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You are what you eat? Meal type, socio-economic status and cognitive ability in childhood

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ABSTRACT

The current study tests if the type of children's daily main meal (slow versus fast food) mediates the association of socioeconomic status (SES) with cognitive ability and cognitive growth in childhood. A Scottish birth cohort (Growing Up in Scotland) was assessed at ages 3 ($N=4512$) and 5 years ($N=3833$) on cognitive ability (i.e. vocabulary and picture similarities), SES, and the frequency of having slow and fast food main meals per week. SES was highly correlated at ages 3 and 5 years, while intelligence and the type of meal were only moderately associated across ages. SES at age 3 was positively related to ability at age 3 but not at age 5. The type of meals partially mediated the effects of SES on cognitive ability at ages 3 and 5, with more slow meals being associated with better cognitive performance. Furthermore, a higher frequency of slow food meals were positively related to cognitive growth between ages 3 and 5 years, after adjusting for SES and prior cognitive ability; however, they only accounted for a negligible amount of the variance in cognitive change. Overall, slow food was associated with better cognitive ability and cognitive growth in childhood, albeit corresponding effect sizes were small.

We may find in the long run that tinned food is a deadlier weapon than the machine-gun. George Orwell (1903–1950)

1 . Introduction

Socioeconomic status (SES) is associated with better cognitive performance and academic achievement throughout childhood and adolescence (cf. Bradley & Corwyn, 2002). Indeed, SES related differences in cognition and achievement are apparent before children even begin formal education (e.g. Heckman, 2006; Tucker-Drob, 2012). Among the most-cited mechanisms that explain the association between SES and cognition is the differential access to resources (Bradley & Corwyn, 2002), which is exemplified in terms of dietary intake and quality of food supply (cf. Mortorell, 1980). Thus, the current study focuses on the types of meals that children eat per week, and how meal types affect cognitive performance and cognitive development in childhood.

Previous studies showed that malnutrition and micronutrient deficiencies (e.g. iron and zinc) are negatively associated with cognitive ability (e.g. Black, 2003a, 2003b; Pollitt, Cueto, & Jacoby, 1998). Conversely, certain food groups — like fresh fruits (Gale et al., 2009), fish (Zhang, Hebert, & Muldoon, 2005), and bread and cereals (Theodore et al., 2009) — have been found to positively affect cognitive performance. They are rich in vitamins and antioxidants that support brain function, for example by participating in enzymatic reactions that synthesize neurotransmitters and by reducing metal ions in the brain (Harrison & May, 2009). However to date, no study tested if the types of meals that children eat affect their cognitive development. In this context, prefabricated dishes (i.e. fast food) may be differentiated from meals that were prepared using fresh produce and ingredients (i.e. slow food). Fast food meals, including frozen dishes (cf. 'TV dinners'), repasts at fast food restaurants, and take-away dinners, characterize the *meat-sweet diet* with an increased consumption of calories,

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sodium, salts and sugars, and a reduced intake of minerals and vitamins including folic acids (Halton et al., 2006). By contrast, slow food meals prepared from fresh produce carry much higher nutritional value (e.g. vitamins, calcium, and magnesium), and they comply with public recommendations and guidelines to achieve a balanced diet (WHO, 2012). In short, fast food meals exclude food groups and nutrients that are associated with better cognitive ability, while the reverse is true for slow food meals (cf. Ebbeling, Pawlak, & Ludwig, 2002). Because fast food has overall less nutritional value than slow food, its respective effects on cognitive ability are thought to be general rather than specific.

That said, slow and fast food meals do not only differ with regard to their respective nutritional values and ingredients. First, the preparation of slow food meals requires time (e.g. marinating food), skill (e.g. correct cooking temperature and timing), and equipment (e.g. kitchen and knifes) and it is often complex. By contrast, fast food tends to come in wrapping paper or a microwave-safe, plastic dish, whose handling do not require much cooking skills and equipment. Second, slow food ingredients are more expensive than fast food meals (Drewnowski & Specter, 2004; Prentice & Jebb, 2003). For example, one US dollar buys 1200 cal of cookies or potato chips but only 250 cal worth of carrots (Drewnowski, 2004). Also, slow food ingredients are sometimes more difficult to shop for because of a lack of well-stocked grocery stores and farmers' markets; by contrast, fast food restaurants are widely spread, especially in low income areas (e.g. Beaulac, Kristjansson, & Cummins, 2009). In line with these differences, people with restricted resources (i.e. low SES) have been found to eat more often prefabricated and fast food than those from wealthier backgrounds (Devine et al., 2006; Patrick & Nicklas, 2005). Furthermore, low SES mothers often have little knowledge about food preparation and nutrition (North & Emmett, 2000; Northstone & Emmett, 2005). On the one hand, this may be due to not having time for preparing meals with fresh ingredients because of work and money constraints (e.g. Devine et al., 2006). On the other, low SES mothers may struggle to grasp the importance of nutrition for children's development (Northstone & Emmett, 2005). Either way, the type of meal that children eat may partially explain the association between SES and cognitive performance (cf. Bradley & Corwyn, 2002; Rosales, Reznick, & Zeisel, 2009). It is, however, likely to be only one of many factors that inform the link between SES and childhood cognitive ability.

The current study tested if meal type partially mediated the association between SES and childhood cognitive performance at the ages of 3 and 5 years (Fig. 1). It was hypothesized that a higher frequency of slow meals per week (i.e. prepared from fresh ingredients) would be associated with higher SES and better cognitive performance at both assessment waves. The cognition–SES link was thought to be mediated by the frequency of having slow meals compared to fast food. Furthermore, slow meals were expected to have a positive effect on cognitive growth between the ages of 3 and 5 years (cf. Bradley & Corwyn, 2002). Specifically, meal type was hypothesized to explain a significant amount of variance in cognitive growth after adjusting for prior SES and cognitive ability. In summary, the frequency of slow and fast food meals was expected to explain part of the cognitive ability differences associated with SES.

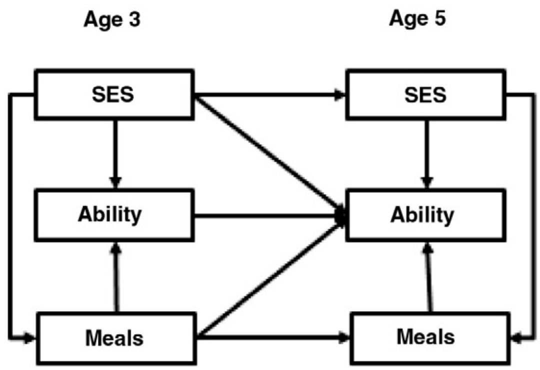

Fig. 1. Illustration of mediation path model.

2. Methods

2.1. Sample

The Growing Up in Scotland study (GUS) sampled 5217 households at baseline that had a child (2683 boys; 51.4%) born between June 2004 and May 2005 across Scotland. The sample was collected to investigate characteristics, circumstances, and experiences of Scottish children, and it is representative of the general Scottish population (Bradshaw, Tipping, Marryat, & Corbett, 2005). Mothers were first interviewed at the children's average age of 10.6 months ($SD=0.62$), and then every year once until the children's average age of 58.2 months ($SD=0.51$; $N=3833$) most recently; that is, about 4 years and 8.5 months, which will be herein referred to as 5 years of age. At the third wave, 4193 households took part in assessment at children's average age of 34.6 months ($SD=0.44$), that is, 2 years and 9 months, which will be herein referred to as age 3 years. With reference to the baseline sample, response rates were 80% and 73% at children's ages of 3 and 5, respectively.

2.2. Measures

All measures were taken twice at children's ages of 3 and 5 years, respectively.

2.2.1. British Ability Scales (BAS II; Elliott, Smith, & McCulloch, 1996, 1997)

The ability tests were age-appropriate versions at each assessment; they are state-of-the-art ability tests for children (cf. Elliott, 2001), and often employed in British longitudinal studies. Test–retest scores correlated between .90 and .95 over follow-up periods of 1 to 9 weeks in three different age groups (Elliott, 2001). *(1) Naming vocabulary*. The test items were colored 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 test had 33 items, and maps onto a crystallized intelligence factor (cf. Elliott, 2001). *(2) Picture similarities*. The test assesses non-verbal reasoning ability. Items included a booklet with four images on each page and a set of cards each with a single image printed on. The child was shown the row of pictures, given a corresponding card and asked to place the card under the image on the page which shares an element or concept with the image on the card. The test had 36 items, and maps onto a fluid intelligence factor (cf. Elliott, 2001).

2.2.2. Meal types

The frequency of the type of the children's *main* meal per week as recorded as frozen/ready-prepared meal, take-away meal, fast-food meal, sit-down restaurant, and meal with fresh ingredients.

2.2.3. Socioeconomic status (SES)

The National Statistics Socioeconomic Classification (NS-SEC) classifies groups on the basis of employment relations, including career prospects, autonomy, mode of payment and period of notice. Respondents and their partners were rated on a 5-point scale as managerial or professional, intermediate, small employers or own account workers, lower supervisory or technical, and semi-routine or routine occupations. Furthermore, respondents' and their partners' highest educational attainment were recorded, ranging from no qualification up to degree level on a 6-point scale. Finally, the overall household income was assessed on a 17-point scale, ranging from earning less than 3999£ per annum to earning more than 56,000£ per annum. Respondents' and partners' NS-SEC, education and the household income form a household NS-SEC variable following the five categories described above.[1]

2.3. Procedure

Interviews lasting between 60 and 90 min were carried out in the respondents' homes by trained social survey interviewers using laptop computers at each assessment wave. Age-specific versions of the BAS were administered to the respondents' children after obtaining parental consent at both waves. Parental consent to the ability tests was 94% at children's age of 3 years, and 98% at age 5.

2.4. Analysis

All analyses were carried out using SPSS 19 and AMOS 19. Children, whose mothers reported them to have food intolerances (e.g. nuts), food allergies (e.g. dairy products) and special diets (e.g. kosher, halal) at age 3, were omitted from all analyses ($N=245$). The five meal types were collapsed into two opposite categories of slow food (i.e. sit-down restaurant, and meals prepared with fresh ingredients) and fast food (i.e. fast food, frozen or ready-made meal, and take-away). Children, whose mothers claimed more or fewer than seven main meals per week (addition of slow and fast meals), were omitted from all further analyses ($N=72$ at age 3, and $N=19$ at age 5). To create a meal type index, the number of fast meals was subtracted from the number of slow meals with a higher score indicating more slow meals per week and a lower score more fast meals per week at each assessment wave, respectively.

The BAS were *z*-transformed and computed as IQ type scores ($M=100$; $SD=15$) at ages 3 and 5, respectively. Outliers ($IQ<10$; $N=16$ at age 5) were omitted from all further analyses. Cognitive change was assessed by subtracting BAS scores at the assessment at age 3 from those at age 5.

SES and sex differences in the means and variances of the study variables were tested for using ANOVAs and Levene's tests of homogeneity, whose alpha level was Bonferroni corrected for multiple comparisons (i.e. .05/20 for sex with $p<.003$, and .05/40 for SES with $p<.001$). Correlations were computed using full information maximum likelihood estimation (FIML) and pairwise deletion (PD). FIML and PD matrices differed negligibly; only the PD matrices are reported here. Next, a series of path models was fitted (Fig. 1). SES, ability scores (picture or vocabulary), and meal types at age 3 were specified to directly predict their respective assessments at age 5. Furthermore, SES at age 3 directly predicted cognitive performance and meal types at age 3, while SES at age 5 directly affected cognitive performance and meal types at age 5. Finally, SES and meal types at age 3 were modeled to have a direct relationship with cognitive performance at age 5. FIML was employed for all models to include cases with missing data points (Arbuckle, 1996). Data were not missing completely at random (Little's MCAR test; χ^2 (65) = 347.08, $p<.0001$), and they mildly violated assumptions of multivariate normality. In particular, SES and meal types were somewhat negatively skewed. Under these conditions, FIML achieves robust model estimates and thus, is a preferred likelihood method (Arbuckle, 1996; Enders & Bandalos, 2001). Model fit was assessed with the Comparative Fit Index (CFI), the Tucker–Lewis Index (TLI), and the Root-mean-square error of approximation (RMSEA); the model χ^2 is also reported. CFI and TLI indicate an adequate model fit at values of .90 and .95 or above (Hu & Bentler, 1999). RMSEA values of .08 and below are considered acceptable (Browne & Cudeck, 1993). In a third and final step, linear regression models were tested to explore the effect of meal types on changes in cognitive performance between waves 3 and 5, after adjusting for cognitive ability at wave 3 and SES. Thus, SES and cognitive ability were entered in a first step, and subsequently meal types at age 3 were added as a predictor variable in a second step. Confidence intervals were set at 98.75% to correct for multiple comparisons.

3. Results

3.1. Descriptives and correlations

For 6 of 10 study variables, there were significant sex differences in means and variances ($p<.003$); thus, all analyses are run separately for boys and girls. Similarly, there were significant SES differences in some of the study variables' variances (3 of 8) and means (6 of 8; $p<.001$). Corresponding eta squared (η^2) values ranged from .02 to .06 (Tables 1 and 2). In both sexes, mean ability scores declined with decreasing social class. SES related differences in cognitive ability were more pronounced for vocabulary than picture similarities, especially at age 3; also, they tended to reduce at age 5 compared to age 3. Girls performed on average better than boys in vocabulary and picture similarities across assessment waves and SES categories. However, boys tended to improve their ability scores from age 3 compared to age 5 across SES categories, while girls experienced losses in ability scores in both vocabulary and picture similarities. That said, SES related

[1] There is also a NS-SEC category labeled never worked, which was excluded from the current study because its sample size was too small for analyses ($N=64$).

Table 1
Sample sizes, means and standard deviations for all study variables for girls across SES.

SES	I			II			III			IV			V			η^2
	N	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	
Pictures age 3	1000	103.63	12.78	264	101.92	12.49	134	100.57	14.30	128	99.99	15.20	282	96.99	16.44	.03
Vocabulary age 3	997	105.54	12.89	265	102.36	12.71	133	100.35	15.46	127	100.55	14.09	283	97.37	14.17	.05
Pictures age 5	950	102.28	13.41	245	101.81	13.15	122	99.85	14.08	113	97.04	13.23	239	97.00	15.49	.02
Vocabulary age 5	949	103.79	12.62	246	100.89	11.45	120	98.72	14.63	113	98.03	12.92	239	95.07	12.78	.06
Vocabulary change	919	−1.84	12.63	240	−1.81	11.41	114	−1.18	14.01	109	−2.86	13.67	229	−2.34	13.69	.02*
Picture change	921	−1.61	14.87	238	−0.54	15.40	116	0.45	18.23	109	−4.00	16.04	227	−0.69	18.82	.01*
Fast meals age 3	1036	0.98	1.17	275	1.35	1.43	141	1.33	1.52	134	1.34	1.39	295	1.59	1.59	.03
Slow meals age 3	1036	6.02	1.17	275	5.65	1.43	141	5.67	1.52	134	5.66	1.39	295	5.41	1.59	.03
Fast meals age 5	944	0.83	1.09	243	1.11	1.21	120	0.98	1.04	109	1.06	1.19	228	1.40	1.53	.03
Slow meals age 5	943	6.17	1.09	243	5.89	1.21	120	6.03	1.04	109	5.94	1.19	228	5.60	1.53	.03

Note. SES I refers to the highest, SES V to the lowest socioeconomic background at age 3. Means for fast and slow meals refer to the frequency of the respective type of meal per week (i.e. ranging from 0 to 7).
* $p>.001$.

differences in cognitive change were not significant in neither boys nor girls ($p<.001$; Tables 1 and 2). Change in cognitive performance ranged from losing 51 to gaining 76 IQ points in vocabulary, and from losing 66 to gaining 70 IQ points in picture similarities; all change scores were normally distributed. Both boys and girls had mostly slow meals per week, with the highest rates in the highest SES category. Differences in meal type frequencies across SES categories were noticeable but small. Over time (i.e. from wave 3 to wave 5), children's frequency of having slow main meals increased compared to fast main meals.

The ability tests scores were moderately positively associated across assessment waves and test types in both boys and girls (Tables 3 and 4). Note that change in cognitive performance was only negligibly correlated across test types in both sexes. While meal types at age 3 correlated moderately with those at age 5 ($r=.30$), the corresponding correlation for SES was very high ($r=.90$). Overall, meal types were positively but rather weakly associated with the cognitive ability scores, change in those scores, and SES across assessment waves. Conversely, SES was not meaningfully associated with change in cognitive ability. Correlation patterns differed minimally between boys and girls.

3.2. Mediation path models

Models fitted the data adequately (Table 5). SES, ability and meal types at age 3 predicted their respective assessments at age 5 with effects ranging from large (SES) to moderate (ability and meals) in boys ($N=1960$) and girls ($N=1910$; Fig. 2). Thus, individual differences in SES were by and large stable, while ability and meal types were more inconsistent across time. In line with the hypothesis, higher SES at age 3 was associated with better performance in vocabulary and picture similarities tests, as well as a higher frequency of slow meals at that age. However, SES at age 3 was not significantly associated with cognitive performance at age 5; the latter was also not significantly influenced by SES at age 5 (Fig. 2). By contrast, meal types at age 3 were significantly associated with vocabulary at ages 3 and 5, and with picture similarities at age 3. Furthermore, meal types at age 5 had significant effects on cognitive performance at

Table 2
Sample sizes, means and standard deviations for all study variables for boys across SES.

SES	I			II			III			IV			V			η^2
	N	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	
Pictures age 3	968	100.73	14.30	256	99.65	14.77	117	98.08	14.88	166	96.45	17.09	290	92.61	17.76	.04
Vocabulary age 3	963	100.65	14.39	256	97.38	13.96	114	94.68	14.92	165	94.55	14.04	286	90.78	16.86	.06
Pictures age 5	948	101.34	14.85	233	98.49	14.19	104	97.51	13.55	137	97.64	16.05	243	96.48	15.10	.02
Vocabulary age 5	947	101.82	14.38	232	99.37	13.84	105	98.22	14.29	139	95.25	15.73	247	93.21	14.81	.05
Vocabulary change	889	1.25	14.69	222	2.04	14.06	102	4.44	14.97	133	0.53	12.39	224	1.95	13.84	.02*
Picture change	895	0.40	17.80	223	−1.25	17.09	104	−0.33	15.99	133	0.33	18.33	225	3.42	18.06	.01*
Fast meals age 3	1030	1.03	1.21	270	1.39	1.40	118	1.11	1.19	179	1.53	1.65	328	1.83	1.85	.05
Slow meals age 3	1030	5.97	1.21	270	5.61	1.40	118	5.89	1.19	179	5.47	1.65	328	5.17	1.85	.05
Fast meals age 5	946	0.84	1.11	234	1.17	1.31	103	1.04	1.41	143	1.27	1.45	249	1.35	1.56	.03
Slow meals age 5	946	6.16	1.11	234	5.83	1.31	104	5.92	1.46	144	5.73	1.45	249	5.65	1.56	.03

Note. SES I refers to the highest, SES V to the lowest socioeconomic background at age 3. Means for fast and slow meals refer to the frequency of the respective type of meal per week (i.e. ranging from 0 to 7).
* $p>.001$.

Table 3
Correlations between study variables for girls.

		1	2	3	4	5	6	7	8	9
1	Pictures at 3	–								
2	Pictures at 5	.32	–							
3	Vocabulary at 3	.40	.30	–						
4	Vocabulary at 5	.30	.36	.53	–					
5	Vocabulary change	−10	.56	−.51	.45	–				
6	Picture change	−.57	.60	−.06	.06	.13	–			
7	Meal type at 3	.08	.07	.08	.13	.04	−02	–		
8	Meal type at 5	.06	.16	.08	.13	.05	.09	.31	–	
9	SES at 3	.17	.15	.22	.25	.02	−.01	.16	.15	
10	SES at 5	.16	.14	.24	.25	.00	−.01	.17	.15	.90

Note. Higher meal type scores refer to a higher frequency of slow than fast meals per week. Correlations above .09 are significant at $p<.001$ ($N=1570$). After pairwise deletion, sample sizes range from $N=1570$ to $N=1910$.

Table 4
Correlations between study variables for boys.

		1	2	3	4	5	6	7	8	9
1	Pictures at 3	–								
2	Pictures at 5	.31	–							
3	Vocabulary at 3	.41	.26	–						
4	Vocabulary at 5	.29	.32	.53	–					
5	Vocabulary change	.12	.07	−.52	.47	–				
6	Picture change	−.60	.57	−.12	.03	.16	–			
7	Meal type at 3	.12	.12	.11	.14	.02	.08	–		
8	Meal type at 5	.10	.13	.05	.12	.06	.08	.30	–	
9	SES at 3	.19	.13	.24	.22	−.02	.07	.20	.15	
10	SES at 5	.18	.11	.22	.22	−.01	−.04	.18	.16	.90

Note. Higher meal type scores refer to a higher frequency of slow than fast meals per week. Correlations above .09 are significant at $p<.001$ ($N=1542$). After pairwise deletion, sample sizes range from $N=1542$ to $N=1960$.

age 5. Thus, type of meals partially mediated the effects of SES at ages 3 and 5 onto cognitive performance ($p<.001$ for Sobel's tests,[2] in all cases; Fig. 2).

Table 6 shows the standardized direct, indirect and total effects for all study variables across boys and girls. SES at age 3 had medium direct and small indirect effects on vocabulary and picture similarities at age 3. The comparatively high indirect effect of SES at age 3 on cognitive performance at age 5 was largely driven by prior cognitive ability at age 3, which accounted for the greatest amount of variance in cognitive ability at age 5. Direct and indirect effects of meal types on ability at both ages were small but consistent, and the effects of SES on meal types were slightly higher. Overall, the models accounted for 31% and 32% of variance in vocabulary and for 11% and 13% in picture similarities for boys and girls, respectively.

3.3. Regression models for cognitive change

The previous correlational analyses suggested that none of the current study variables was strongly associated with cognitive change, with the exception of prior cognitive ability that had moderate, negative correlations (Tables 3 and 4). In line with this, SES was associated with small, positive parameter estimates across models, suggesting that higher SES contributed to gains in cognitive ability between the ages of 3 and 5 years. Conversely, prior cognitive ability (i.e. vocabulary and picture similarities test scores, respectively) at age 3 accounted for 26% to 36% of the variance in cognitive change in boys and girls (Table 7). That is, higher ability at age 3 was associated with reduced cognitive growth or gains until the age of 5 years. Having more often slow meals was significantly and positively associated with change in vocabulary for boys and girls and in picture similarities for boys ($p<.01$, in all cases) but not in picture similarities for girls. Overall, having more often slow meals accounted for negligible amounts of variance in cognitive change.

[2] Sobel's tests determine if the relationship between an independent variable and a dependent variable is significantly attenuated after including a mediator variable (Sobel, 1982).

4. Discussion

The primary aim of this study was to explore if the type of meal — that is, the frequency of having prefabricated or fast food compared to slow food meals in a week — constitutes a mechanism through which socioeconomic status (SES) affects cognitive performance and cognitive growth in childhood. In line with previous theories (cf. Bradley & Corwyn, 2002; Mortorell, 1980), the current findings suggest that meal types partially mediate the effect of SES on childhood cognitive ability. Specifically, SES at children's age of 3 years was directly associated with childhood cognitive performance at ages of 3 and 5 years, and it also had indirect effects through the type of meals that children had per week. Furthermore, eating more often slow food meals than prefabricated food was positively associated with gains in cognition between the ages of 3 and 5 years, even though the effect sizes were modest. Meal type and other dietary variables are likely to constitute many determinants that cause SES-related differences in cognitive performance and development. Thus, meal types can be expected to be associated with a number of social and economic circumstances that also affect childhood cognition or brain functioning.

Previous research established that nutritional deficiencies and the consumption of certain food groups affect cognitive performance (e.g. Black, 2003a, 2003b; Gale et al., 2009; Pollitt et al., 1998; Theodore et al., 2009). Categories of slow and fast food meals differ with regard to nutritional value (cf. Ebbeling et al., 2002) and thus, in the extent to which they benefit brain functioning (e.g. neurotransmitter synthesis) and cognitive performance. The current findings suggest that the fundamental distinction between fast and slow meals is related to

Table 5
Fit indices for path models.

	χ^2	df	CFI	TLI	RMSEA	CI (95%)	
Vocabulary boys	1.58	4	1.000	1.003	.000	.000	.021
Vocabulary girls	18.64	4	.996	.980	.044	.025	.065
Picture boys	6.22	4	1.000	1.004	.000	.000	.021
Picture girls	1.57	4	1.000	1.004	.000	.000	.021

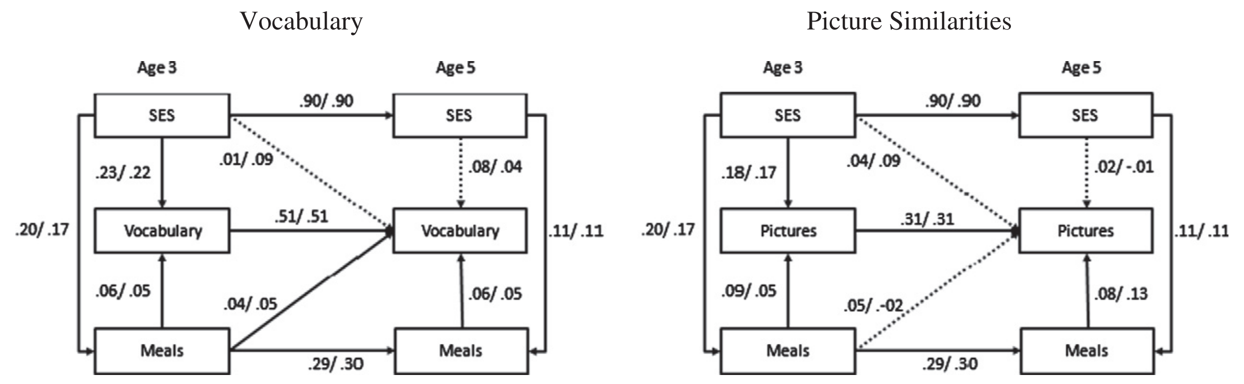

Fig. 2. Results of the mediation path model for SES, meal types and cognitive ability in boys/girls. *Note*. Error terms have been omitted to sustain graphical clarity. Path parameters are standardized estimates. Dashed arrows represent non-significant paths ($p > .05$). All variables were coded that higher scores indicate better outcomes. Meals refer to a higher frequency of slow meals per week.

cognitive performance and growth in childhood. That said, the current study could not directly compare nutritional values of slow and fast meals but inferred the differences based on previous research findings (e.g. Drewnowski, 2004; Halton et al., 2006; Harrison & May, 2009). Notwithstanding, the types of meals that children consume as their main meal of the day were here shown to constitute one mechanism through which childhood SES affects cognitive ability. Specifically, children in higher SES groups scored on average better in tests of cognitive ability (i.e. vocabulary and picture similarities) than children from lower SES backgrounds. Similarly, higher SES was related to a slightly increased frequency of slow meals per week, which then led to better cognitive performance at the ages of 3 and 5 years. Thus, the differential access to resources of low and high SES groups appears partly reflected in their nutrition and diet, which in turn are associated with cognitive development. However, meal type scores were only moderately associated over the time period of two years (age 3 to age 5), while individual differences in SES were comparatively stable. As diets vary substantially in young childhood — perhaps because children develop their own taste preferences, or because they begin to eat in places other than the home (e.g. kindergarten or with friends) — so might their association with SES and cognitive ability. Here, it seems particularly important to ensure that children have healthy meals when spending time outside the home, for example day-care centers or school. Together with previous reports on the role of micronutrients and antioxidants for brain functioning (e.g. Harrison & May, 2009), the current results suggest that nutrition is an important determinant of cognitive development that offers a straightforward opportunity for practical intervention.

Table 6
Standardized direct, indirect and total effects of all study variables for boys/girls.

	SES at 3		SES at 5		Meals at 3		Meals at 5		Vocab at 3	
Direct effects										
SES at 5	.90	.90	–	–	–	–	–	–	–	–
Meals at 3	.20	.17	–	–	–	–	–	–	–	–
Meals at 5	–	–	.11	.11	.29	.30	–	–	–	–
Vocabulary at 3	.23	.22	–	–	.07	.05	–	–	–	–
Vocabulary at 5	.01	.09	.08	.04	.05	.05	.06	.05	.51	.51
Picture at 3	.18	.17	–	–	.09	.05	–	–	–	–
Picture at 5	.04	.09	.02	−.01	.05	−.02	.08	.13	.29	.31
Indirect effects										
SES at 5	–	–	–	–	–	–	–	–	–	–
Meals at 3	–	–	–	–	–	–	–	–	–	–
Meals at 5	.16	.15	–	–	–	–	–	–	–	–
Vocabulary at 3	.01	.01	–	–	–	–	–	–	–	–
Vocabulary at 5	.22	.17	.01	.01	.05	.04	–	–	–	–
Picture at 3	.02	.01	–	–	–	–	–	–	–	–
Picture at 5	.10	.07	.01	.02	.05	.06	–	–	–	–
Total effects										
SES at 5	.90	.90	–	–	–	–	–	–	–	–
Meals at 3	.20	.17	–	–	–	–	–	–	–	–
Meals at 5	.16	.15	.11	.11	.29	.30	–	–	–	–
Vocabulary at 3	.25	.22	–	–	.07	.05	–	–	–	–
Vocabulary at 5	.23	.09	.09	.04	.10	.05	.06	.05	.51	.51
Picture at 3	.20	.18	–	–	.09	.05	–	–	–	–
Picture at 5	.13	.16	.03	.01	.09	.04	.08	.13	.29	.31

Key. Vocab = vocabulary. Meals refer to a higher frequency of slow meals per week.

With regard to changes in cognitive performance across two years in early childhood, three notable results were obtained. First, change scores spanned a very wide range with children gaining and losing up to 76 IQ points (i.e. five standard deviations) within two years. Indeed, 21% of children experienced positive or negative changes in cognitive performance scores greater than one standard deviation (i.e. +/− 15 IQ points). Thus, while test scores in vocabulary and picture similarities were positively associated across both assessment time points, the intra-personal variance in development was unexpectedly high. Second, change scores in vocabulary and picture similarities were not meaningfully correlated, suggesting that gaining or losing in one ability dimension is fairly independent of changes in another. With reference to Spearman's *g*-factor and the positive manifold, this observation is somewhat counterintuitive (cf. Johnson, 2011). Equally counterintuitive is that changes in cognition were not systematically associated with SES (cf. Heckman, 2006; Tucker-Drob, 2012). That is, SES related differences in

Table 7
Standardized regression weights for predictors of cognitive change (vocabulary and picture similarities) in boys and girls.

	Model		Vocabulary change						Model		Picture similarities change					
			β	t	p	CI		R^c			β	t	p	CI		R^c
Male	1	SES	.11	4.78	.000	.49	1.55		1	SES	.06	2.97	.003	.11	1.32	
		Vocabulary	−.53	−23.69	.000	−.56	−.45	.264		Picture	−.61	−29.75	.000	−.77	−.65	.361
	2	SES	.10	4.20	.000	.37	1.44		2	SES	.05	2.45	.014	−.01	1.21	
		Vocabulary	−.53	−23.92	.000	−.56	−.46			Picture	−.61	−29.94	.000	−.78	−.66	
		Meals	.07	3.13	.002	.07	.63	.005		Meals	.06	2.77	.006	.04	.68	.003
N=1570									N=1580							
Female	1	SES	.13	6.01	.000	.66	1.60		1	SES	.09	4.08	.000	.35	1.47	
		Vocabulary	−.54	−24.88	.000	−.56	−.46	.278		Picture	−.58	−27.84	.000	−.75	−.62	.325
	2	SES	.12	5.48	.000	.56	1.51		2	SES	.08	3.88	.000	.31	1.45	
		Vocabulary	−.54	−25.05	.000	−.57	−.46			Picture	−.58	−27.82	.000	−.75	−.63	
		Meals	.06	2.96	.003	.05	.57	.004		Meals	.02	.87	.384	−.20	.42	.000
N=1611									N=1611							

Note. All independent variables are assessed at age 3. Picture refers to the Picture similarities test score; R^c refers to the change in variance accounted; CI refers to the confidence interval of 98.75%; Meals refer to a higher frequency of slow meals per week.

cognitive ability have been previously shown to manifest and augment as children grow older (e.g. Tucker-Drob, Rhemtulla, Harden, Turkheimer, & Fask, 2011); however in the current sample, no such development was observed. In fact, SES differences in cognitive ability reduced over the examined two year period, and average change scores were not consistently greater in higher SES compared to lower SES groups. It is possible that additional variables, such as children's pre-schooling or kindergarten experience, interact with SES causing the presently observed data pattern (e.g. Tucker-Drob, 2012).

Third, boys and girls differed with regard to cognitive change: while boys gained on average in cognitive ability scores with increasing age, the reverse was observed for the girls. That said, girls obtained higher test scores than boys at age 3 and continued to outperform their male peers at age 5 but to a lesser extent. Additional longitudinal studies that follow children's cognitive growth through infancy and early childhood are needed to substantiate the current findings and explain the noted sex differences. So far, the present results appear supporting Bayley's (1955) conclusion after reviewing the Berkley Growth Study: "[there is] little hope of ever being able to measure a stable and predictable intellectual factor in the very young. […] I see no reason why we should continue to think of intelligence as an integrated (or simple) entity or capacity which grows throughout childhood by steady accretions." (p. 807).

4.1. Strengths and limitations

This study benefits from a large representative cohort sample that was frequently assessed using well established tests of cognitive ability and measures of SES. It is also not without weaknesses. First, cognitive performance was only assessed at two time points, which makes a more sophisticated approach to the analysis of cognitive developmental change difficult (i.e. latent growth curve models; cf. Johnson, 2011). Second, the data collected on the GUS study do not include a detailed record of participants' food consumption. Such information would have helped to substantiate the current results, as well as to make them better comparable to previous studies in this area (cf. Gale et al., 2009; Theodore et al., 2009). Similarly, slow and fast food categorization may not always be correct because general nutritional values are assumed for different meal categories (e.g. some take-aways may have more fresh ingredients than restaurant meals do). Perhaps related to this, only small SES-related differences in the frequency of slow versus fast food meals were observed, resulting in low effect estimates. Third and like all longitudinal studies, GUS suffered from attrition with people of lower SES being less likely to continue participating than those from higher socioeconomic backgrounds (Bradshaw, Marryat, Mabelis, Ferrandon, & Tipping, 2010). Thus, the reported parameters might be slightly biased. Finally, the current study did not control for additional confounding variables, such as birth weight, body-mass index or parental intelligence, which may also contribute to explaining SES differences in cognitive performance and growth.

5. Conclusions

The present study adds to understanding the mechanisms through which SES contributes to differences in cognitive performance and growth in early childhood. Specifically, higher SES was associated with better cognitive performance at children's ages of 3 and 5 years, and this effect was partially mediated by the frequency of having more often slow than fast food meals per week. Furthermore, a higher frequency of slow meals predicted small gains in cognitive ability over a two year period. Therefore, it is not only *what* and *how much* children eat that matters for their cognitive development but also *how* it was prepared.

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