The effect of a high versus low glycaemic index breakfast cereal and snack on children’s cognitive performance

Greta Defeyter
Background

Nutritional Benefits

- Better nutritional profiles (Williams, 2007)
- Skipping breakfast associated with higher levels of snack food consumption (Billon et al., 2002).

Cognitive Benefits

- Consumption of breakfast has positive effects
- Short-term improvements to memory (Smith, 1999)
- Attention (Ingwersen et al., 2007)
- Mood (Smith et al., 1999; though see Benton et al., 2001)
- Behaviour (Bro et al., 1994).

However, no consensus on the specific processes that are affected by breakfast consumption (Dye et al., 2000)
Background


9- to 16-year-olds
Cheerios, Shreddies, glucose drink or no breakfast
Computerised tests of attention and memory
Prior to and at 30, 90, 150 and 210 minutes after breakfast

Glucose Drink & No Breakfast:
Decline in Focused Attention and Episodic Memory

Cheerios & Shreddies:
Decline seen in Focused Attention and Episodic Memory was significantly reduced
Background

The ‘Best’ Breakfast...“You are what you eat”

Few studies have investigated the impact of the composition of breakfast on children’s cognitive processes.

(Wyon et al., 1997; Wesnes et al., 2003; Mahoney et al., 2005; Benton, 2003; Smith & Foster, 2008).
Background

- **High Glycaemic Index (GI > 70)**
- **Low Glycaemic Index (GI < 40)**

![Blood glucose response after intake of high and low GI carbohydrates](Roberts, 2000)

**Fig. 1:** Blood glucose response after intake of high and low GI carbohydrates (Roberts, 2000)
Aims

a) Does the glycaemic index of breakfast have an effect on cognitive performance?

Prediction: low rather than high GI breakfast more beneficial to performance, particularly in late morning

b) Are the effects found across all cognitive functions or restricted to particular processes?
Three age groups:

7-year-olds (N = 18)
    Mean age 7:2 (range 6:3-7:11); 10 females, 8 males

9-year-olds (N = 23)
    Mean age 9:1 (range 8:2-9:11); 10 females, 13 males

11-year-olds (N = 23)
    Mean age 11:0 (range 10:0-11:7); 18 females, 5 males
Procedure

- Two consecutive days
- High GI: Coco Pops
  (35g with 125ml semi-skimmed milk)
- Low GI: All Bran
  (35g with 125ml semi-skimmed milk)

Baseline  Breakfast  Test 1  Test 2  Test 3

9:00  9:30  9:40  10:40  11:40
Procedure

Cognitive Drug Research (CDR)
Computerised Assessment Battery (Wesnes et al, 2003)

Word Presentation
Immediate Word Recall
Picture Presentation
Simple Reaction Time
Digit Vigilance
Choice Reaction Time
Spatial Working Memory
Numeric Working Memory
Delayed Word Recall
Delayed Word Recognition
Delayed Picture Recognition

Fig. 2: CDR Test Battery
Cognitive Drug Research
computerised assessment battery

**Fig 3: Computerised assessment battery**

<table>
<thead>
<tr>
<th>measure</th>
<th>TASK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number correct (%)</td>
<td>Immediate Word Recall</td>
</tr>
<tr>
<td>Errors (number)</td>
<td></td>
</tr>
<tr>
<td>Intrusions (number)</td>
<td>Simple Reaction Time</td>
</tr>
<tr>
<td>Reaction time (msec)</td>
<td>Digit Vigilance Task</td>
</tr>
<tr>
<td>Accuracy (%)</td>
<td>Choice Reaction Time</td>
</tr>
<tr>
<td>Reaction time (msec)</td>
<td>Spatial Memory Task</td>
</tr>
<tr>
<td>False alarms (number)</td>
<td>Numeric Working Memory</td>
</tr>
<tr>
<td>Reaction time (msec)</td>
<td>Delayed Word Recall</td>
</tr>
<tr>
<td>Accuracy (%)</td>
<td>Delayed Word Recognition</td>
</tr>
<tr>
<td>Reaction time (msec)</td>
<td>Delayed Word Recognition</td>
</tr>
<tr>
<td>Accuracy original stimuli (%)</td>
<td></td>
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<tr>
<td>Accuracy new stimuli (%)</td>
<td></td>
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<tr>
<td>Reaction time (msec)</td>
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<tr>
<td>Accuracy original stimuli (%)</td>
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<td>Reaction time (msec)</td>
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<td>Accuracy original stimuli (%)</td>
<td></td>
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<tr>
<td>Accuracy new stimuli (%)</td>
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</tbody>
</table>
Analysis of Data

- Focused Attention
- Sustained Attention
- Working Memory
- Episodic Memory
- Speed of Memory
Analysis of Data

- Change from Baseline
  Test 1/2/3 - Baseline

- (3 x 2 x 3) ANOVA
  (assessment x breakfast x age group)
Results

- Older children perform better than younger children
- Decline in performance throughout the morning
Results

Episodic Memory

Main effect of Breakfast
$F(1,61) = 5.313, p < 0.05$

Significantly smaller decline in performance after consumption of low GI All Bran compared to high GI Coco Pops

Fig. 4: Performance on Episodic Memory
Results

Sustained Attention

Breakfast * Assessment Time
\( F(2,122) = 3.820, \ p < 0.05 \)

Significantly decline in performance on Test 3 after consumption of high GI Coco Pops compared to low GI All Bran

Fig. 4: Performance on Sustained Attention
Aims

a) Can the Glycaemic Index of breakfast affect children’s cognition?

b) Are the effects found across all cognitive functions or restricted to particular processes?
Discussion

Significantly less decline on Episodic Memory and Sustained Attention across the morning after consumption of Low GI (All Bran) compared to high GI (Coco Pops)

Changes in cognitive performance may be a reflection of changes in blood glucose levels, in this case triggered by glycaemic index
Effect of GI may be different for different cognitive processes

Micronutrients and other macronutrients can also influence cognitive performance (Lieberman et al, 1986)

Are there similar findings for a mid-morning snack?

Does a mid-morning snack have a beneficial effect on cognitive performance?
Experiment 2

- Busch et al. (2002) Attention significantly better following consumption of a confectionary snack vs. placebo drink.
- Muthayya, Thomas, Srinivasan, Rao, Kurpad, van Klinken, Owen and de Bruin (2007) found no effect of snack on sustained attention or on psychomotor speed. Smaller decline in immediate and delayed memory (Low SES children)
- Benton et al. (1987) showed that 7-year-olds showed better performance, in terms of attention, following a glucose drink compared to a placebo
Participants

30 children aged 12 to 13 years (mean age = 12:10, range: 12:5-13:3) were recruited. 21 were females (mean BMI = 16) and 9 were males (mean BMI = 18).

All children consumed the same breakfast (toast)
Treatments

Children consumed an apple (approx. 160g), a banana (approx. 170g, medium ripe) or no snack.

Table 1: Nutritional characteristics of a 160g apple and a 170g banana. The GI value is taken from an international table of glycaemic index (Foster Powell et al., 2002) and the nutritional values are taken from USDA National Nutrient Database for Standard Reference (2006).

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Units</th>
<th>Apple (160g)</th>
<th>Banana (170g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>kcal</td>
<td>83</td>
<td>151</td>
</tr>
<tr>
<td>Protein</td>
<td>g</td>
<td>0.42</td>
<td>1.85</td>
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<tr>
<td>Fat</td>
<td>g</td>
<td>0.27</td>
<td>0.56</td>
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<tr>
<td>Fibre</td>
<td>g</td>
<td>3.8</td>
<td>4.4</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>g</td>
<td>22.10</td>
<td>38.83</td>
</tr>
<tr>
<td>Sugars</td>
<td>g</td>
<td>16.62</td>
<td>20.79</td>
</tr>
<tr>
<td>Starch</td>
<td>g</td>
<td>0.08</td>
<td>9.15</td>
</tr>
<tr>
<td>Glycaemic Index</td>
<td>GI</td>
<td>38</td>
<td>52</td>
</tr>
</tbody>
</table>
Measures

- Simple Reaction Time
- Choice Reaction Time
- Corsi Blocks (measure of spatial working memory)
- RVIP (measure of visual sustained attention)
- Odd-one-Out (measure of working memory)
Procedure

8.30am Breakfast

10.00 Pre-snack measures

11.00am Snack

12.00am Post-snack measures
## Results

<table>
<thead>
<tr>
<th>Measure</th>
<th>Condition</th>
<th>Pre-snack</th>
<th>Post-snack</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple reaction time (msec)</td>
<td>Apple</td>
<td>338.08 (53.89)</td>
<td>356.31 (75.28)</td>
</tr>
<tr>
<td></td>
<td>Banana</td>
<td>351.67 (34.31)</td>
<td>352.58 (60.71)</td>
</tr>
<tr>
<td></td>
<td>No Snack</td>
<td>415.91 (59.22)</td>
<td>439.53 (64.32)</td>
</tr>
<tr>
<td>Choice Reaction time (msec)</td>
<td>Apple</td>
<td>581.73 (147.27)</td>
<td>556.38 (119.52)</td>
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<tr>
<td></td>
<td>Banana</td>
<td>533.40 (63.71)</td>
<td>529.47 (76.21)</td>
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<tr>
<td></td>
<td>No Snack</td>
<td>631.57 (115.91)</td>
<td>652.29 (165.40)</td>
</tr>
<tr>
<td>Corsi Blocks (# correct)</td>
<td>Apple</td>
<td>19.10 (2.60)</td>
<td>19.30 (4.57)</td>
</tr>
<tr>
<td></td>
<td>Banana</td>
<td>19.30 (1.06)</td>
<td>18.60 (3.60)</td>
</tr>
<tr>
<td></td>
<td>No Snack</td>
<td>19.60 (3.24)</td>
<td>19.70 (3.86)</td>
</tr>
<tr>
<td>Measure</td>
<td>Condition</td>
<td>Pre-snack</td>
<td>Post-snack</td>
</tr>
<tr>
<td>--------------------</td>
<td>----------------</td>
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<td>-------------------</td>
</tr>
<tr>
<td>RVIP (d’)</td>
<td>Apple</td>
<td>3.83 (1.04)</td>
<td>3.98 (1.01)</td>
</tr>
<tr>
<td></td>
<td>Banana</td>
<td>4.42 (1.25)</td>
<td>4.49 (1.09)</td>
</tr>
<tr>
<td></td>
<td>No Snack</td>
<td>4.16 (1.24)</td>
<td>3.54 (1.07)</td>
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<tr>
<td>Odd one out Recall</td>
<td>Apple</td>
<td>20.10 (4.07)</td>
<td>19.20 (4.10)</td>
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<tr>
<td>(# correct)</td>
<td>Banana</td>
<td>19.10 (3.21)</td>
<td>19.70 (3.56)</td>
</tr>
<tr>
<td></td>
<td>No Snack</td>
<td>18.30 (4.69)</td>
<td>19.00 (4.35)</td>
</tr>
</tbody>
</table>

A one-way Annova revealed no significant differences between the pre-snack scores (with the exception of Simple Reaction Time.) Annova’s or Ancova revealed no significant differences between pre-snack scores and post-snack scores on any of the measures.
Discussion

Contrary to Busch et al. (2002) & Muthayya et al. (2007), Benton & Jarvis (2007) present study showed no effect of mid-morning snack on cognitive processes.

- Controlled for breakfast composition
- Overnight fasting
- SES
- Parental Education
- School Attendance
- Same environment
Discussion

- Some evidence for positive effect of low GI breakfast on cognition
- No effect of snack (mid-morning)
- Differences between studies
- Biological differences between individuals
Acknowledgments

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Collaborators:

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