Foods for cognitive function

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Overview

• What is cognitive function?
• How can we measure cognitive function in response to dietary components or whole foods/meals/diet?
• Target groups – young, old
  Obesity & T2DM
• Evidence & Mechanisms
• What do we need to find out?
What is Cognitive Performance?

Perception, understanding & action

Complex tasks – operating machinery, driving, learning, making decisions

Evolved to give us control over the environment

We are all using our cognitive abilities all the time
How can we measure cognitive function in response to dietary components or whole foods?
The shape of things to come?
Domains of Cognitive Function

Perception – attention (vigilance)
Information processing
Learning & memory
  - acquisition
  - storage & retrieval
  - recall & recognition
Problem solving
Motor control
  - reaction time:
  - tracking
Blueberry Supplements reverse deleterious effects of ageing on motor behaviour

prevent behavioural deficits in mice
Reverse age related decline in spatial memory
-antioxidant effect
(Joseph et al., 2003)

Louise Dye, HARI, Leeds
Rats are not little humans
& humans are not big rats

Louise Dye, HARU, Leeds
Mechanism of Action

- Ingested Dietary component
- Physiological change in central process
  - Cognitive Function
- Improved Health e.g. Reduced BP, Obesity, improved Glycaemic control or blood flow
- Biomarkers - potential vs known
- Time course of action
- Age/gender dependent effects - soy IF
Scientific Direct

Neuroscience and Biobehavioral Reviews

Review

Acute effects of macronutrient manipulations on cognitive test performance in healthy young adults: A systematic research review

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Acute interventions in young healthy adults

- 31 studies (100’s excluded!!)
- 134 cognitive outcome measures
- Manipulations – glucose, macronutrients
- Memory
- High demand situations
- 62 measures showed significant effects

Delayed Memory is most sensitive to glucose manipulations

Hoyland et al. (2008)
Energy and the human brain

2% of body mass (~3 lb)

20% energy (glucose and oxygen)

2-3,000 pints blood/day pass through the brain
Validation of interstitial glucose against arterialised venous and capillary samples

Dye et al, (2009)
Continuous glucose profiles before and after 5 different breakfasts

- Cereal A
- Cereal B
- Water
- Toast & Yogurt
- Cereal C

Time (3 min bins)
Immediate verbal recall

Later in the morning: Cereal B - better recall relative to baseline than water or Cereal C. Toast/Yoghurt better recall than water or Cereal C

Change from baseline in immediate recall: Breakfast * session interaction

-3
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
1 2 3
session
no of words
Cereal A
Cereal B
Water
Toast & Yoghurt
Cereal C
Cognition throughout life

infant  child  adult  elderly

ability  cognitive development
Nutrition for the Growing Brain
Basic needs

Micro-nutrients such as Iron, Zinc, Iodine and B-vitamins are required for key metabolic and control processes in brain development.

A developing child’s brain uses 200-300% more energy than that of an adult.

Nutrition should provide **adequate glucose sources** to meet these high demands.
A systematic review of the effect of breakfast on the cognitive performance of children and adolescents

Alexa Hoyland, Louise Dye* and Clare L. Lawton

*Human Appetite Research Unit, Institute of Psychological Sciences, University of Leeds, Leeds LS2 9JT, UK

Breakfast is recommended as part of a healthy diet because it is associated with healthier macronutrient and micronutrient intakes, BMI and lifestyle. Breakfast is also widely promoted to improve cognitive function and academic performance, leading to the provision of breakfast initiatives by public health bodies. Despite this positive and intuitive perception of cognitive benefits, there has been no systematic review of the evidence. Systematic review methodology was employed to evaluate the effects of breakfast on cognitive performance in well-nourished children and nutritionally at-risk or stunted children. Acute experimental studies, school feeding programmes and studies of habitual breakfast intake are reviewed. Comparisons of breakfast vs. no breakfast and breakfasts differing in energy and macronutrient composition are discussed. Included are forty-five studies described in forty-one papers published between 1950 and 2008. The evidence indicates that breakfast consumption is more beneficial than skipping breakfast, but this effect is more apparent in children whose nutritional status is compromised. There is a lack of research comparing breakfast type, precluding recommendations for the size and composition of an optimal breakfast for children’s cognitive function. Few studies examined adolescents. Studies of school breakfast programmes suggest that such interventions can have positive effects on academic performance, but this may be in part explained by the increased school attendance that programmes encourage. The present systematic review considers methodological issues in this field and makes recommendations for future research design and policy priorities.
Breakfast and cognition in children

Systematic review

Two aims:

- Does breakfast per se confer benefits?
- Is breakfast type important?
- 45 studies

<table>
<thead>
<tr>
<th>Category</th>
<th>Number of studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute effects in well-nourished children</td>
<td>21</td>
</tr>
<tr>
<td>Acute effects in children of differing nutritional status</td>
<td>7</td>
</tr>
<tr>
<td>Long-term effects of school breakfast programs and breakfast clubs</td>
<td>13</td>
</tr>
<tr>
<td>Effects of habitual breakfast intake</td>
<td>4</td>
</tr>
</tbody>
</table>
Acute interventions in well-nourished children

21 studies

- 9 USA and 6 UK
- Industry sponsored or product related
- Charitable foundations
- Most compared BF vs. No BF
- 9 compared breakfasts

Advantage of breakfast but small effect of breakfast type
School breakfast programs

Breakfast consumption

- better nutritional profiles of children who habitually skip breakfast

Breakfast skipping associated with:
- Increased snack food consumption
- Increased likelihood of being overweight

Positive effects on cognitive or academic performance in 10/13 studies
improvement mainly in maths or arithmetic scores

Artefact of increased attendance?


Defeyter, et al.(2010)
Some confounds & little considered variables

Socio-economic status
Associated with other health & lifestyle behaviours
Child’s weight – tendency to normal/overweight in US & UK
- Effect on glucoregulation, development and cognitive function
Intellectual functioning – IQ not measured or controlled for
- Higher IQ protective?
- Intervention has bigger impact on less able children?
Expectancy effects & selection bias
- Habitual BF eaters recruited/interested
- Blinding difficult
Habitual Diet

Obesity
Central Adiposity,

Impaired Glucose Tolerance
Type 2 Diabetes
### Epidemiological studies: dietary intake & cognitive function

<table>
<thead>
<tr>
<th>Dietary component</th>
<th>Cognitive impairment risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatty Fish</td>
<td>↓</td>
</tr>
<tr>
<td>Omega 3 PUFA</td>
<td>↓</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>↑</td>
</tr>
<tr>
<td>Sat Fat</td>
<td>↑</td>
</tr>
<tr>
<td>Homocysteine</td>
<td>↑</td>
</tr>
</tbody>
</table>

Rotterdam Study - 45-70 year old (Kalmijn et al., 2004)
Fish consumption is negatively related to the risk of dementia

Barberger-Gateau, 2002

Cases per 100 person-years

Fish meals per week

p<0.01

(Barberger-Gateau, 2002)
Obesity & Cognitive Function: Data from Framingham

4 findings

Effects of Obesity & HT on learning & memory in men not women
Indpt of other CVD risk
Suggest similar pathophysiological mechanisms
Are cumulative (men) - presence of O & HT - more cog deficits than either/none

(Elias et al. 2002)

Figure 1 Relation of number of CVD risk factors (0 = none; 1 = either obesity or hypertension present; 2 = both obesity and hypertension present) to cognitive test performance in men.
Effects of glucose on cognition in relation to glucose regulation

Epidemiological studies of IGT–clear association with impaired cognitive function (Kalmijn et al., 1995)

Systematic review

NGT –
Normal glucose tolerance

Clear effects on cognition
Memory – worse
- specific tests

Only in poor regulators in the normal range

IGT –
Impaired glucose tolerance

Pre Diabetic state – losing regulation
Unaware, not on treatment
Middle aged
Few effects on cognition
Poor range of insensitive tests (e.g. MMSE)

Study 1: IGT and cognition

Recruited 65 females aged 30-50 years from general population

Screening

OGTT (oral glucose tolerance test)

normal glucose tolerance (NGT)
N = 47

Impaired glucose tolerance (IGT)
N = 18

Lamport et al., (under review)
Glycaemic response to the OGTT

Blood glucose mmol/l

NGT

IGT

Time

Lamport et al., (under review)

8.45 9.00 9.15 9.30 9.45 10.00 10.15 10.30 10.45 11.00 11.15 11.30

Lamport et al., (under review)  Time

NGT  IGT

Lamport et al., (under review)
IGT and cognitive function

IGT group impaired on...

VVLT (immediate & delayed)
Word recognition
VSLT (immediate & delayed)
Corsi block tapping
Psychomotor Test

IGT impaired on 12/27 cognitive test outcomes

Subtle impairments in prolonged concentration in ostensibly healthy middle aged women

Lamport et al., (under review)
T2DM and cognitive function

Type 2 diabetes - impairments in
• verbal memory,
• spatial memory,
• psychomotor skill,
• executive function

compared to NGT adults matched for education, age, depression, & IQ.

Lamport et al., (Clin. Nutr. in press)
Cognition throughout life

Infant | Child | Adult | Elderly

Prevention of cognitive aging

Louise Dye, HARU, Leeds
Systematic review: Polyphenols and cognition

- **Inclusion criteria**
  - Human participants
  - Objective measure of cognitive function
  - Control condition

- **Exclusion criteria**
  - Studies of green tea or Ginkgo Biloba
  - Dementia as the cognitive outcome

<table>
<thead>
<tr>
<th>Category</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Juice studies</td>
<td>4</td>
</tr>
<tr>
<td>Cocoa studies</td>
<td>4</td>
</tr>
<tr>
<td>Isoflavone studies</td>
<td>13</td>
</tr>
<tr>
<td>Supplement studies (e.g. Resveratrol)</td>
<td>3</td>
</tr>
<tr>
<td>Epidemiological survey</td>
<td>3</td>
</tr>
</tbody>
</table>

27 studies

Lamport et al. (2012a)
## Summary of isoflavone studies (Lamport et al., 2012a)

<table>
<thead>
<tr>
<th>Domain</th>
<th>Number of measures</th>
<th>Number of significant effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbal memory (immediate)</td>
<td>13</td>
<td>2 (15%)</td>
</tr>
<tr>
<td>Verbal memory (delayed)</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Spatial memory (immediate)</td>
<td>14</td>
<td>4 (29%)</td>
</tr>
<tr>
<td>Spatial memory (delayed)</td>
<td>4</td>
<td>3 (75%)</td>
</tr>
<tr>
<td>Working memory</td>
<td>8</td>
<td>1 (13%)</td>
</tr>
<tr>
<td>Executive Function</td>
<td>25</td>
<td>7 (28%)</td>
</tr>
<tr>
<td>Attention</td>
<td>5</td>
<td>1 (20%)</td>
</tr>
<tr>
<td>Psychomotor Speed</td>
<td>14</td>
<td>4 (29%)</td>
</tr>
</tbody>
</table>
Systematic Review of Polyphenol containing Juice studies

5 studies

• 3 grape juice, 1 blueberry juice, 1 cranberry juice

• One acute, a 6-week intervention, two 12 week and one 16 week interventions

• Most in older adults >60 years; 1 in young healthy

• some with mild cognitive impairment

Lamport et al, (2012b)
Krikorian et al. (2010a) – Grape Juice

• Significantly better verbal recall at 12 weeks in grape juice group

![Bar chart showing comparison between placebo and grape juice groups](chart.png)

**Fig. 1.** List acquisition performance assessing verbal learning on the California Verbal Learning Test. Values are adjusted means, with standard errors represented by vertical bars. Subjects consuming Concord grape juice demonstrated significant improvement ($F(1, 8) = 5.55; P=0.04;$ Cohen’s $f = 0.28$).

• Mean age =78 (5)
• But grape juice group were younger than control (75 years vs 80 years – ns)
Krikorian et al. (2010b)
Effect of Blueberries on memory

12 week intervention, Parallel groups, Mean age=76(5)

Better Verbal PAL
No sig effect on CVLT

Placebo –from CGJ Study (n=7)
BB n=9
Summary of RCT juice studies

• 12 week grape juice intervention showed memory benefits....
• 16 week grape juice intervention reduced interference
• ......but no effect in acute grape juice (*but young*)

• 12 week blueberry intervention also showed memory benefits (*but not on same test!*)

• No effects of 6 weeks of cranberry juice or
• acute effects of Resveratrol (*but again young & no memory tests included*)
Epidemiological studies

Nurk - 1yr n=2031
  chocolate, wine, tea & memory, executive function tests
Letenneur – 10yr n=1640
  total polyphenols & global cognitive function

Butchart FFQ 882 adults aged 70+
No association between flavonoid intake & combined measures of different cognitive domains
Kesse-Guyot – 13yr n=1413
Higher polyphenol intake - Better language & memory
But catechins, proanthocyanins & flavonals – poorer exec function
Devore et al (2012) Nurses Health Study

16010 women aged 70+
Follow up – 2yr intervals
Greater intake of &
Slower rate of cognitive decline (up to 2.5 years equivalent)
(6 cognitive tests)

infant child adult elderly

prevention of cognitive aging

Louise Dye, HARU, Leeds
Possible Mechanisms

• Protection of neuronal signalling pathways
  - Inhibit neuroinflammatory processes (Spencer, 2010)

• Modulation of synaptic plasticity
  - rodent studies - fruit polyphenols can increase neuronal communication efficiency (Williams et al, 2008)

• Increased cerebrovascular blood flow
  - Grape juice shown to reduce platelet aggregation, lower blood viscosity & increase blood flow
  - Polyphenol extract increased FMD in men with CVD (Lekakis et al., 2005)

• Effects on estrogen receptors (soy isoflavones)
Problems......
And recommendations

• Habitual consumption of BF, polyphenols or other dietary characteristics not always reported

• Confounded by other intake/health behaviours—proxy for good lifestyle—e.g. BF consumers likely to have lower BMI & more PA
  Berry consumers – higher PA & income (& eat more fish)

• Covariates e.g. Dietary intake, Age, IQ, depression, diabetes, medication etc either restricted or covaried.

• Rationale for cognitive test selection – not related to mechanism

• Cognitive test procedures MUST be documented
  e.g. Time of day, fasted etc.
Take away messages....

• Breakfast = good for you (better than no BF) – especially if you are undernourished/deficient, lower in IQ, young (<16)

• Verbal & spatial memory most likely to be affected by macronutrients (delayed verbal), missing BF, polyphenols

• Epid studies - associations between diet (e.g. fish) & food components (eg omega 3s, polyphenols) & cognition

• Obesity, IGT & T2DM associated with subtle but important cognitive deficits

BUT
• no consistent dose response effects or association between cognitive outcomes & duration of intervention, or population studied
BioPsychology Group

Dr Clare Lawton – Appetite control, satiety & weight management

Dr Alexa Hoyland – Hon RF – effect of breakfast

Katie Adolphus – breakfast and cognition/behaviour in children

Dr Nicola Lasikiewicz – Hon RF – stress, obesity & cognition

Neil Boyle – stress and cognitive function & dairy components

Dr Dan Lamport – Glycaemic response, IGT Diabetes. PPs

Iria Myrissa – predictors of weight loss and maintenance

Amy Weeks – effects of exercise on cognition & CV markers

Fiona Croden – research dietician

Thank You!
Why the need for new European legislation?

“To ensure the effective functioning of the internal market as regards nutrition and health claims whilst providing a high level of consumer protection”

EFSA, 2006

• New rules are stricter
• High standards set for the quality of scientific evidence needed
• Claims cannot be misleading
• Consumer protection
• Promotion of product innovation