Ingestive Behaviors - Thursday October 27th, 2016

Why worry about ingestive behaviors?

Can be *symptoms* of many psychological disorders
- Mind and body need to be in 'balance'
- Psychological dysfunctions may cause biological dysfunctions: drinking (alcohol), eating (anorexia, bulimia), sexual…
- Depression

Can be the *source* of psychological disorders
- Metabolic encephalopathy (how the brain metabolizes things): dementia, seizures
- Alcohol (as a source) -> liver degeneration -> lack of estrogen breakdown -> feminization
- Pickwickian syndrome: Type of obesity accompanied by irritability, aggressiveness, jealousy, suspiciousness
  - Psychological traits coming from an eating disorder

Homeostasis and Regulation

- Body: needs proper nutrition (stored in fat, muscle…)
- Mind/Brain: needs proper neurochemical environment (hormones, ions…)
  - Homeostasis: process used to regulate the mind/brain-body balance (to correct and compensate for variations)
- Process of regulation:
  - System variable (actual) - a number (air temperature)
  - Detector - a device that tests this number (thermostat)
  - Set point - (temperature setting)
  - Mechanism to change the variable - (electric heater)
    - Negative feedback -> when something is too high the negative feedback system brings it back down

Homeostasis and Regulation: Drinking

1. Body loses water
2. Detector signal loss of water
3. Drinking occurs
4. Stomach fills with water, send signal to brain
5. Satiety mechanism inhibits further water drinking
6. Water is absorbed: body fluids back to normal
- Drinking trigger = 'low fluid detectors'
- Drinking termination = 'satiety mechanism' (fast signals in anticipation of the slow signals). Partly established through experience.

Ingestive Behaviors: Drinking
The four drinking 'compartments'
  o Intracellular: 2/3 of body water
  o Extracellular
    - Interstitial: between cells
    - Intravascular: in blood vessels
    - Cerebro-Spinal Fluid (CSF)

Vascular balance
  o Blood/plasma volume is regulated independently. Important for a good functioning heart and kidneys
  o Loss of blood volume: Hypovolemia (bellow the volume). Blood loss, dehydration, severe burns
  o Too much blood volume: urination. Edema (feet and ankles) - accumulation of water in the extremities
  o Exception: Pregnant women, about 50% more blood stored by vasodilation. Increased cardiac output and rate.
    - Graph showed that as the weeks of pregnancy increased so did the plasma volume

Intracellular vs. Interstitial Balance
  o 'tonicity' = concentration of solutes (e.g. ions)
  o Cell membranes are permeable to water not solute
  o Hypertonic vs Isotonic vs Hypotonic
    - Hypertonic solutions have more solute than water
    - Isotonic solutions have equal concentrations of solute and water
    - Hypotonic solutions have more water than solute
      - If you have a semipermeable membrane, you cannot move the salt, so you move water from the hypotonic solution to the hypertonic solution to equal out the concentrations.

2 types of thirsts
  o Osomometric thirst: When interstitial tonicity increases (e.g. after a salty meal there will be more salt between cells in the interstitial fluid - the increase in salt concentration in the interstitial fluid will cause you to be thirsty)
    - Mechanical detection of changes in tonicity: Osmoreceptors
      - Increased solute concentration of interstitial fluid causes osmoreceptors to lose water and shrink in size
    - Osmoreceptors are located in the hypothalamus, near the third ventricle
  o Osmoreceptor in AV3V
    - Water enters cell (volume increases)
      - Hypotonic solution added to medium surrounding osmoreceptor. Water enters, cell expands.
      - As the cell volume increases -> Membrane potential decreases -> firing rate decreases
    - Water leaves cell (volume decreases)
      - Hypertonic solution added to medium surrounding osmoreceptor. Water leaves, cell shrinks
Lauren

- Cell volume decreases -> membrane potential increases -> firing rate increases
- Osmometric Thirst: AV3V
  - Experiment: Injection of hypertonic saline in humans
  - Just after drinking: Anterior Cingulate cortex and AV3V are active. Few minutes after drinking, only AV3V remains active
    - -> anterior cingulate is part of the satiety system (the fast loop ~seconds)
    - AV3V contains the osmoreceptors (the relatively slower loop ~minutes)
  - AV3V -> Median Preoptic Nucleus -> Drinking (if stimulated)
- Volumetric thirst: When blood plasma volume decreases
  - Loss of blood (hypovolemia) -> loss of water -> loss of sodium
- Renin/ Angiotensin system:
  - 'blood flow' detectors in the kidneys
  - Angiotensin (blood) -> subfornical Organ (SFO) -> Median Preoptic Nucleus -> drinking

Neural Substrate of Drinking: the big picture
  Median Preoptic Nucleus is a site of integration of thirst formation (put in diagram)

Ingestive Behaviors: Eating

- Some facts about weight
  - 60% of Americans 20 years old or older are overweight. 30% of these are obese.
  - Mexican and African Americans have 10% more incidence for overweight/obesity.
  - American Indians with most obesity are in AZ
  - Cities with most obesity:
    - Houston, New Orleans
  - Cities with less obesity:
    - San Diego, Boston, Tucson
  - Reason???: Environmental factors (exercise) and attitude factors (brain/psychology)

Energy Set Point Theory
- Hypothesis: Hunger is a 'low energy' detector signal. Eating starts when the signal decreases below a given 'set point' - Hunger fluctuates about this set point. When we are full we are above the set point and as we get hungry we fall below the set point.
- Energy, Fuels
  - Glucose: Carbohydrates (calories).
  - Fatty acids: Fat
  - Amino acids: Proteins
- 2 fuel storage systems
  - 1% - short term: Carbohydrates (glycogen) In liver and muscles.
  - 85% -long term: Triglycerides. In fat cells.
  - 14% - long term: Amino acids
Short term: The Energy Rush

- Glucose -> insulin (from the pancreas) -> glycogen
- Glycogen -> glucagon (from the pancreas) -> glucose
  - Glucose is the only source of energy in the CAN/PSN (neurons and glia).
    - Detected in PET Scans.
  - Extra glucose is used to form triglycerides.
  - Glucagon secreted early morning when glucose is low.
  - Glucagon stimulates the release of energy from long-term storage.

Long term storage: Dieting/prolonged fasting

- Triglycerides (fat tissue) -> glucagon -> glycerol + fatty acids
  - Glycerol -> glucose -> brain
  - Fatty acids -> body
- Triglyceride breakdown under neural control (sympathetic system) and hormonal control (glucagon and adrenaline)
- The brain has priority
  - PNS-CNS cells: passive absorption of glucose
  - Other cells: need insulin receptors and active glucose transport.

Long term storage: The benefits of exercising

- Muscle proteins -> amino acids -> body
- Absorptive and Fasting phases Summary:
  - Parasympathetic activity - when digestive system contains food
    - insulin
  - Sympathetic activity - when digestive system is empty
    - No insulin glucagon

Starting a meal

- Cultural signals: Eating can be a social behavior
- Eating can be triggered by learned external signals (Pavlovian condition, sight of food)
- Eating can be triggered by hormonal (Ghrelin) signals from the stomach and duodenum (part of the small intestine). Injections of Ghrelin will trigger thoughts of food/eating.
  - Ghrelin secretion is inhibited by digestive activity
- Metabolic signals
  - Stomach is not necessary to 'feel' hungry
  - Glucoprivation. Hypoglycemia: Glucose does not enter the cells.
  - Lipoprivation: Fatty acids are not converted to 'fuel'
- Evidence
  - Glucoprivic hunger:
    - Injection of 2-DG (blocks glucose entry into cells)
    - -> hunger
Lesion of vagus nerve -> no hunger

Lipoprivic hunger:
  - Injection of drugs that blocks fatty acid metabolism
  - Hunger
  - Lesion of vagus nerve -> no hunger

Conclusion: Liver and Vagus nerve monitor glucose and fat levels and send signals to the brain to start a meal

Ending a meal: Satiety

- Gastric factors: Nutrient receptors in the stomach. Stretch receptors in the stomach
- Intestinal factors: detection of fat in the duodenum -> CCK->
  - Stomach (decrease outflow)
  - Bile (increase fat break-down)
  - Brain ('stop' signal via vagus nerve)
    - PPy released by the duodenum after a meal. Proportional to calories ingested.
    - Injections of PPy -> less caloric intake
    - PPy provides a satiety signal
- Liver factors: Glucose receptors -> Satiety signal in brain via vagus nerve.
- Pancreatic factor: Absorptive phase. Insulin -> insulin receptors in brain
  - Satiety signals (hypothalamus)
- Cephalic (cognitive) factors: Learning to identify right food

Ingestive Behaviors: Control

Long-term satiety: fatty storage factors
Leptin secreted by fat cells, increase fat metabolism
OB mouse: leptin deficient (these mice are about 3x as large as other mice)
Injecting leptin -> smaller meals
  - Leptin is a (fat related) satiety signal