the GCA score. A key feature of the BAS is that each sub-scale is also suitable for use in its own right. Due to time limitations within the GUS interview only two of the four scales were used so an overall GCA score cannot be calculated.

2.9 Naming vocabulary requires the child to name a series of pictures of everyday items. In the picture similarities assessments children are shown a row of four pictures on a page. They are asked to place a free-standing card with a fifth picture underneath the picture with which the card shares a similar element or concept. There are 36 items in total in the naming vocabulary assessment and 33 items in the picture similarities assessment. In both scales the items are ordered in terms of increasing difficulty, and to avoid children being upset from repeatedly failing items the number of items asked is dependent on performance, e.g. the naming vocabulary assessment is terminated if five successive items are answered incorrectly.

2.10 The analyses in this report used normative BAS scores, derived from the standard BAS tables and defined with reference to the standardisation samples used in developing the assessments. These normative scores were converted into T-scores based on the values in the standardisation sample for the

applicable age band. T-scores range from 20 to 80 and have a mean of 50. A child with a T-score of 50 is therefore placed at the mean value for their age. Higher scores on either scale denote an increase in cognitive ability and, conversely, lower scores indicate a reduced level of ability. The distributions of these two outcomes, which are approximately normal, are shown in figures 2.1 and 2.2.

Figure 2.1: Distribution of Naming Vocabularly T-Scores

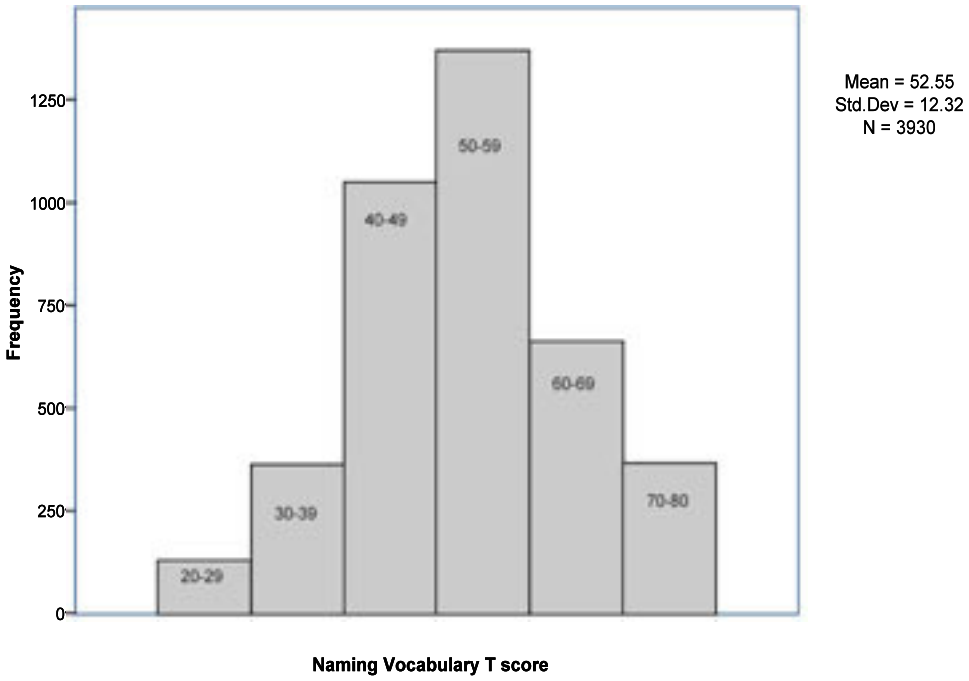
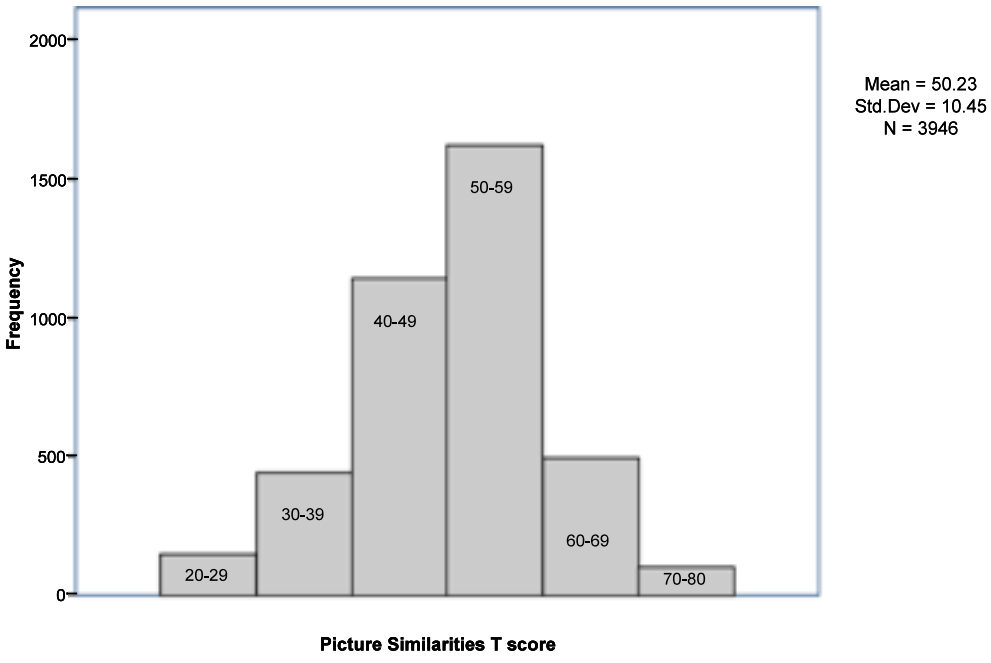


Figure 2.1: Distribution of Picture Similarities T-Scores



Children's activities in the home

Measuring children's activities

2.11 GUS has collected parental reports of children's activities at sweeps 1, 2 and 3. It is worth noting that these reports may be subject to error. Parents may be unaware of the full extent of activities that their children experience, especially if they spend some of their time in the care of others, which could lead to under-reporting. Conversely, parents might be mistaken and recall activities that their child has not actually done. Nevertheless, the parental reports provide a useful overview of children's recent experiences.

Children's activities at 10 months of age

2.12 The range of children's activities asked about at sweep 1 of the study (e.g. playing games with child, reciting nursery rhymes), when the children were aged 10 months, was less extensive than has been the case in subsequent sweeps. This is partly due to time pressures and the range of information it was necessary to include at the very first interview, but it also reflects the less active nature of children at this young age. The questions (see Appendix 3) used the following format:

How often do you (or your partner) look at books with (child) or read stories with (him/her)?

Activities at 22 and 34 months of age

2.13 Subsequent GUS sweeps looked in more detail at the kinds of activities children had done in the previous week (e.g. visiting friends, activities involving a computer). The focus shifted away from parent-child interactions and instead the questions (see Appendix 3) took the following format:

Can you tell me on how many days in the last week (child) has done each of the following things either on (his/her) own or with someone else? By 'the last week', I mean the last 7 days.
On how many days in the last week has (child) looked at books or read stories?

2.14 A question was also included about a different range of activities (e.g. visit to cinema, visit to zoo) - some of which tend to take place, if at all, on a less regular basis than the kinds of activities discussed above. The question took the form of a showcard with a list of places of events (see Appendix 3) that parents could choose from and used the following introduction:

I now have some questions about places or events that (child) might visit or be taken to either by someone in the family, (his/her) childcare provider or someone else.

For these questions, we would like you to think about how often (child) has been to the places or events in the last year.

First of all can you tell me which of the following places or events (child) has visited since (month of interview in previous year)?

2.15 As with the daily activities asked about in the survey, this range of places and events is meant to be illustrative of the kinds of activities that children experience rather than an exhaustive picture of their lives. It is also the case that some of the less commonly visited places might have been visited on a large number of occasions by those particular children, while the more common ones (such as a zoo) might have only been a one-off visit, so this data cannot be used to draw conclusions on the volume of children's activities. Additionally, the study may have omitted to ask about many other types of event that the children could have been to. Despite these limitations, this approach provides a good indicator of the range and variety of experiences that children have had by the time they are 22 months or 34 months of age.

3. STATISTICAL ANALYSIS

Introduction

3.1 An analysis data set was compiled from the existing three separate birth cohort data sets. The variables were then examined for their characteristics and, where necessary, transformations of certain variables was undertaken so that they were in a form suitable for subsequent analyses.

Producing baseline demographic models

3.2 Multilevel models[1] were constructed for each of the cognitive outcomes (BAS naming vocabulary and picture similarities at age 3 years), with the following tested as predictors[2]:

- Child characteristics - gender, birth weight (where low birth weight or not), and age (33 – 36.5 months), child developmental status in the first year, and child health status in first, second and third years.

- Family characteristics - number of siblings (0,1,2 or 3+), respondent and partner (parental) highest level of education, household socio-economic status in terms of the highest occupational status of the parents, lone parent status[3], and "equivalised" household income[4].

- Other characteristics - amount of centre-based care/education, and home area level of deprivation and urban/rural characteristics.

3.3 Of these predictor variables, child health status in the first, second and third years, and amount of centre-based care/education[5] proved not to be statistically significant predictors of either of the two cognitive outcomes. These variables were therefore dropped from the final multilevel models.

Creating different achievement groups

3.4 From the baseline demographic multilevel models for naming vocabulary and picture similarities, measures of relative over- and under-achievement were calculated. For each outcome, three categories of relative achievement (performance) were used: unexpected over-achievers, average (as expected), and unexpected under-achievers. Child residual scores[6] were derived from the

[1] More information on multilevel modelling is provided in Appendix 1.
[2] The characteristics of the sample in relation to these predictor variables are presented in Appendix 2.
[3] Note that lone parent status was combined with the partner education comparisons in analyses as this optimised the sample size in the analyses. Where the partner is not present, no partner education measure is present, and hence this code and lone parent status coincide.
[4] 'Equivalisation' of household income allows the comparison of living standards between households that vary in size and composition. This adjustment reflects the fact that a family of several people requires a higher income than a single person in order for both households to enjoy a comparable standard of living.
[5] This is probably because the effects of centre-based care/education will not yet be apparent at 3 years of age, when the outcomes considered in this report were measured.
[6] A residual score is the deviation of a case from the regression line i.e. from its predicted value.

baseline demographic model. Where these residual scores deviated by +1 standard deviation or above the child was categorized as an over-achiever, while those children with residual scores of -1 standard deviation or below were categorized as under-achievers. Those children whose residual scores were within 1 standard deviation of the mean were categorized as average. Each category of unexpected over- or under-achievement is a nominal outcome variable with *average achieving* children as the reference category.

3.5 Table 3.1 gives the distribution of the over-, average, and under-achieving groups for naming vocabulary and picture similarities. Approximately 15% of children are achieving better than would be predicted on the basis of their background, and similar proportions are achieving less well than would be predicted.

Table 3.1: Distribution of achievement groups

	Naming vocabulary	**Picture similarities**
Over-achievers	619 (15.8%)	593 (15.0%)
Average achievers	2693 (68.6%)	2791 (70.8%)
Under-achievers	615 (15.7%)	559 (14.2%)
Total n	3927	3943

Testing for possible components of the HLE

3.6 Arriving at a comprehensive set of measures for inclusion within a composite measure always presents challenges in terms of ensuring adequate coverage of a topic. Having too many measures could result in findings that are difficult to unpick and interpret. Too few, and there is a danger that the issue has not been explored to its fullest potential. While existing literature in the area is an essential starting point, these kinds of selection processes are ultimately a matter of judgement.

3.7 In this report, eight activity measures from the Year 1 interview, 18 from the Year 2 interview and 25 from the Year 3 interview, i.e. 51 measures in total, were considered for their relationship with cognitive development. A small number of these measures had been examined in the original EPPE work on this topic (Melhuish et al., 2001; 2008) but the majority had not been tested in this way in previous research. The full list of the GUS measures tested in this way for possible inclusion in a Home Learning Environment index is listed in Appendix 3.

3.8 Each of the 51 home activity items derived from the GUS interviews was analysed separately with a multinomial logistic regression for any significant association with the individual categorical variables of over- or underachievement (average achieving children as the reference group) for each of the two outcomes; i.e., four tests of significance for each activity. The results of these multinomial logistic regressions are shown in Appendix 4.

3.9 This procedure tested for a large number of possible significant effects, and some significant results might occur by chance. To offset this, only those measures that showed a consistent significant association with better

achievement for at least two of the four possible associations were considered as candidates for inclusion in the Home Learning Environment index.

3.10 No activity measures from year 1 met this criterion. Activity measures from years 2 and 3 that met the criterion are listed in table 3.2. These items were coded on a 0-7 scale (0 indicating does not happen, to 7 indicating very frequent occurrence) so that all items would be equally weighted in any combined Home Learning Environment scale. This necessitated recoding some items.

Table 3.2 - Measures meeting the criterion for inclusion in the HLE index

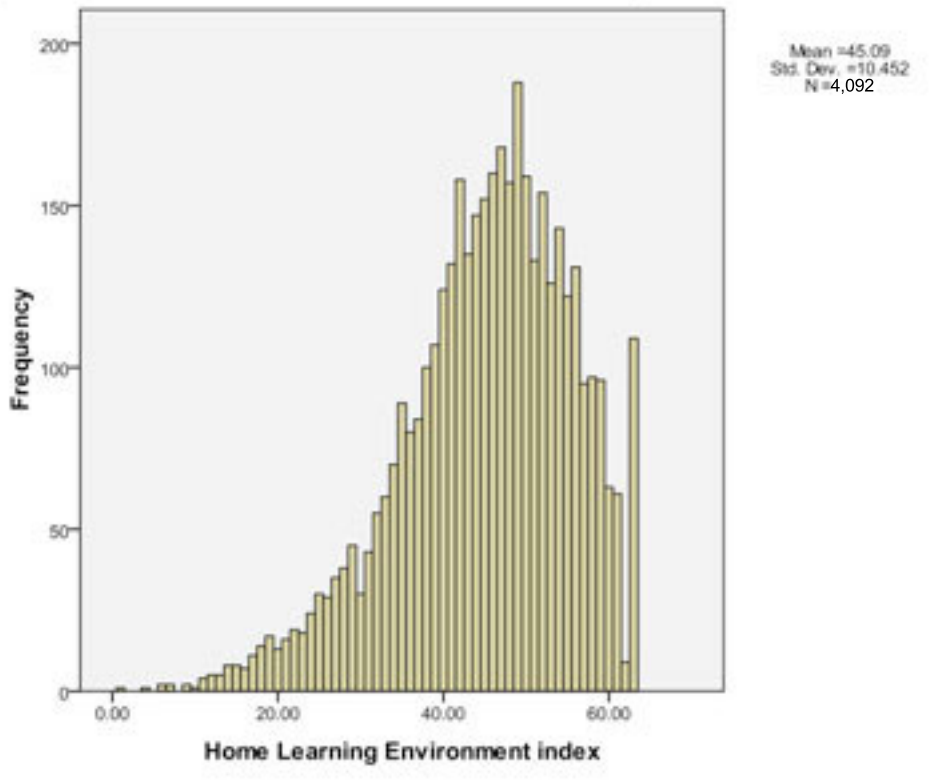
	Measure	Coding
Year 2	1. How often do you/partner look at books with child or read stories with him/her in last week?	The coding 0-7 reflected the number of days per week on which the activity occurred.
	2. How often has the child done activities involving painting or drawing in last week?	
	3. How often do you/partner recite nursery rhymes or sing songs with child in last week?	
	4. How often has the child played at recognising letters, words, shapes or numbers in last week?	
	5. Frequency of visits to gallery etc. last year.*	0 – never 2 – at least once 4 – every few months 5 – monthly 7 – more than once a month
Year 3	6. How often do you/partner look at books with child or read stories with him/her in last week?	The coding 0-7 reflected the number of days per week on which the activity occurred.
	7. How often has the child done activities involving painting or drawing in last week?	
	8. How often do you/partner recite nursery rhymes or sing songs with child in last week?	
	9. How often has the child played at recognising letters, words, shapes or numbers in last week?	
	10. Number of days child has watched TV for at least 10 minutes in last week.*	
	11. About how many children's books do you have in your home at the moment, including library books, that are aimed at children under 5?	0 – none 2 – 1 to 10 items 4 – 11 to 20 items 5 – 21 to 30 items 7 – 30 + items
	12. About how many children s videos or DVDs do you have in your home at the moment, including any from the library, that are aimed at children under 5?*	

*Not included in the final Home Learning Environment index

3.11 These 12 items formed a provisional Home Learning Environment index. This provisional index was examined for internal consistency using Cronbach's Alpha. It was found that removing several items improved the internal consistency - the Cronbach's Alpha was optimised at 0.68, by removing items 5, 10, and 12. Therefore, the Home Learning Environment (HLE) index was finalised as the sum of nine items: 1, 2, 3, 4, 6, 7, 8, 9 and 11. This index had a

possible range of 0 to 63, a mean of 45.09, and a standard deviation of 10.45. The distribution is illustrated in figure 3.1.

Figure 3.1: Distribution of the Home Learning Environment index



3.12 The index approximates a normal distribution but with a ceiling effect reflected in some clustering at the highest point of the scale. This may reflect reality, or is possibly due to some parents wishing to create a positive impression. The correlations of this HLE index with household socio-economic status was 0.22, with respondent's (mother's) education was 0.20, and with partner's (father's) education was 0.10. This indicates that this measure of learning opportunities provided in the home is only slightly associated with parental socio-economic and educational status, and that it can be regarded as a measure that is relatively independent of family demographics.

HLE as a predictor of achievement

3.13 To further examine the effects of HLE on the prediction of achievement over that provided by family and background characteristics for children, new multilevel models for Naming Vocabulary and Picture Similarities were created that added the HLE index (see Tables 3.3 and 3.4). For these multilevel models, children are treated as clustered within primary sampling units (PSUs). Comparison of models indicates a significant contribution of the HLE to children's attainment. When the HLE index was added to the demographic model, the child level variance explained increased from 13.8% to 18.0% (a relative increase of 30%) for Naming Vocabulary and from 7.1% to 8.6% (a 21% relative increase) for Picture Similarities.

3.14 Does the HLE predict achievement across the ability range? To answer this question, analysis was undertaken to see if the HLE would be associated with an improved probability of becoming a high achiever (over-achievement) and of avoiding being an under-achiever. Multinomial logistic regressions confirm, as hypothesized, that children with a higher HLE are more likely to be over-achievers ($p<0.0001$) in Naming Vocabulary, while lower HLE scores are associated with under-achievement ($p<0.0001$). For Picture Similarities the effects were also significant ($p<0.02$ for over-achievers; $p<0.0001$ for under-achievers) but not as strong with regard to predicting over-achievement as for Naming Vocabulary. Children with higher HLEs had a greater likelihood of over-achieving in Picture Similarities, and those with lower HLEs had a greater likelihood of under-achieving.

Table 3.3: Fixed and random effects at child and sampling area levels for the prediction of Naming Vocabulary (standard errors in brackets)

	Random effects	**Demog. model**	**Add HLE**
Intercept	52.32* (0.31)	40.73* (2.01)	42.70*** (1.99)
Home learning environment	-	-	2.87*** (0.198)
Random effects			
Individual error variance (δ)	145.36*** (3.34)	125.31*** (2.88)	119.16*** (2.77)
Sampling area variance (*T*)	6.95*** (1.58)	1.83* (0.79)	1.69* (0.746)
Inter-class correlation between sampling areas	0.046	0.014	0.014
Explained area level variance		73.6%	75.7%
Explained individual variance		13.8%	18.0%

Statistically significant * p<0.05; ** p<0.001; *** p<0.0001

Table 3.4: Fixed and random effects at child and sampling area levels for the prediction of and Picture Similarities (standard errors in brackets)

	Random effects	**Demog. model**	**Add HLE**
Intercept	49.98*** (0.31)	41.51*** (1.75)	42.42*** (1.77)
Home learning environment	-	-	1.734 *** (0.18)
Random effects			
Individual error variance (δ)	100.70*** (2.31)	93.58*** (2.15)	92.06*** (2.14)
Sampling area variance (*T*)	8.70*** (1.54)	4.86*** (1.04)	5.07*** (1.07)
Inter-class correlation between sampling areas	0.080	0.049	0.052
Explained area level variance		44.2%	41.7%
Explained individual variance		7.1 %	8.6%

Statistically significant * p<0.05; ** p<0.001; *** p<0.0001

Effect sizes for predictor variables

3.15 Effect sizes were calculated for each of the predictors in the final multilevel models controlling for the influence of all other variables in the model (Table 3.5 and figures 3.2 and 3.3). For categorical variables, the effect size was calculated as the change in the outcome (in standard deviation units) between the top and bottom categories. For the continuous variables, the effect size was the change in the outcome (in standard deviation units) from 1 standard deviation above the mean to 1 standard deviation below the mean.

Table 3.5: Effect sizes of predictors for Naming Vocabulary and Picture Similarities

	Naming Vocabulary	Picture Similarities
Gender	0.24	0.13
Age (+1sd vs. -1sd.)	0.08	non-significant
Low birth weight (<2500gms vs. rest)	0.15	0.19
Development 1st year (+1sd vs. -1sd)	0.18	0.15
3+ vs. 0 siblings	0.31	0.14
Household socio-economic status	0.20	0.29
Mother's education	non-significant	non-significant
Father's education	0.18	0.15
Highest vs. lowest income	0.15	0.15
Area deprivation	0.13	0.21
Remote rural vs. large urban area	0.28	0.23
Home Learning Environment (+1sd vs. -1sd.)	0.47	0.33

Figure 3.2: Effect sizes of predictors for Naming Vocabulary

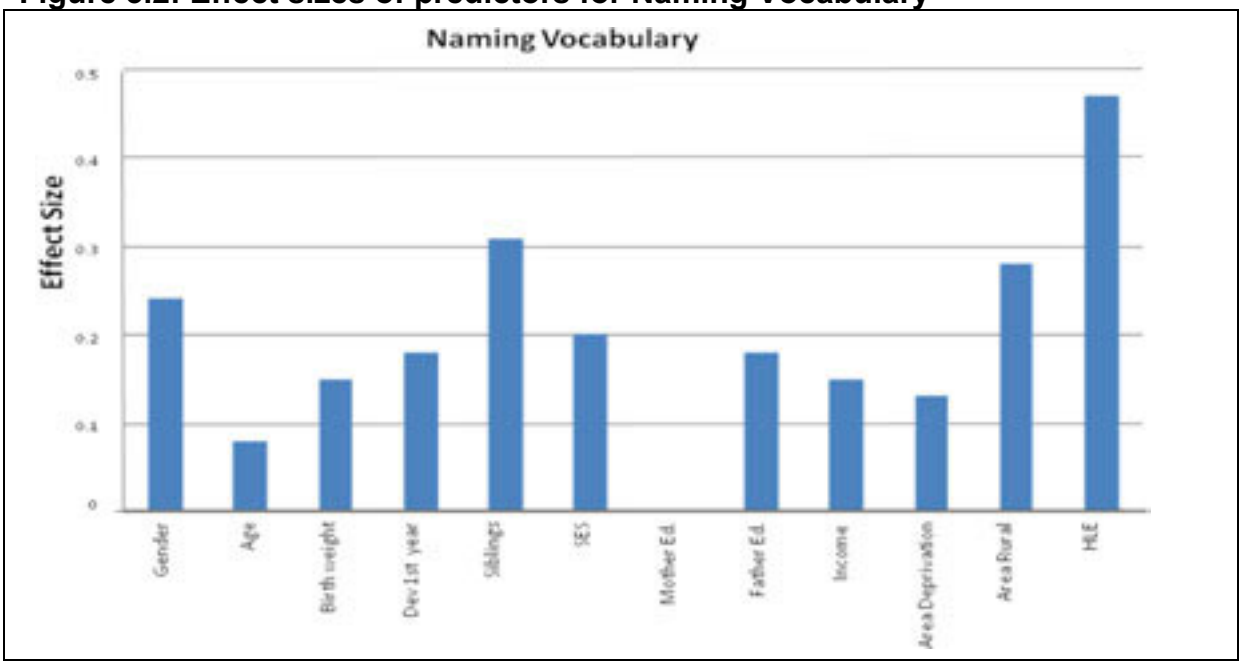
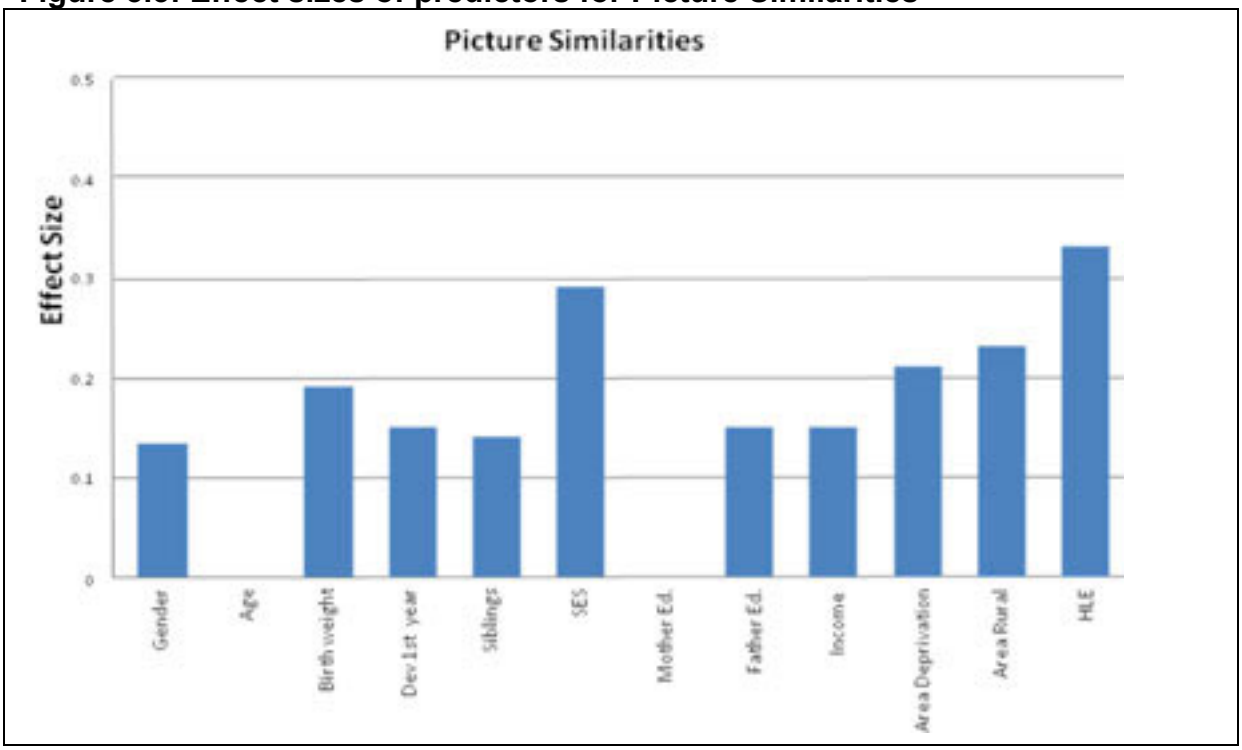


Figure 3.3: Effect sizes of predictors for Picture Similarities



3.16 For both Naming Vocabulary and Picture Similarities, the HLE measure has a larger effect than any of the other variables in the model. The effect size for HLE is most marked for Naming Vocabulary, which suggests that its effects will be more pronounced for verbal than non-verbal abilities, while still having a strong effect for both verbal and non-verbal abilities. The stronger effect of HLE upon verbal abilities is as found in the EPPE project (e.g. Melhuish et al, 2008: Sammons et al., 2008), and is perhaps not surprising given that language related activities are more prevalent than non-language related activities in the HLE, and that in the age range considered language is the most rapidly changing aspect of development.

4. DISCUSSION AND CONCLUSIONS

4.1 In the analyses presented in this report, it is clear that a measure of the Home Learning Environment (HLE) added to the understanding of the influences that might affect a child's cognitive development. While other family factors such as parents' education and socio-economic status are also important, the extent of home learning activities exerts a greater and independent influence on children's cognitive development at three years of age. The results also demonstrate that this interview data within GUS is useful for identifying some key variability in parenting. The results reported here are supported by similar findings from studies in England (Melhuish et al., 2008a) and in Northern Ireland (Melhuish et al., 2006).

4.2 The comparison of over, average, and under-achieving groups indicates that at age 34 months the HLE is effective in differentiating both over and under-achieving groups from children achieving as expected, i.e. across the ability range for both Naming Vocabulary and Picture Similarities.

4.3 Of the nine items selected in this report for inclusion in the Home Learning Environment measure, eight are the same four measures used at two time points, and these four measures are similar to those identified in the original EPPE research in England (Melhuish et al., 2001; 2008a). The ninth item (number of children's books in home) is similar to an item (number of books in home) identified in several previous studies (e.g. Kirsch et al., 2002) as being related to children's cognitive development or educational achievement. Hence the findings in this report are supported by research on other populations. It is interesting to note that none of the other items in the 51 tested added further to a measure of the Home Learning Environment.

4.4 The effects of the various socio-demographic factors upon the cognitive outcomes were much as have been reported in previous research, with the exception of mother's education. In the analyses reported here, the effects for mother's education became non-significant when the HLE variable was added to the model. This could be partly explained by the effect of mother's education being mediated through the HLE. However, this does not completely explain this discrepancy with earlier research (e.g. Sammons et al., 2002; 2008), where strong effects for mother's education were still present even after allowing for the HLE and other socio-demographic variables. Also, the effect of mother's education was small even when the HLE was not included in the analysis. It was consistently less than the effects of father's education, household socio-economic status and household income. Yet it has commonly been found that mother's education is that aspect of household socio-demographic status that has been most strongly linked to children's cognitive development in the early years (e.g. Mercy & Steelman, 1982, Sammons et al., 2004). This may possibly be due to the way mother's education has been measured in the GUS study or to the covariation of mother's education and other socio-demographic variables (e.g. father's education; household socio-economic status and income) being greater in the GUS study than in other studies. The current analyses do not offer an explanation for the relatively low impact of mother's education upon child outcomes in the GUS study.

4.5 It is quite possible that the strong relationship between Home Learning Environment and cognitive scores is mediated by some intervening, unmeasured factor. Those parents who answer the questions in a way leading to a high HLE score may have other characteristics that lead their children to have higher cognitive scores. Such unmeasured characteristics might include aspects of parents' behaviour or possibly genetic factors. Even if this were so, the HLE would still be an efficient proxy measure of such unmeasured factors. This point is mentioned to alert readers to the possible need for further research in this area, as the question of possible unmeasured confounding variables cannot yet be answered with existing data.

Future research

4.6 It will be important to investigate the role of the HLE in affecting cognitive and also social development for the children in the GUS study as they grow up. It might be the case that the HLE measure used in the GUS study could be refined further when data on later cognitive development is available.

4.7 The importance of early years home experience for later children's development is supported by NICHD study evidence (Belsky et al., 2007) indicating that parenting sensitivity at 4.5 years predicts cognitive development at age 10 with current parenting controlled. Also the importance of early parenting variables is further supported with evidence on adolescent educational achievement provided by Englund, Collins & Egeland (2008). In terms of the longer-term impact of the early years home experience upon later outcomes it is unclear whether this is because of the particular potency of early experiences or because early experiences tend to predict later experiences which also have an impact on later outcomes. Developmental versus environmental continuity issues are complex and difficult to resolve yet they pervade longitudinal research and will require ongoing attention. This is possibly a topic that future work with the GUS study can address, for example using structural equation modelling.

Policy implications

4.8 Research findings such as those discussed here suggest that policies that encourage active parenting strategies (including for disadvantaged parents) can help to promote young children's cognitive development and educational achievement both early and later in development.

4.9 Research involving 0-3 year-olds from the evaluation of the Early Head Start (EHS) program, which provided combinations of home-visits and centre childcare intervention for disadvantaged families, found that the intervention increased both the quantity and quality of parents' interaction with children, as well as children's social and cognitive development (Love et al., 2005). In England, there is evidence that the Sure Start programme in disadvantaged areas has produced some benefits for the Home Learning Environment when children are three years old (Melhuish et al., 2008c). A thorough review of early interventions concluded that, to gain the most impact, interventions should include both parent and child together, with a focus on enhancing interactions (Barnes & Freude-Lagevardi, 2003). Such work indicates that parenting

behaviours are learnable, and changes in parenting are associated with improved child development. Similar conclusions derive from a study by Hannon, Nutbrown & Morgan (2005) in the UK, where children showed better literacy progress when parents received a program on ways to improve child literacy during the preschool period.

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APPENDIX 1 – CHARACTERISTICS OF THE SAMPLE

Variable	N	%	*Notes*
Gender			
girls	2534	48.6%	
boys	2683	51.4%	*Comparison group in analysis*
Birth weight			
Low birth weight	339	6.5%	Defined as <2500gms.
Not low birth weight	4871	93.5%	*Comparison group in analysis*
Urban/Rural			
Large urban	1462	34.9%	*Comparison group in analysis*
Other urban	1341	32.0%	
Small accessible towns	440	10.5%	
Small remote towns	122	2.9%	
Accessible rural	569	13.6%	
Remote Rural	259	6.2%	
Area deprivation			
1st quintile -least deprived	905	21.6%	*Comparison group in analysis*
2nd quintile	884	21.1%	
3rd quintile	873	20.8%	
4th quintile	698	16.6%	
5thquintile –most deprived	883	19.9%	
Mother's Education			
No qualifications	471	9.0%	*Comparison group in analysis*
Standard/other	915	17.5%	
Higher	401	7.7%	
Vocational	1953	37.4%	
Degree	1477	28.3%	
Father's Education			
No qualifications	392	7.8%	*Comparison group in analysis*
Lone parent –no partner	978	19.4%	*Included here to optimise analysis*
Standard/other	629	12.5%	
Higher	303	6.0%	
Vocational	1542	30.6%	
Degree	1192	23.7%	
Siblings			
None	1333	31.8%	*Comparison group in analysis*
1	1889	45.1%	
2	722	17.2%	
3 or more	249	5.9%	
Equivalised income			
£0-11250	783	15.0%	*Comparison group in analysis*
£11251-17916	803	15.4%	
£17917 -25000	761	14.6%	
£25001-37500	858	16.4%	
£37500 +	721	13.8%	
Lone Parent status			
Dual Parent	4239	91.3%	

Lone Parent	978	18.7%	*This variable was grouped with father education to optimise analysis*
Health problem year 1			
none	3341	64.0%	*Comparison group in analysis*
1	1249	23.9%	
2 or more	627	12.1%	
Health problem year 2			
none	3707	71.1%	*Comparison group in analysis*
1	1108	21.2%	
2 or more	402	7.7%	
Health problem year 3			
none	3913	75.0%	*Comparison group in analysis*
1	997	19.1%	
2 or more	307	5.9%	
Highest Occupational status in household			
Managerial/professional	2615	50.1%	*Comparison group in analysis*
Intermediate	729	14.0%	
Small employer/self-employed	347	6.7%	
Supervisory/technical	433	8.3%	
Semi-routine/routine	974	18.7%	
Never worked	116	2.2%	
	Mean	**SD**	
Age in months	34.60	0.44	
Developmental status Year 1	10.02	1.65	
Amount of centre-based care/education	7.20	10.97	

APPENDIX 2 – MULTILEVEL MODELLING

Why use multilevel modelling?

Multilevel modelling was used to determine which variables to include in the HLE index, and to examine the relationship between the HLE index and cognitive outcomes.

The statistical method traditionally used to understand the relationship between an outcome and some predictor variables is regression analysis (multiple linear regression or Ordinary Least Squares regression). Social scientists dealing with difficult hierarchical data have traditionally utilised individual-level statistical tools such as regression, usually disaggregating group-level information to the individual level, so that all predictors are tied to the individual level of analysis. In applying regression to data on children clustered within areas (or preschools or schools) the error variance estimation is problematic, because some predictor variables will be measured at the individual pupil level (e.g. gender, ethnicity) and some will be measured at the area level (e.g. percentage of poor families, urban/rural). However children are nested within areas and hence there is a hierarchical structure to the data.

Standard regression techniques have difficulty with such a hierarchical structure and treat all variables as measured at the individual level. With a hierarchical data structure, this leads to inaccurate error variance estimates, and this affects the estimation of the effects for predictor variables. Potentially there is greater similarity between children within the same area, and such correlation between child scores within an area means that the independence of measurement assumption of standard regression is violated, which results in lower standard errors of the estimates than would happen if nesting within the data were acknowledged, and this results in errors in estimating level of significance. Additionally using standard regression assumes that the regression coefficients apply across all contexts. Such a notion may well be misleading in that predictor variables may vary in their effect, say between urban and rural areas.

Multilevel modelling (Goldstein, 2003) was invented to overcome such problems. It is a development of regression analysis, but takes account of the hierarchical structure within the data. Thus multilevel modelling (also known as hierarchical linear modelling – HLM) produces more accurate predictions, and estimates of the differences between children and between areas.

An alternative to multilevel modelling is to conduct standard regression modelling and then adjust the standard errors of the regression coefficients so obtained to take account of the clustering in the sample. (Such estimators are known as "sandwich estimators".) There are two main disadvantages to this approach compared to multilevel modelling. Firstly, although the standard errors are corrected the estimates (i.e. regression coefficients) themselves may still be biased. This is because the clustering is only used in the estimation of the standard errors and not in the estimation of the regression coefficients (as is the case for multilevel estimates). Raudenbush and Bryk (2002, pp276-280) give an example illustrating differences between the estimates under the two approaches. Such differences tend to be

smaller the larger the number of high level units. Secondly, this approach does not lend itself to the estimation of residuals or effects at higher levels - robust estimates developed in an analogous manner tending to be very unstable (Goldstein 2003, pp80-81) - and thus cannot be used in studies of the effectiveness of schools, area initiatives etc.

Multilevel modelling and GUS

In the GUS longitudinal study, the children were sampled in clusters based on area of residence (primary sampling unit – PSU – which is an aggregation of data zones), and multilevel models were used in analyses to take account of this clustering. However, the area level variables (deprivation, urban/rural classifications) are coded to the individual level and not at the level of the PSU. This is probably because the area level variables relate to an area smaller than the PSU (possibly datazones). These areas upon which deprivation and urban/rural classifications are based are not available in the GUS dataset, and therefore are not included in the analysis. Because there were no explanatory variables measured at the area level, the advantages of the multilevel model over the alternative single level regression are less. However, the multilevel model still allows for any unmeasured similarities between cases resulting from being sampled within the same area.

In the multilevel models, 95% (naming vocabulary) and 98.5% (picture similarities) of the variance is at the individual level and only 5% (naming vocabulary) and 1.5% (picture similarities) is at the area (PSU) level. The relatively small degree of cluster-level variability in outcomes also lessens the advantages of undertaking multilevel modelling rather than single level regression modelling with the GUS data.

In practice, the removal of an intermediate level (in this case a small area between individual and PSU) results in the variance at that level being distributed to the PSU and individual levels in unknown proportions. So we are possibly underestimating the importance of small areas whilst overestimating the importance of the PSUs, and possibly also overestimating the importance of individual variables. Moreover, the fact that we are treating area level variables (deprivation and urban/rural classification) as if they were observed at the individual level means that we may not estimate the standard errors associated with these variables accurately, and consequently may not estimate significance levels as accurately as should be the case.

APPENDIX 3 - ACTIVITIES TESTED FOR POSSIBLE INCLUSION IN THE HOME LEARNING ENVIRONMENT INDEX FOR GUS

Variable name	Activity
	Year 1 activities
MaAlit01T	How often do you/partner look at books with child or read stories with him/her
MaAply01T	How often do you/partner play indoor or outdoor games with child
MaAmus01T	How often do you/partner recite nursery rhymes or sing songs with child
MaAlit02T	How often do you/partner take child to the library
MaAbok01	About how many children s books do you have in your home at the moment, including library books, that are aimed at children under 5
MaAcds01	About how many children s records, audio tapes, or CDs do you have in your home at the moment, including any from the library, that are aimed at children under 5
MaAdvd01	About how many children's videos or DVDs do you have in your home at the moment, including any from the library, that are aimed at children under 5
MaAtv01	In the past week, on how many days did child watch television for least 10 minutes at a time
	Year 2 activities
MbAvst01T	Frequency visited friends with kids
MbAvst02T	Frequency visited by friends with kids
MbAlit04	How often do you/partner look at books with child or read stories with him/her in last week
MbAply02	How often has the child run around or played outdoors in last week
MbAart02	How often has the child done activities involving painting or drawing in last week
MbAmus02	How often do you/partner recite nursery rhymes or sing songs with child in last week
MbAedu02	How often has the child played at recognising letters, words, shapes or numbers in last week
MbAict02	How often has the child done activities involving a computer etc in last week
MbAlib20T	Frequency of visits to library last year
MbAliv20T	Frequency of visits to concert/play etc. last year

MbAswm20T	Frequency of visits to swimming pool last year
MbAart20T	Frequency of visits to gallery etc last year
MbAzoo20T	Frequency of visits to zoo etc last year
MbAcnm20T	Frequency of visits to cinema last year
MbAath20T	Frequency of visits to sport event last year
MbAfai20T	Frequency of visits to religious event last year
DbAtv09	Hours of TV watched (weekdays)
DbAtv10	Hours of TV watched (weekends)

Year 3 activities

McAlit04	How often do you/partner look at books with child or read stories with him/her in last week
McAply02	How often has the child run around or played outdoors in last week
McAart02	How often has the child done activities involving painting or drawing in last week
McAmus02	How often do you/partner recite nursery rhymes or sing songs with child in last week
McAedu02	How often has the child played at recognising letters, words, shapes or numbers in last week
McAict02	How often has the child done activities involving a computer etc in last week
McAvst01T	Frequency visited friends with kids
McAvst02T	Frequency visited by friends with kids
McAbok01	About how many children s books do you have in your home at the moment, including library books, that are aimed at children under 5
McAcds01	About how many children s records, audio tapes, or CDs do you have in your home at the moment, including any from the library, that are aimed at children under 5
McAdvd01	About how many children s videos or DVDs do you have in your home at the moment, including any from the library, that are aimed at children under 5
McAtv01	Days child watch TV in last week
McAtv09	Time child watches TV week days
McAtv10	Time child watches TV weekends

DcAtv09	Hours of TV watched (weekdays)
DcAtv10	Hours of TV watched (weekends)
McAphy01	Time riding bicycle in last wk
McAphy02	Time kicking a ball in last wk
McAphy03	Time dancing in last wk
McAphy04	Time running/jumping in last wk
McAphy05	Time on trampoline in last wk
McAphy06	Time swimming in last wk
McAphy07	Time playing in soft play area in last wk
McAphy08	Time playing in park in last wk
physactlastweekyr3a	Whether another physical activity (listed in interview) occurred in the last week or not

APPENDIX 4 - RESULTS OF TESTING FOR THE ASSOCIATION OF HOME ACTIVITIES WITH OVER- AND UNDER-ACHIEVEMENT

Logged odds coefficients (reference: achievement as predicted by demographic characteristics)
Standard errors in brackets; * p<0.05

	Deviation from Predicted T-Scores			
	Pictorial Similarities		Naming Vocabulary	
Predictors:	**Over-achievers (1+ std)**	**Under-achievers (-1 std)**	**Over-achievers (1+ std)**	**Under-achievers (-1 std)**
MaAlit01T	0.017 (0.024)	-0.031 (0.022)	0.114 * (0.029)	0.001 (0.022)
MaAply01T	0.044 (0.081)	-0.081 (0.059)	0.061 (0.078)	0.031 (0.072)
MaAmus01T	-0.007 (0.052)	-0.079 (0.044)	0.119 (0.067)	-0.011 (0.047)
MaAlit02T	0.0009 (0.019)	-0.020 (0.020)	0.037 * (0.018)	-0.001 (0.019)
MaAbok01	0.041 (0.037)	-0.054 (0.038)	0.007 (0.037)	-0.073 * (0.037)
MaAcds01	0.036 (0.052)	0.053 (0.052)	0.054 (0.050)	-0.087 (0.054)
MaAdvd01	-0.017 (0.034)	-0.0008 (0.034)	-0.077 * (0.034)	-0.072 * (0.034)
MaAtv01	0.015 (0.014)	-0.009 (0.015)	0.028 * (0.014)	0.012 (0.014)
MbAvst01T	-0.032 (0.022)	-0.041 (0.022)	-0.006 (0.022)	-0.0006 (0.022)
MbAvst02T	-0.026 (0.020)	-0.027 (0.020)	0.008 (0.020)	-0.031 (0.019)
MbAlit04	0.066 * (0.032)	-0.111 * (0.025)	0.199 * (0.038)	-0.031 (0.026)
MbAply02	0.019 (0.019)	0.007 (0.019)	0.002 (0.018)	-0.043 * (0.018)
MbAart02	0.059 * (0.019)	-0.071 * (0.020)	0.062 * (0.019)	-0.091 * (0.020)
MbAmus02	0.020 (0.018)	-0.065 * (0.017)	0.081 * (0.019)	-0.051 * (0.017)
MbAedu02	0.029 (0.016)	-0.043 * (0.017)	0.084 * (0.016)	-0.022 (0.016)
MbAict02	0.028 (0.031)	0.042 (0.031)	-0.006 (0.032)	0.039 (0.030)
MbAlib20T	0.011 (0.031)	-0.053 (0.033)	0.086 * (0.031)	-0.019 (0.032)
MbAliv20T	0.037 (0.066)	-0.058 (0.071)	-0.027 (0.067)	-0.082 (0.070)
MbAswm20T	0.018 (0.036)	-0.105 * (0.036)	0.025 (0.035)	0.002 (0.036)

MbAart20T	0.061 (0.045)	-0.114 * (0.051)	0.194 * (0.043)	0.028 (0.047)
MbAzoo20T	0.072 (0.043)	-0.050 (0.046)	0.054 (0.042)	-0.073 (0.045)
MbAcnm20T	0.025 (0.129)	-0.104 (0.147)	0.033 (0.127)	-0.026 (0.135)
MbAath20T	-0.0005 (0.055)	-0.024 (0.058)	-0.057 (0.057)	0.010 (0.054)
MbAfai20T	0.023 (0.034)	0.012 (0.035)	0.029 (0.033)	-0.025 (0.035)
DbAtv09	0.029 (0.041)	-0.116 * (0.046)	0.064 (0.040)	0.035 (0.043)
DbAtv10	0.002 (0.033)	-0.078 * (0.036)	-0.008 (0.032)	0.039 (0.034)
McAlit04	0.032 (0.034)	-0.129 * (0.028)	0.110 * (0.036)	-0.043 (0.029)
McAply02	-0.012 (0.019)	0.031 (0.020)	0.039 (0.020)	-0.015 (0.019)
McAart02	0.03 (0.021)	-0. 038 * (0.019)	0.028 (0.021)	-0.046 * (0.021)
McAmus02	0.0001 (0.023)	-0.086 * (0.021)	0.0896 * (0.025)	-0.081 * (0.021)
McAedu02	0.023 (0.018)	-0.077 * (0.018)	0.108 * (0.019)	-0.044 * (0.018)
McAict02	-0.003 (0.024)	-0.001 (0.024)	0.012 (0.023)	-0.031 (0.025)
McAvst01T	-0.004 (0.023)	-0.070 * (0.021)	0.021 (0.023)	-0.008 (0.022)
McAvst02T	-0.032 (0.021)	-0.048 * (0.021)	0.015 (0.021)	-0.007 (0.020)
McAbok01	0.061 (0.053)	-0.217 * (0.047)	0.242 * (0.057)	-0.117 * (0.046)
McAcds01	0.082 (0.047)	-0.082 (0.052)	0.062 (0.047)	-0.102 * (0.051)
McAdvd01	0.061 (0.037)	-0.087 * (0.038)	0.018 (0.037)	-0.105 * (0.037)
McAtv01	0.033 (0.028)	-0.072 * (0.024)	0.029 (0.028)	-0.076 * (0.023)
McAtv09	-0.00007 (0.001)	-0.002 * (0.0008)	0.001 (0.0007)	-0.0005 (0.0007)
McAtv10	-0.00005 (0.0004)	-0.0009 (0.0005)	-0.0004 (0.0004)	-0.0003 (0.0004)
DcAtv09	-0.006 (0.035)	-0.113 * (0.037)	0.057 (0.034)	-0.065 (0.036)
DcAtv10	-0.023 (0.026)	-0.080 * (0.028)	-0.021 (0.026)	-0.034 (0.026)

McAphy01	-0.024 (0.024)	0.058 * (0.024)	-0.048 * (0.024)	-0.038 (0.024)
McAphy02	-0.006 (0.027)	0.016 (0.028)	-0.011 (0.027)	-0.009 (0.027)
McAphy03	-0.003 (0.022)	-0.070 * (0.023)	0.028 (0.021)	0.010 (0.021)
McAphy04	0.025 (0.031)	-0.052 (0.030)	0.022 (0.030)	-0.035 (0.029)
McAphy05	-0.022 (0.023)	0.057 * (0.022)	-0.077 * (0.023)	-0.056 * (0.023)
McAphy06	-0.029 (0.027)	-0.057 * (0.028)	-0.028 (0.027)	-0.018 (0.027)
McAphy07	-0.009 (0.023)	-0.031 (0.024)	0.006 (0.022)	-0.004 (0.022)
McAphy08	-0.009 (0.022)	-0.011 (0.023)	0.047 * (0.022)	-0.011 (0.022)
physactlastweekyr3a	0.003 (0.112)	-0.299 * (0.125)	0.079 (0.111)	0.047 (0.112)

ISSN 0950 2254
ISBN 978 0 7559 9286 7
(Web only publication)

www.scotland.gov.uk/socialresearch

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133574_04/10

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ISBN: 978-0-7559-9286-7