Children's Brain Responses to Food:
Obesity Implications for the Developing Child

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CANDLE Brain Awareness Week

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Thank you

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USDA

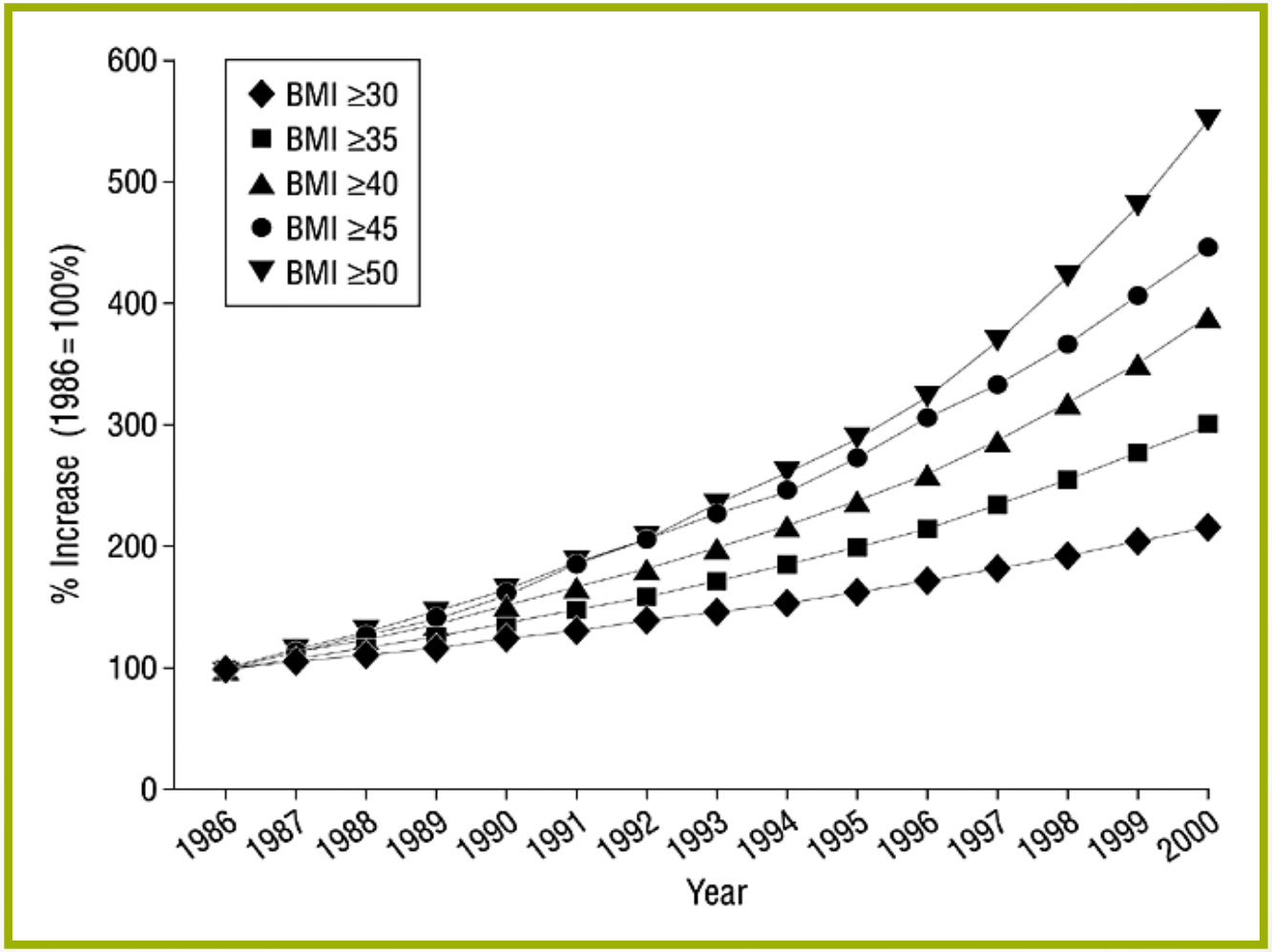
Overview

- Food motivation and obesity
- Functional neuroimaging
- Current knowledge
- Future directions

Food Motivation

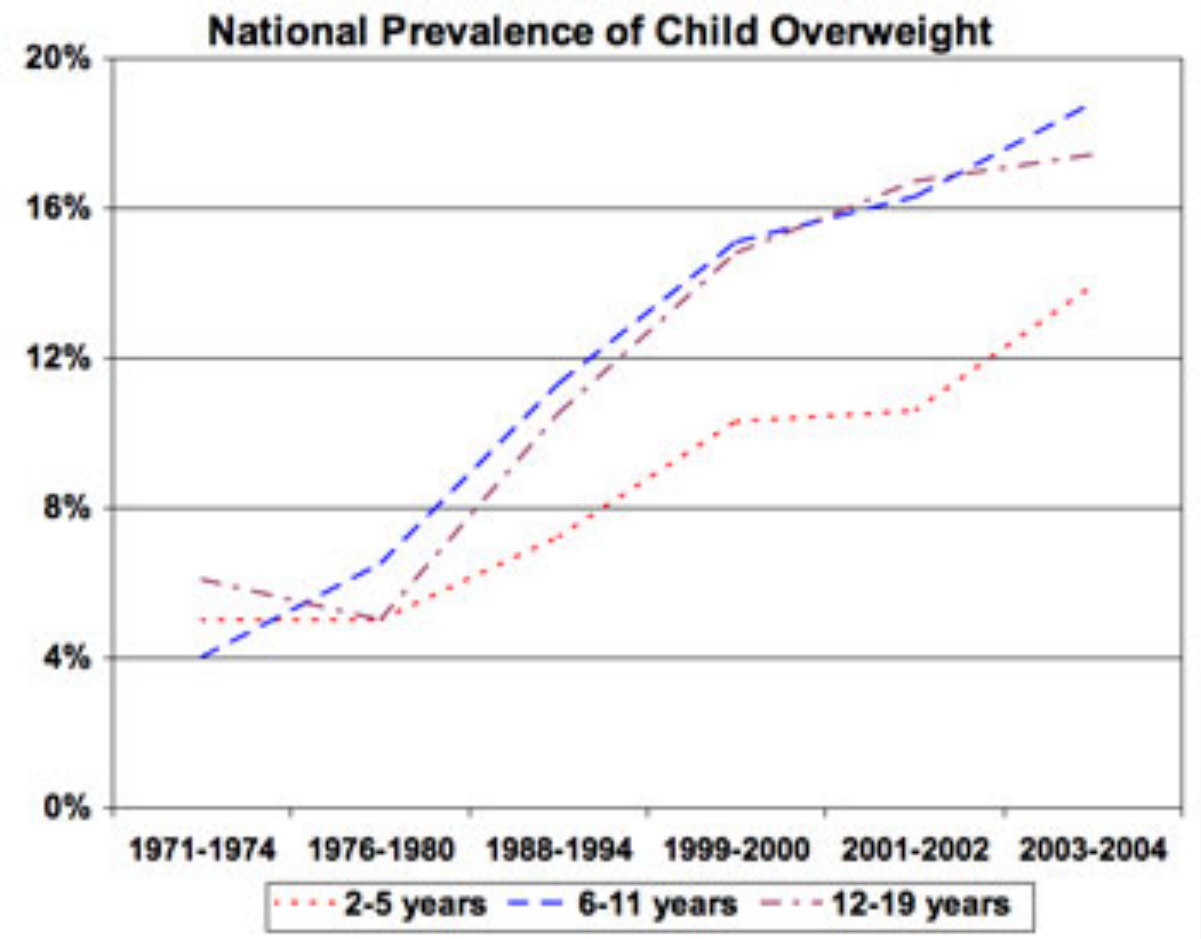
- Physical sensations
  - Stomachache
  - Headache
  - Fatigue
  - Thirst
- Environmental Cues
  - Time of day
  - Social situation
  - Sensory cues

Incidence of Obesity



Sturm. Arch Intern Med 2003;163:2146

Childhood Obesity on the Rise



Ogden et al, 2002; Ogden et al, 2006


THE ANTHRAX ATTACKS
HOW THE FBI SMEARED THE WRONG MAN
the Atlantic
Michael Kinsley On Money, Media, And Free Speech ▸ 40
China's Quiet Takeover Of Africa ▸ 58
Christopher Hitchens On The Dark Side Of Dickens ▸ 88
FAT NATION
IT'S WORSE THAN YOU THINK


How Obama Is Fighting Internet Innuendo
Inside China's Gold Medal Machine
TIME
SPECIAL HEALTH ISSUE
Our Super-Sized Kids
It's not just genetics and diet. An in-depth look at how our lifestyle is creating a juvenile obesity epidemic—


LET'S MOVE!

Energy Imbalance

Energy Intake

High fat, high calorie diet

Energy Expenditure

Sedentary Lifestyle

Genetic Disposition

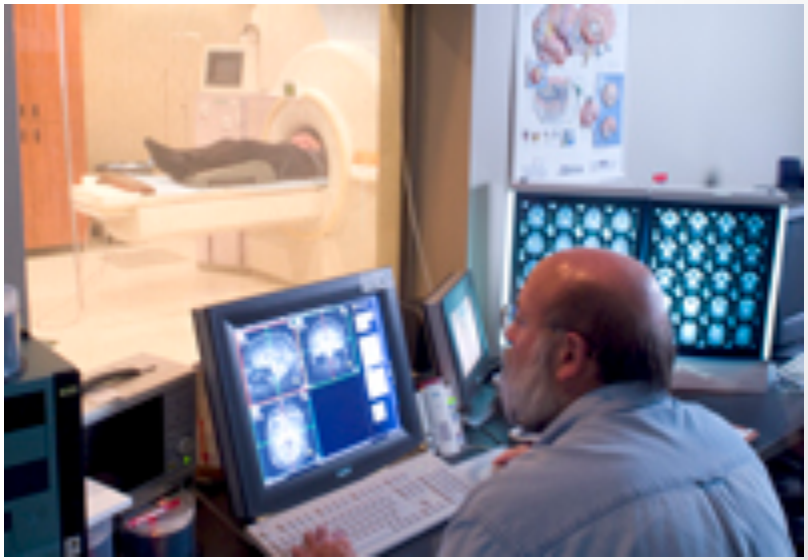
Social factors, Economic factors, Societal factors

Causes of Obesity

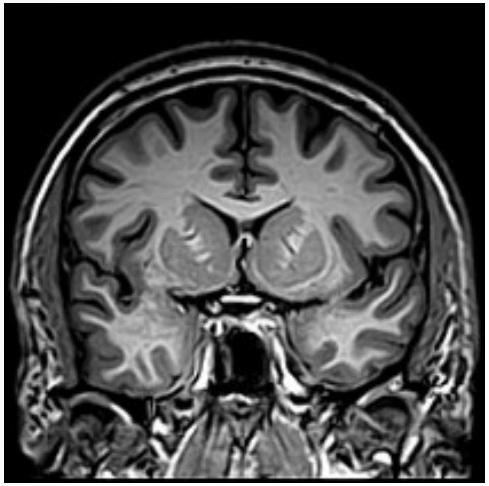
- ***Why*** there is a disruption in energy balance is much more complicated
  - Genetic
  - Physiological/Hormones
  - Behavioral
  - **Economic**
  - **Societal**
  - **Brain**

Magnetic resonance imaging MRI

Producing pictures of the brain with *noninvasive* techniques



Magnetic resonance imaging MRI



Coronal

Sagittal

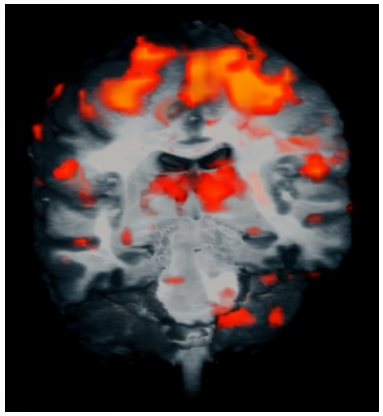
Axial (Transverse)

Functional Magnetic resonance imaging (fMRI)

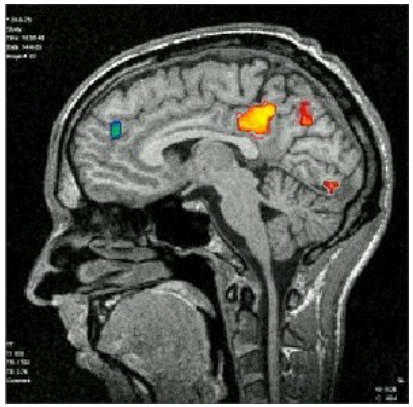
- Changes in blood flow and blood oxygenation are associated with neural activity (BOLD response)

- fMRI measures brain activations while a person is engaged in a certain task

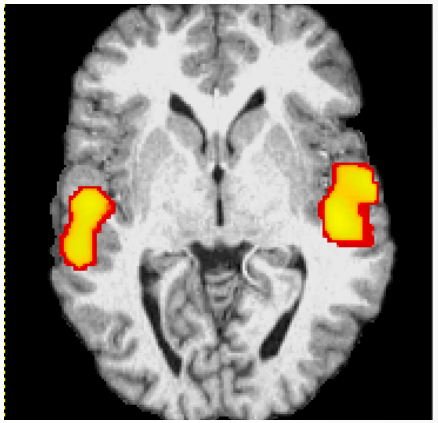
Functional Magnetic resonance imaging (fMRI)



Coronal



Sagittal



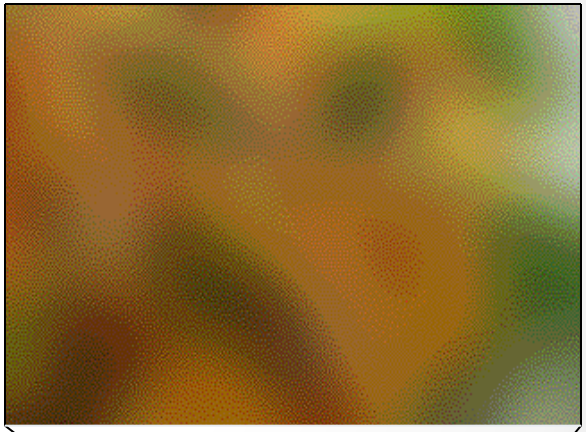
Axial (Transverse)

fMRI Food Motivation paradigm

Food

Non-food

Baseline



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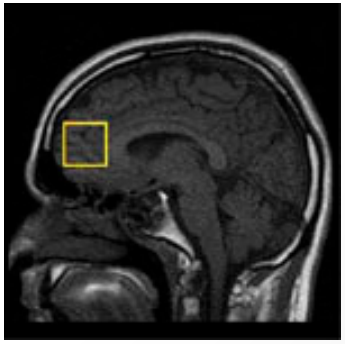
What we know: Food motivation & the brain

Two aspects of eating behavior influenced by brain regions and neural pathways

1. Homeostatic mechanisms

2. Motivation and reward processing



What we know: Obesity & the brain

Brains of obese individuals act differently than brains of healthy weight individuals.

(Martin et al. 2009; Bruce et al., 2010, Bruce et al., in press)

What we know: Child obesity & the brain

- Neural correlates of pediatric obesity (Bruce et al., 2011)

- Past fMRI studies have used visual stimuli, tastant delivery, and auditory stimuli

fMRI Study in Obese & Healthy Weight Children

Bruce et al., (2010)

Procedure

- Scanned before and after eating a small meal (pre-meal, post-meal)
- Time between meals: 4 hours
- Standardized meal: ~500 calories
  - Matched for macro- and micro-nutrients

Demographics

	HW Controls	Obese	P
N (M/F)	10 (5/5)	10 (5/5)	–
Handedness	All R	All R	–
Age	13 (10-17)	13 (11-16)	0.99
Years of Education	At grade level	At grade level	–
BMI	18.8 (15.9-22.3)	31.3 (27.0-41.6)	<0.000002
Percentile for Age	50.88 (5-88)	All > 95%	<.00007

Obese & Healthy Weight Kids

- Obese children show greater activation than healthy weight children to food pictures both pre-meal and post-meal
  - Prefrontal cortex (PFC)
  - Paralimbic cortex (OFC)

Bruce et al., (2010)

Obese & Healthy Weight Kids

- Obese children **fail** to show significant post-meal modulation of activation
  - Prefrontal, limbic, and reward processing regions

Bruce et al., (2010)

The Next Step

If some children are more susceptible to images of food than others…

…could this mean they might be more susceptible to advertisements?

Food logos















Nonfood logos




















Pilot Validation of Logos

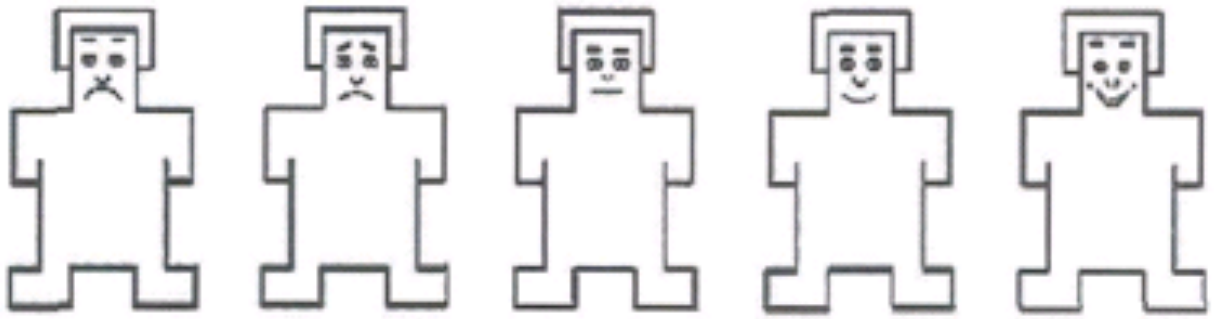
- 34 children ages 8-17 recruited for offline study to validate visual stimuli
- Rate each logo (Intl Affective Picture Set; Lang et al., 1997)
  - Familiarity
  - Association with food/drink
  - Valence (positive/negative)
  - Intensity (interesting/boring)
- Select most appropriate logos for use in scanner

How familiar is it to you?

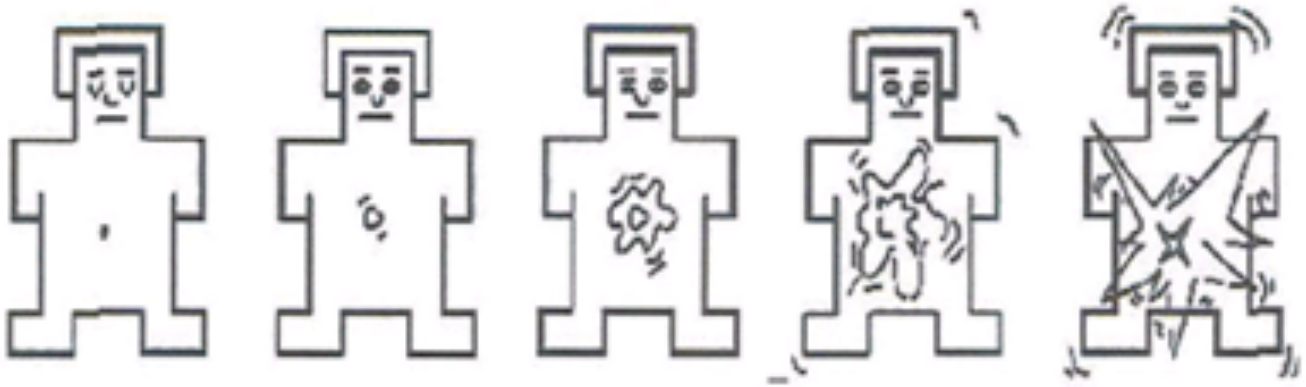
Not at all **1------2-------3-------4-------5** ***A lot***

How much does it make you think of food/drink?

Not at all **1------2-------3-------4-------5** ***A lot***



How sad or happy does it make you feel?



How bored or excited does it make you feel?

Pilot Validation of Logos

Results

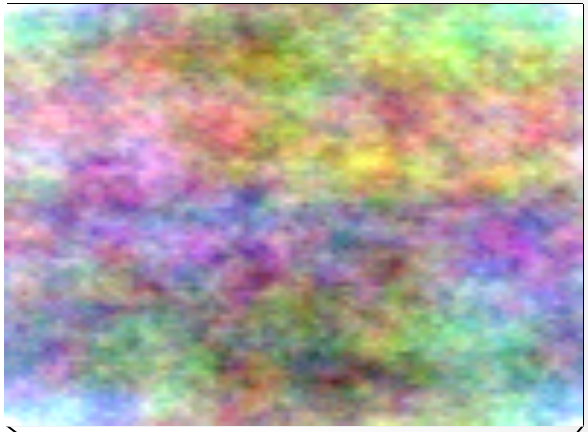
- 60 food logos and 60 nonfood logos
  - Matched on familiarity, intensity, happiness
  - Significantly different on food/drink

fMRI Logo Study Paradigm

Food

NonFood

Baseline



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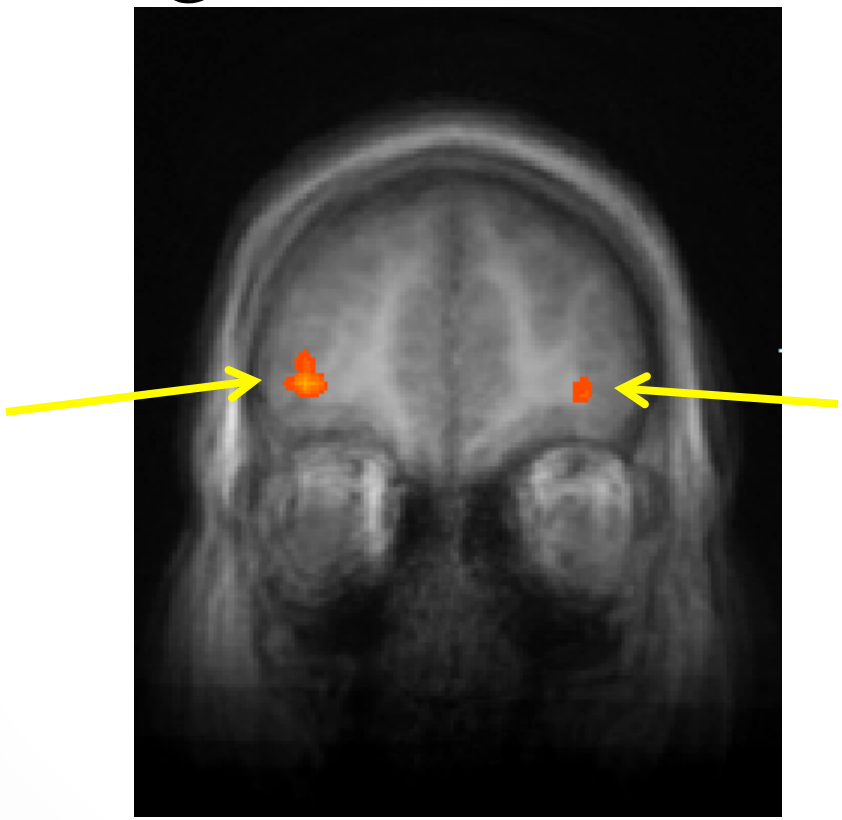
fMRI Logo study: Demographics

	HW	Obese	p
N (M/F)	10 (3/7)	10 (6/4)	0.18
Handedness	All R	All R	–
Age	12.1 (10-14)	11.6 (10-14)	0.38
Years of Education	At grade level	At grade level	–
BMI Percentile	49.97%	98.9%	<.001

Healthy Weight> Obese Results

Food logos vs. Nonfood logos



Bilateral activation of inferior frontal gyrus

Bruce et al., in press, J Peds

Behavioral Data: Logo study

Eysenck Impulsivity scale

Obese and healthy weight difference

$t = -2.27$; $p = .035$

<u>Examples of items:</u>

5. *Do you generally do and say things without stopping to think?*

12. *Do you often do things on spur of the moment?*

22. *Do you get restless if you have to stay around home for any length of time?*

Logo study Interpretation

- Similar brain regions activate to food logos as actual images of food
- Differential activation between obese and healthy weight children
- Healthy weight children exhibit more brain activation in areas of inhibitory control
  - Inferior frontal gyrus is implicated in self-control

Logo study Implications

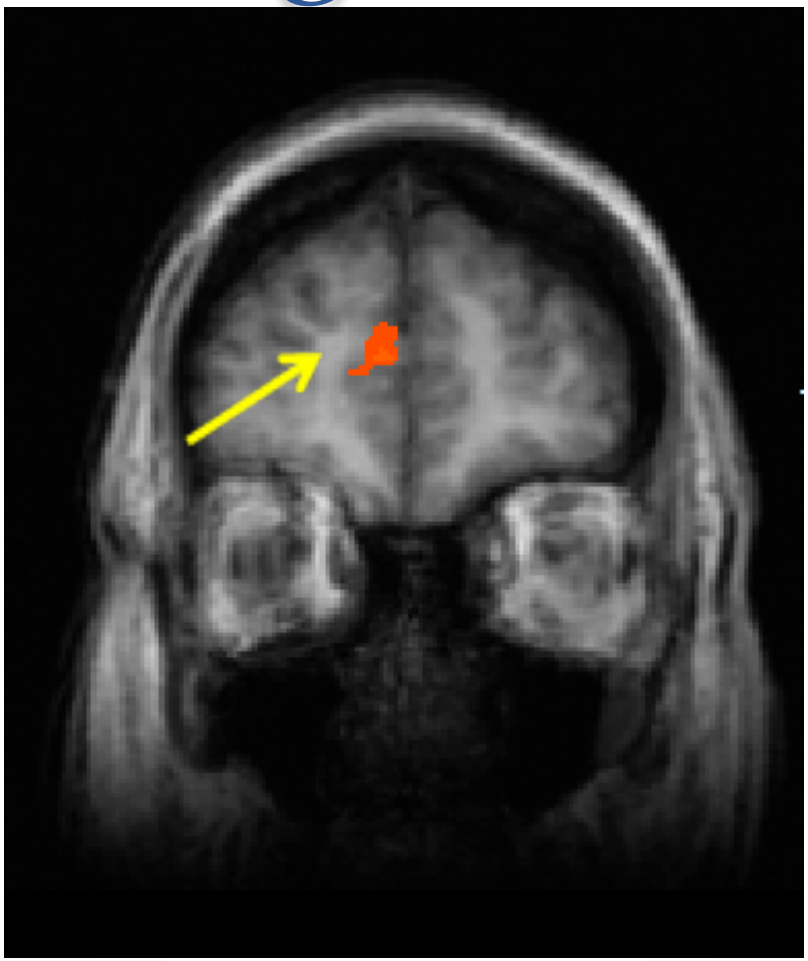
- Children need to learn to become more critical of advertising
- Use principles for positive health changes
- Is it ethical to advertise unhealthy foods to children who may be particularly vulnerable?
- Policy changes…

Future directions

Does the brain change with weight loss?

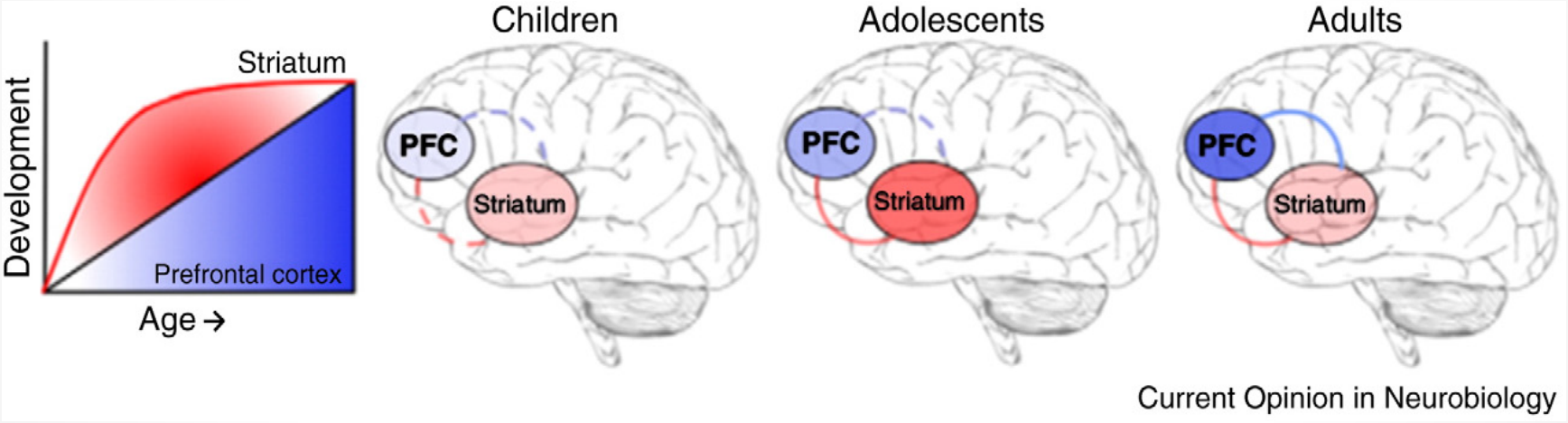
- Yes. (In adults).
  - Some behavioral, some surgical weight loss
  - Bruce et al., 2012; Rosenbaum et al., 2007; Murdaugh et al., 2012
- Compare bariatric surgery vs. diet weight loss
  - Matched for % of weight loss
  - Results (Bruce et al., under review)

Bariatric vs. Behavioral weight loss



Future directions

Prefrontal cortex (self-control) and striatum (reward)



Future directions

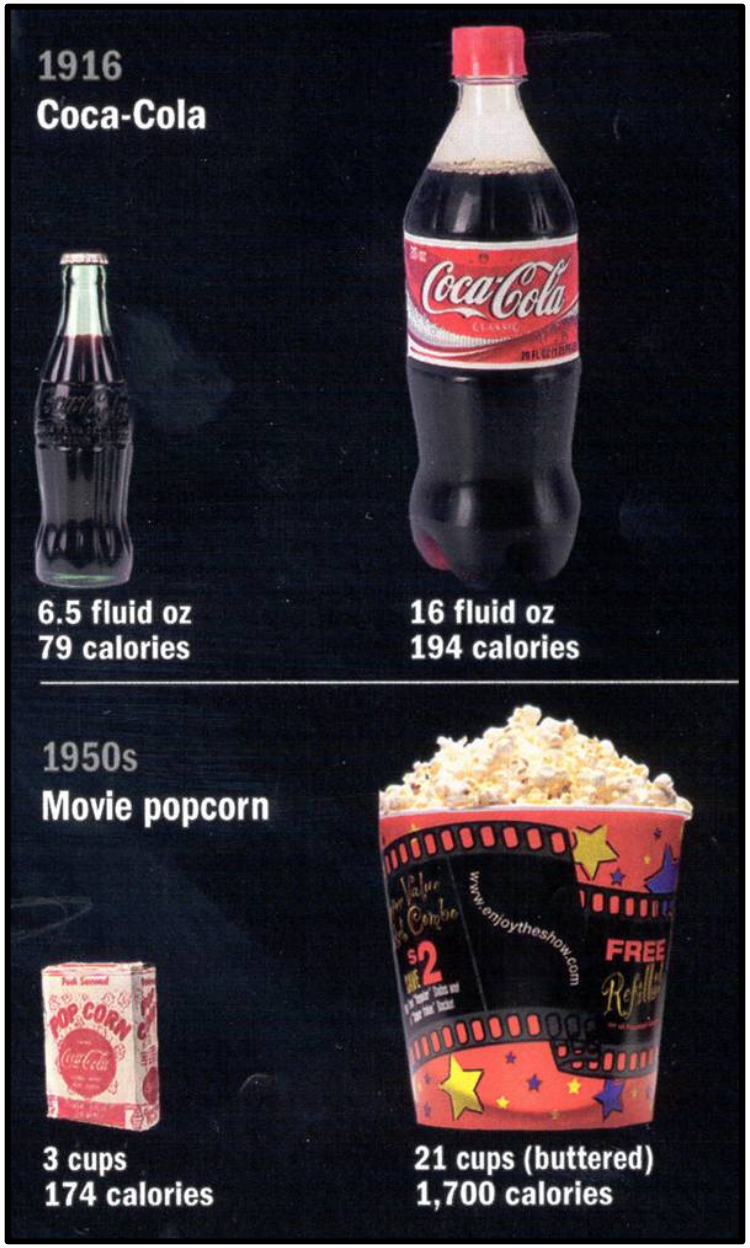
- Incorporate cognitive control /self-control training into interventions
- Teach self-regulation skills early!

Any questions?


Pamela's
PRODUCTS
WHEAT-FREE & GLUTEN-FREE
Chocolate Brownie Mix
Microwaveable Brownies in about a minute!
Instant Gratification!
Fast, Easy, Delicious
NET WT 100g
Dairy


Windows
Prudential
Life
SONY
Sports Illustrated

National Geographic August 2004



National Geographic August 2004


STOP
OZY 3671


24 HOUR
FITNESS