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Cognitive, Behavioral, and Social Factors Are Associated with Bias in Dietary Questionnaire Self-Reports by Schoolchildren Aged 9 to 11 Years

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Cognitive, behavioral and social factors are associated with bias in 9-11 year old schoolchildren's dietary questionnaire self reports.

Background: Measuring children's dietary behavior is central to evaluating interventions and identifying predictors and outcomes of dietary behaviors. Systematic biases may obscure or inflate associations with self-reported intakes.

Objective: To identify cognitive, behavioral and social correlates of bias in children's reporting of breakfast items on a self-completion questionnaire.

Design: Cross-sectional survey. Children completed standardized tests of episodic memory, working memory and attention, and a questionnaire assessing attitudes towards breakfast. Teachers completed a classroom behavior measure. Associations between measures and children's under-reporting of breakfast foods (i.e., cereals, bread, milk, fruits, sweet items and potato chips) on a self-completion questionnaire relative to validated 24-hour recall were examined.

Subjects and setting: Subjects were aged 9-11 years (n=678). Data were collected from 111 schools throughout Wales in 2005.

Results: A larger percentage of less healthy breakfast items (i.e., sweet snacks and potato chips) than healthier items (i.e., fruits, cereals, bread and milk) were omitted from questionnaire self-reports. Children from lower socioeconomic status schools omitted more items than those from wealthier schools ($H=12.51$, $p<0.01$), with omissions twice as high for less healthy items than for healthier items within the lowest socioeconomic status schools. Those with positive attitudes ($H=23.85$, $p<0.001$), better classroom behavior ($H=7.04$, $p<0.05$) and better episodic memory ($H=8.42$, $p<0.05$) omitted fewer items than those with negative attitudes, poorer behavior and poorer episodic memory. Children who ate more

items omitted more than those who ate fewer ($H=47.65$, $p<0.001$). No differences were observed in terms of attention and working memory.

Conclusions: Episodic memory, classroom behavior, attitudes, socioeconomic status and total items consumed are associated with bias in questionnaire self reports. Such biases have implications for examination of associations between breakfast eating and cognitive and behavioral factors, examination of effect modification by socioeconomic status in intervention trials, and for the sensitivity of measures to detect intervention effects.

Introduction

Accurate assessment of children's dietary intake is central to understanding predictors and outcomes of children's diets, identifying targets for intervention, developing an understanding of behavior change processes and evaluating interventions. As such, a number of methods for assessing children's dietary behaviors have been developed in recent years, with some promise, but equally, some substantial limitations. Twenty-four hour dietary recall interviews for example can offer a good assessment of children's dietary intake (1, 2, 3-5), although they are a labor and cost intensive means of collecting data in the context of large scale evaluation studies. Methods such as food records and weighed food intake also involve a high level of respondent burden and associated non-response bias, as well as being prone to under-reporting and Hawthorne effects (5, 6). Furthermore, although parents of preschool children may provide accurate reports of their children's food consumption (7), reports appear to be no more valid than children's self reports once children reach school age (8). Finally, food frequency questionnaires, commonly used in large scale evaluations with adults, are unsuitable for children, since their estimates of portion sizes and frequency are limited by cognitive abilities (9).

In studies such as cluster randomized controlled trials of nutritional interventions, substantial numbers of participants are typically required (10). The need for measurement on such a scale essentially makes the methods described above impracticable, arguably rendering questionnaire based dietary reporting the most viable option. Hence, the development and testing of self-report questionnaire measures of children's dietary intake is of significant importance. Measures ideally need to be cost effective and time efficient, and to be sufficiently sensitive to detect change and provide unbiased estimates of differences in children's dietary intakes between experimental groups.

However, in adults, a growing body of evidence indicates that inaccuracies in dietary self reporting are neither uniform, nor randomly distributed, but are influenced by characteristics of the reporter (6, 11-15). Although systematic biases have only recently begun to be examined in studies with children (5), factors such as cognitive function and motivation to comply have commonly been assumed to limit reporting accuracy (8), with such error potentially obscuring or inflating observed associations between dietary behaviors and outcomes of interest.

In beginning to address the issues raised above, the present study will focus upon inter-individual differences in the concordance of reporting of breakfast foods on a dietary recall questionnaire, relative to a validated 24-hour recall interview method. Recent research indicates that breakfast is a meal that is often poorly reported by schoolchildren (16). Furthermore, given the current interest in social inequalities in dietary behaviors, as well as in cognitive and behavioral effects of breakfast consumption (17), examination of the extent to which cognitive, social and behavioral factors are systematically associated with reporting concordance is important.

This study will test the hypotheses that questionnaire self reports from children with more positive attitudes towards breakfast, better cognitive functioning (in terms of scores on validated measures of episodic memory[1] (18), working memory (20), and selective attention (21)) and classroom behavior will be more concordant with the dietary recall interview data. Furthermore, given the commonly reported association of socioeconomic status with classroom behavior and children's cognition (22), the study will also test the hypothesis that there will be weaker concordance between questionnaire and dietary recall reports among children attending schools with lower socioeconomic status populations.

[1] Episodic memory refers to ability to recall information about past experiences, embedded within temporal and spatial contexts (19).

Methods

Participants

All maintained primary and junior schools in 9 Local Educational Authorities across Wales were invited to participate in the evaluation of the Welsh Assembly Government's Primary School Free Breakfast Initiative (N=608). One-hundred and eleven schools agreed to take part. In each school, one class from Year 5 (aged 9-10) and one from Year 6 (aged 10-11) were randomly selected to complete cognitive tasks, an attitudes questionnaire and a dietary recall questionnaire, which they did in the morning of the data collection visit. Three to 5 pupils from each of these classes were also randomly selected to undertake the recall interview. In total, 800 children were sampled to complete the one-to-one interviews.

Measures

Socioeconomic status of school catchment area. The percentage of children within each school entitled to receive free school meals was used to indicate socioeconomic status. Free school meals are available to children in the United Kingdom (UK) whose parents' income is sufficiently low for them to be eligible for welfare. The percentage of children within a school entitled to free school meals is commonly used as a marker of school level socioeconomic status (23).

Episodic memory. Episodic memory was assessed using a standardized word recall task (18). Twenty five-letter words were consecutively projected onto a white board, for two seconds each. Once all twenty words had been shown, children were allowed two minutes to independently write down as many words as they could remember. The number of words correctly remembered was taken as a score for episodic memory. Possible scores ranged from 0 to 20.

Working memory. Woking memory was assessed using the backward letter-span task (20). Children were shown a consecutive series of 3 letters for two seconds each. After the 3

letters had been shown, children were asked to write them down in reverse order. This was repeated for a series of 4, 5 and 6 letters respectively. The number of letters recalled in the correct order was taken as a score for working memory. Possible scores for working memory ranged from 0 to 18.

Attention. Attention was assessed using a letter search task, designed to assess sensory selective attention by requiring children to scan information, filtering out distracters and selecting relevant information (21). Children were given a 210mm x 297mm piece of paper containing 24 lines of letters. At the beginning of each line of letters, a target letter was printed, separated from the main line of letters by a short space. Children scanned each line of letters searching for that line's target letter, putting a mark through the target letter each time it appeared. The exercise was timed for two minutes, at the end of which children marked how far through the page they had scanned by placing an X on the letter they were looking at when asked to stop. Children were given a separate score for the two components of selective attention assessed through this task, speed (number of letters scanned) and accuracy (percentage of targets marked, within letters scanned).

Attitudes towards eating breakfast. Attitudes were assessed using a questionnaire containing thirteen statements referring to a variety of domains, such as concentration and behavior, energy, and the general importance placed on breakfast. Children were asked to indicate the extent to which they agreed or disagreed with each statement via a 5 point agree/disagree Likert scale. This measure was developed for use with the present sample and demonstrates good construct and convergent validity (24). In the present study, the measure demonstrated good internal consistency (α=.83).

Behavioral problems. The Strengths and Difficulties Questionnaire was used to assess behavioral problems. This is a brief questionnaire, with a number of statements relating to the child's conduct. The present study used the global scale for total difficulties, which is the sum

of sub-scales for emotional difficulties, conduct problems, hyperactivity and peer problems. Teachers were asked to respond to statements via 'not true', 'somewhat true' or 'certainly true' response boxes. The measure has been validated with children aged 5-15 and demonstrates good validity and reliability (25). In the present study, the measure demonstrated good internal consistency (α=.80).

Dietary recall questionnaire[2]. Children were asked to list all foods and drinks consumed at chronologically ordered time points throughout the day. Food related questions were embedded within items related to the child's activities (e.g., 'Did you watch television at home yesterday morning before school started?' preceding the item 'Did you have anything to eat or drink at home yesterday morning before school started?') Activity related items, served a two-fold purpose, firstly acting as prompts to enhance recall and secondly as distractions from the researcher's interest in eating behaviors, hence minimising social desirability biases. The questionnaire requests details of two breakfast occasions (i.e., the morning of reporting and the previous morning). The measure has been validated against 24-hour recall interviews with a sub-sample of children from the present study and offers an acceptable level of validity and reliability. For a full description, see (26).

24 hour dietary recall interview. Fully structured multiple-pass dietary recall interviews were conducted using a standardized protocol (2), which was modified to include two breakfasts rather than just one. As with the dietary recall questionnaire, details of foods eaten on the morning of reporting were gathered prior to details of foods eaten during the course of the previous day.

Procedures

[2] A copy of the questionnaire can be obtained by emailing the lead author at MooreG@cardiff.ac.uk

This cross-sectional investigation involved secondary analysis of baseline data from the evaluation of the Welsh Assembly Government's Primary School Free Breakfast Initiative. Study design, including sampling and data collection procedures are described at length elsewhere (10), and will be discussed only briefly here.

The study received ethical approval from the Cardiff University Social Science Ethics Committee. Three researchers visited each participating school. Cognitive tests, the attitudes questionnaire and the dietary recall questionnaire were completed between 9am and 12pm as supervised classroom exercises with a maximum class size of 40 children. As children completed measures, teachers were asked to complete the Strengths and Difficulties Questionnaire for 5 to 10 randomly selected pupils. From this subsample, 3 to 5 children from each year group were selected to complete a dietary recall interview. Where a sampled child was absent on the day of testing, a further child was randomly selected to take their place.

Statistical analysis

For each breakfast occasion, the number of items consumed by each participant, from each of six food categories (i.e., bread, cereal, milk, fruit, sweet items and potato chips) according to responses on the recall questionnaire and during the 24 hour recall interview were calculated. Where more items from a category were reported in the interview than on the questionnaire for a breakfast occasion, the difference was taken as the number of omissions for that category, for that breakfast occasion. For each of the six categories, total omissions for day one were added to total omissions for day 2. The primary dependent variable *percentage total omissions,* was the percentage of the total items reported in the dietary recall interview which were not reported on the self-completion measure. This dependent variable was also disaggregated into *percentage of healthier items omitted* (i.e., cereals, bread, milk and fruits) and *percentage of less healthy items omitted* (i.e., sweet snacks and potato chips).

Baxter and colleagues (5) highlight the importance of considering omissions (where a food is not reported on a measure, but is recorded on the tool it is validated against) and intrusions (where a food is reported on a measure, but not on the tool it is validated against) as separate forms of misreporting. However, given the infrequency of intrusions in the present sample, the decision was made to focus analysis solely upon omissions. For children who reported eating nothing for breakfast on the recall interview on both days, omissions were not possible and they were not included in analysis. Similarly, for analysis of each of the disaggregated dependent variables *percentage of healthier items omitted* and *percentage of less healthy items omitted,* only children who reported at least one item from the included food categories in the 24 hour recall interviews were entered into analysis.

Independent variables were socioeconomic status of school catchment area, attitudes toward eating breakfast, episodic memory, working memory, attention, behavioral difficulties and the total number of breakfast items consumed (according to the 24 hour recall questionnaire). Each independent variable was divided into tertiles in order that tests of difference could be conducted to examine the magnitude of differences between those scoring low, medium or high on each variable of interest and in order to maximise statistical power in these comparisons. Differences in sizes between tertiles are a result of tied scores.

All three dependent variables were highly skewed. Therefore, for each tertile of each independent variable, the geometric mean and its 95% confidence interval are presented. However, log transformation did not fully correct the skewness in the data. Therefore, the calculation of an H-statistic through the use of non-parametric Kruskal-Wallis tests statistics was favoured over analysis of variance (ANOVA) for assessing the significance of between group difference. This test is an alternative to the independent group ANOVA when assumptions of normality or equality of variance are violated. Ranks of data are used rather than raw values, and hence, it offers a lower degree of statistical power than ANOVA. No

standardized guidelines are available for conducting power calculations for Kruskal-Wallis tests. A p-value of less than .05 was interpreted as indicating a significant between group difference. Significance tests were conducted for *percentage total omissions* only, as the numbers of children consuming at least one item from the disaggregated categories (total healthier items omitted and total less healthy items omitted) was lower, reducing power and comparability between analyses.

Results

Response rates and sample description

Of the 800 participants sampled, 15 were excluded due to special educational needs, 4 declined to participate and a further 80 were not available on the day of testing, giving a sample of 701 children for dietary recall interviews. A further 23 had not filled out the questionnaire, leaving 678 children who had completed both measures. Table 1 details the range of scores within each tertile of each independent variable, as well as the number of participants assigned to each ordinal category of each independent variable.

Thirteen pupils who did not consume any of the above items for breakfast on either day were excluded from analysis, giving a total sample of 665 children. For the percentage of healthier items omitted, a further 13 children were excluded from analysis. For less healthy items, analysis was conducted for only 229 children, as only this number consumed at least one sweet item or serving of potato chips.

Associations between cognitive and behavioral factors and socioeconomic status and reporting concordance

Percentage total omissions

For all 665 children included in analysis, the geometric mean percentage of total omissions was 21.74. Geometric mean percentage total omissions by individuals categorized as low, moderate or high (as described above) for each of the variables of interest are presented in Table 2. This table also presents H-statistics for each independent variable, derived from Kruskal-Wallis tests of between group difference.

Between group differences were significant for socioeconomic status, attitudes toward breakfast, episodic memory, behavioral difficulties and total items consumed. Children from lower socioeconomic status schools omitted significantly more items than children from more affluent schools, although differences between those in moderate or high socioeconomic status schools were marginal. A clear graded trend is demonstrated for attitudes toward breakfast, with more positive attitudes associated with lower levels of underreporting. A clear graded trend is also demonstrated for total items consumed, with consumption of a higher number of items associated with higher levels of underreporting. Children with higher behavioral difficulties omitted significantly more items. No significant differences were observed for working memory or attention.

Percentage of healthier items and less healthy items omitted

For all 652 children included in analysis for the percentage of healthier items omitted, the geometric mean percentage of healthier items omitted was 19.51. For the 229 included in analysis for the percentage of less healthy items omitted, the geometric mean percentage of less healthy items omitted was 28.56. Geometric mean percentages of healthier items omitted and less healthy items omitted by individuals categorized as low, moderate or high for each of the variables of interest are presented in Tables 3 and 4 respectively, as well as 95% confidence intervals of the geometric mean.

In general, though omissions are higher for less healthy items, similar trends are observed across both tables. However, for attitudes toward breakfast, a gradient is observed for 'healthier items', suggesting that those with less positive attitudes toward breakfast were more likely to omit healthier items reported in the interview, whereas a smaller but opposite gradient is observed for less healthy omissions. It is also notable that children in the lowest socioeconomic status schools, who consumed at least one less healthy breakfast food, omitted almost half of these less healthy items, whereas children in these schools who consumed at least one healthier item, omitted only a quarter of these healthier items.

Discussion

A number of important issues in relation to reporting concordance were observed. First, almost a quarter of items reported in the recall interviews were not reported on the questionnaire. Second, percentage omissions were substantially higher for less healthy items than for healthier items. This possibly indicates a degree of social desirability bias, though it is also possible that this reflects systematic differences in reporting between those children who report eating healthier breakfast items and children who eat less healthy items.

Children from the most deprived schools under-reported on the questionnaire to a greater extent than those in more affluent areas. Furthermore, omission of less healthy items was approximately twice as high as omission of healthier items amongst those in the schools of lowest socioeconomic status. Whereas those in the lowest tertile for socioeconomic status omitted only a slightly greater percentage of healthier items than those in the other two tertiles, children within the lowest socioeconomic status schools, who ate at least one sweet snack or portion of potato chips according to the interview, omitted 30% more of these less healthy items than those in the moderate tertile, and 13% more than those in the high socioeconomic status tertile. Interestingly, trends were not always linear, with those in high

socioeconomic groups omitting a greater percentage of less healthy items than those in moderate socioeconomic groups. Although some studies have investigated the influence of socioeconomic status upon reporting accuracy in relation to other areas of health, such as use of health care (27), finding little association, its relationship to dietary under-reporting in children has not previously been explored. The trends revealed by the analyses in this paper merit further investigation. Of particular concern is the high level of underreporting of less healthy items. Previous analysis of baseline data from the evaluation of the Primary School Free Breakfast Initiative indicated that children in lower socioeconomic status schools ate significantly more sweet snacks and potato chips for breakfast than those in wealthier schools (28). However, the observed systematic underreporting of less healthy items amongst children in lower socioeconomic status schools perhaps indicates that the magnitude of this social gradient may have been underestimated.

Children with positive attitudes toward breakfast omitted less food items in general than those with less positive attitudes. Possible explanations for this include increased processing of food-related stimuli, leading to increased transference of such information to long-term memory stores (29). Alternatively, children with more positive attitudes may simply be demonstrating increased engagement with the reporting process. Interestingly however, disaggregation of omissions into healthier and less healthy items indicated that, contrary to the trend in relation to percentage total omissions, those with more positive attitudes were more likely to omit less healthy items than those with less positive attitudes. This perhaps indicates a degree of systematic social desirability bias linked to more positive attitudes toward the target behavior.

Those scoring poorest on the measure of episodic memory omitted the most items, with minimal differences observed between moderate and high scoring groups. This perhaps indicates that the dietary recall task proved more difficult only for those with below average

cognitive capacity. For working memory, although a graded trend in the hypothesised direction was observed, this was marginal and non-significant. No associations of attention with under-reporting were observed. Although the model of processes involved in dietary recall proposed by Baranowski and colleagues (29) describes attention and working memory as significantly shaping the recall process at the levels of both retention and retrieval, the findings of this study appear to indicate that inter-individual differences in these factors did not impact substantially upon underreporting on the dietary recall questionnaire relative to the interview.

In relation to behavioral difficulties, the lowest levels of omissions were observed amongst those with few teacher reported difficulties. This association is perhaps consistent with the aforementioned view that motivations to comply with data collection procedures influence the accuracy of reporting (8), with children exhibiting higher degrees of behavioral difficulty perhaps less compliant than others.

The most pronounced between group differences occurred in terms of consumption levels, with those who reported consumption of 5 or more items during the interview omitting approximately 22% more items than those consuming 3 or 4 items and approximately 42% more than those consuming 2 or less items. Although this trend is unsurprising, given the greater capacity to forget items where there is more to report, its magnitude indicates that such measures may offer a limited view of variation between individuals in terms of absolute consumption levels, with implications for their ability to detect intervention effects.

A number of limitations of the present study and directions for further investigation merit consideration at this stage. The first limitation is the absence of a 'gold standard' measure against which to examine concordance, in particular, the absence of an objective point of reference. Although a number of studies have used 24 hour recall interviews in order to validate more brief self report measures (26, 30), these methods clearly share some of the

same limitations due to their common reliance upon self report. Because of this, it is impossible to firmly attribute any lack of concordance to the questionnaire as it is possible that some discordance was due to reporting errors during the interview rather than on the questionnaire. Concordance does not guarantee accuracy and it is quite possible to be incorrect across both measures. No viable alternatives were available however, due to the focus upon recording breakfast intakes in naturalistic settings.

Given the number of sources of potential bias explored, the measure of concordance was necessarily somewhat reductionist. Investigating specific identified sources of error in greater depth, in terms of, for example, disaggregating further whether under-reporting is universal across food types, would be a useful direction for future research. Furthermore, though this study has demonstrated an association of school level socioeconomic status with discordance, further research could usefully focus upon associations of individual level measures of socioeconomic status. In addition, although it was possible to explore associations with episodic memory and working memory, no measures of general long-term recall capabilities were available. Examination of the influence of long-term memory upon the accuracy of dietary recall on the questionnaire would be a useful direction for future research.

Conclusions and implications

In summary, the validity of the measure did not appear to be adversely associated with working memory or attention. However, deprivation, episodic memory, attitudes toward the target behavior and classroom behavior were all associated with reporting bias in questionnaire self reports when compared to dietary recall interview data. Such biases have implications for cross-sectional examination of associations between breakfast eating and these factors. Trends that may be influenced by such biases should be interpreted with a degree of caution and discussion made of potential biases.

Although employment of cluster randomized controlled trials (10) offers the potential to overcome, to some extent, problems associated with inter-individual differences in reporting accuracy, with these likely to be evenly distributed across intervention and control arms, statistical power to detect effects may be reduced where measures lack sensitivity through their reduced precision in certain sub-groups, particularly where intervention effects differ between these groups. Furthermore, within the context of randomized controlled trials such biases are problematic given recent calls to go beyond simple examination of aggregate effects in order to examine effect modification by socio-demographic factors such as socioeconomic status (31, 32). Such analyses, examining the extent to which intervention effects differ in higher or lower socioeconomic groups may prove difficult where socioeconomic status is itself related to varied reporting accuracy.

References

1. Blum JW, Jacobsen DJ, Donnelly JE. Beverage consumption patterns in elementary school aged children across a two-year period. *J Am Coll Nutr.* 2005;24:93-98.
2. Lytle LA, Nichaman MZ, Obarzanek E, Glovsky, E, Montgomery, D, Nicklas, T, Zive, M, Feldman, H. Validation of 24-hour recalls assisted by food records in 3rd-grade children. *J Am Diet Assoc.* 1993;93:1431-1436.
3. Weber JL, Lytle L, Gittelsohn J, Cunningham-Sabo L, Anliker KHJ, Stevens J, Hurley J, Ring K. Validity of self-reported dietary intake at school meals by American Indian children: The pathways study. *J Am Diet Assoc.* 2004;104:746-752.
4. McPherson RS, Hoelscher DM, Alexander M, Scanlon KS, Serdula MK. Dietary assessment methods among school-aged children: Validity and reliability. *Prev Med.* 2000; 31:S11-S33.

5. Baxter SD, Smith AF, Guinn CH, Thompson WO, Litaker MS, Baglio ML, Shaffer NM, Frye FHA. Interview format influences the accuracy of children's dietary recalls validated with observations. *Nutr Res.* 2003;23:1537-1546.
6. Macdiarmid J, Blundell J. Assessing dietary intake: Who, what and why of under-reporting. *Nutr Res Rev.* 1998;11:231-253.
7. Hill RJ, Davies PSW. The validity of self-reported energy intake as determined using the doubly labelled water technique. *Br J Nutr.* 2001;85:415-430.
8. Livingstone MBE, Robson PJ. Measurement of dietary intake in children. *Proc Nutr Soc.* 2000;59:279-293.
9. Baranowski T, Baranowski J, Doyle C, Wang, DQT, Smith, M, Lin, LS, Hearn, MD, Resnicow, K, Thompson, W. O. Toward reliable estimation of servings of fruit and vegetables and fat practices from adults' 7-day food records. *J Nutr Educ*. 1997;29:321-326.
10. Moore L, Moore G, Tapper K, Lynch, R, Desousa, C, Hale, J, Roberts, C, Murphy, S.. Free breakfasts in schools: design and conduct of a cluster randomised controlled trial of the Primary School Free Breakfast Initiative in Wales [ISRCTN18336527]. *BMC Public Health*. 2007;7.
11. Goris AHC, Westerterp-Plantenga MS, Westerterp KR. Undereating and underrecording of habitual food intake in obese men: selective underreporting of fat intake. *Am J Clin Nutr.* 2000;71:130-134.
12. Novotny J, Rumpler WV, Riddick H, Hebert, JR, Rhodes, D, Judd, JT, Baer, DJ, McDowell, M, Briefel, R,Personality characteristics as predictors of underreporting of energy intake on 24-hour dietary recall interviews. *J Am Diet Assoc.* 2003;103:1146-1151.

13. Tooze JA, Subar AF, Thompson FE, Troiano R, Schatzkin A, Kipnis V. Psychosocial predictors of energy underreporting in a large doubly labeled water study. *Am J Clin Nutr.* 2004;79:795-804.
14. Black AE, Cole TJ. Biased over- or under-reporting is characteristic of individuals whether over time or by different assessment methods. *J Am Diet Assoc.* 2001;101:70-80.
15. Rennie KL, Jebb SA, Wright A, Coward WA. Secular trends in under-reporting in young people. British Journal of Nutrition 2005;93:241-247.
16. Baxter SD, Royer JA, Hardin JW, Guinn CH, Smith AF. Fourth-grade Children are Less Accurate in Reporting School Breakfast than School Lunch during 24-Hour Dietary Recalls. *J Nutr Educ Behav.* 2007;39:126-133.
17. Bellisle F. Effects of diet on behaviour and cognition in children. *Br J Nutr.* 2004;92:S227-S232.
18. Baddeley AD. Human memory: Theory and practice 2nd ed. Hove: Psychology Press, 1997.
19. Tulving E. Elements of Episodic Memory. New York, 1983.
20. Baddeley AD, Hitch G, eds. Working memory New York: Academic Press, 1974.
21. Folkard S, Wever RA, Wildgruber C. Multioscillatory control of circadian rhythms in human performance. *Nature*. 1983;305:223-226.
22. Buckhalt JA, El-Sheikh M, Keller P. Children's sleep and cognitive functioning: Race and socioeconomic status as moderators of effects. *Child Development.* 2007;78:213-231.
23. Wardle J, Robb K, Johnson F. Assessing socioeconomic status in adolescents: the validity of a home affluence scale. *J Epidemiol Community Health*. 2002;56:595-599.

433 24. Tapper K, Murphy S, Lynch R, Clark R, Moore G, Moore L. Development of a scale
434 to measure 9-11 year olds' attitudes towards breakfast. *Eur J Clin Nutr.* 2007;Epub
435 ahead of press March 21.
436 25. Goodman RPD. Psychometric Properties of the Strengths and Difficulties
437 Questionnaire. [Article]. *J Am Acad Child Adolesc Psychiatry.* 2001;40:1337-1345.
438 26. Moore GF, Tapper K, Murphy S, Clark R, Lynch R, Moore L. Validation of a self-
439 completion measure of breakfast foods, snacks and fruits and vegetables consumed by
440 9-11 year old schoolchildren. *Eur J Clin Nutr.* 2007;61:420-430.
441 27. Reijneveld SA, Stronks K. The validity of self-reported use of health care across
442 socioeconomic strata: a comparison of survey and registration data. *Int J Epidemiol.*
443 2001;30:1407-1414.
444 28. Moore GF, Tapper K, Murphy S, Lynch R, Raisanen L, Pimm C, Moore L.
445 Associations between deprivation, attitudes towards eating breakfast and breakfast
446 eating behaviours in 9-11 year olds. *Public Health Nutr.* 2007;10:582-589.
447 29. Baranowski T, Domel SB. A Cognitive Model of Childrens Reporting of Food-Intake.
448 *Am J Clin Nutr*. 1994;59:S212-S217.
449 30. Moore L, Tapper K, Dennehy A, Cooper A. Development and testing of a
450 computerised 24-h recall questionnaire measuring fruit and snack consumption among
451 9-11 year olds. *Eur Journal Clin Nutr.* 2005;59:809-816.
452 31. Kremers SPJ, de Bruijn GJ, Droomers M, van Lenthe F, Brug J. Moderators of
453 environmental intervention effects on diet and activity in youth. *Am Journal Prev*
454 *Med.* 2007;32:163-172.
455 32. Armstrong R, Waters E, Moore L, Riggs E, Cuervo LG, Lumbiganon P, Hawe P.
456 Improving the reporting of public health intervention research: advancing TREND

457 and CONSORT. *J Public Health*. 2008; Advance access epub.

458 [doi:10.1093/pubmed/fdm082]

459

460 Table 1. Ranges and frequencies for ordinal categories of all independent variables.

Independent Variable	Low tertile		Moderate tertile		High tertile		
	Range	n	Range	n	Range	n	Missing (n)
Socioeconomic Status[a]	35.10-65.90	222	17.40-34.90	218	3.10-17.00	238	0
Attitudes towards Breakfast[b]	1.31-3.58	221	3.62-4.25	223	4.31-5.00	226	18
Episodic memory[c]	0-4	213	5-7	287	8-13	163	15
Working memory[d]	0-9	280	10-13	220	14-18	174	4
Attention (speed)[e]	96-412	201	413-534	220	535-1068	226	31
Attention (accuracy)[f]	7-86	166	87-94	194	100	286	31
Behavioural Difficulties[g]	0.00-0.70	195	0.70-1.95	207	2.00-5.80	173	103
Total items Consumed[h]	0-2	166	3-4	332	5-15	180	0

461

462 [a] Percentage of children within the school entitled to free school meals (a higher percentage

463 equals lower socioeconomic status)

464 [b] Measured on a likert scale with a possible range of 1-5

465 [c] Number of correct words remembered, with a possible range of 0-20

466 [d] Number of letters correctly remembered, with a possible range of 0-18

467 [e] Number of letters scanned within 2 minutes

468 [f] Percentage of targets marked within letters scanned

469 [g] Measured on a likert scale, with a possible range of 0-8

470 [h] Total number of items reported on 24 hour recall interview from the six food categories

471 under investigation

472

473 Table 2. Between group comparisons for eight independent variables of interest (geometric
474 means, 95% confidence intervals and h-statistics) in terms of percentage of total items
475 omitted from the dietary questionnaire.

		Geometric mean percentage total omissions	95% confidence interval of the geometric mean		H-statistic
			Lower bound	Upper bound	
Socio-economic status	Low	25.56	20.14	32.38	12.51**
	Moderate	18.91	14.79	24.10	
	High	21.16	16.71	26.74	
Attitudes	Low	29.42	23.19	37.25	23.85***
	Moderate	20.62	16.22	26.14	
	High	17.54	13.70	22.37	
Episodic Memory	Low	25.60	20.14	32.46	8.42*
	moderate	19.29	15.51	23.94	
	High	19.93	14.95	26.48	
Working Memory	Low	24.95	20.42	30.44	1.70
	moderate	19.92	15.37	25.73	
	High	19.35	14.60	25.54	
Attention – speed	Low	20.74	16.11	26.63	1.83
	moderate	20.74	16.17	26.53	
	High	24.41	19.34	30.74	
Attention – accuracy	Low	24.70	18.93	32.14	1.26
	Medium	20.40	15.58	26.61	
	High	21.49	17.39	26.49	
Behavioral difficulties	Low	18.06	13.84	23.47	7.04*
	moderate	20.11	15.54	25.95	
	High	27.30	21.12	35.22	
Total items	Low	5.56	3.63	8.30	47.65***
	moderate	25.80	21.75	30.57	
	High	47.31	41.45	53.97	

476 * p<.05, ** p<.01, *** p<.001

477 Table 3. Between group comparisons for eight independent variables of interest (geometric

478 means and 95% confidence intervals) in terms of percentages of healthier items omitted from

		Geometric mean percentage of healthier items omitted	95% confidence interval of the geometric mean	
			Lower bound	Upper bound
Socio-economic status	Low	23.08	17.10	28.45
	moderate	19.08	13.99	23.30
	High	19.58	14.51	23.73
Attitudes	Low	27.57	21.36	25.50
	moderate	18.38	14.27	23.59
	High	15.18	11.75	19.53
Episodic memory	Low	22.38	17.35	28.78
	moderate	17.93	14.25	22.50
	High	17.65	13.06	23.72
Working memory	Low	21.43	17.21	26.62
	moderate	17.27	14.25	22.25
	High	19.42	13.14	22.62
Attention – speed	Low	18.81	14.39	24.49
	moderate	18.61	14.31	24.11
	High	22.02	17.26	28.03
Attention - accuracy	Low	21.65	16.22	28.79
	medium	17.75	13.40	23.41
	High	20.22	16.22	25.13
Behavioral difficulties	Low	16.46	12.44	21.68
	moderate	19.04	14.60	24.76
	High	24.35	18.34	31.74
Total items	Low	4.68	2.98	7.11
	moderate	23.40	19.45	28.11
	High	40.15	33.83	47.62

479 a dietary questionnaire.

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Table 4. Between group comparisons for eight independent variables of interest (geometric means and 95% confidence intervals) in terms of percentages of less healthy items omitted from a dietary recall questionnaire.

		Geometric mean percentage of less healthy items omitted	95% confidence interval of the geometric mean	
			Lower bound	Upper bound
Socio-economic status	low	44.92	31.03	64.86
	moderate	15.18	8.84	25.60
	high	31.90	19.94	50.69
Attitudes	low	24.90	15.13	37.42
	moderate	26.72	16.25	43.53
	high	39.39	25.49	60.58
Episodic memory	low	48.38	33.14	70.42
	moderate	23.26	14.67	36.56
	high	20.00	11.32	34.80
Working memory	low	28.48	19.09	42.25
	moderate	35.71	23.06	55.01
	high	20.40	10.93	37.39
Attention (speed)	low	29.74	18.12	48.40
	moderate	36.70	23.72	56.50
	high	22.06	13.52	35.64
Attention (accuracy)	low	26.99	16.41	43.98
	medium	31.11	18.61	51.57
	high	28.07	18.16	43.10
Behavioral difficulties	low	17.45	9.80	30.51
	moderate	31.16	19.37	49.78
	high	30.85	17.92	51.21
Total items	low	9.41	3.18	24.92
	moderate	25.61	16.20	40.16
	high	39.60	28.68	54.55

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