Chemosensory Changes in Obesity and after Metabolic Surgery

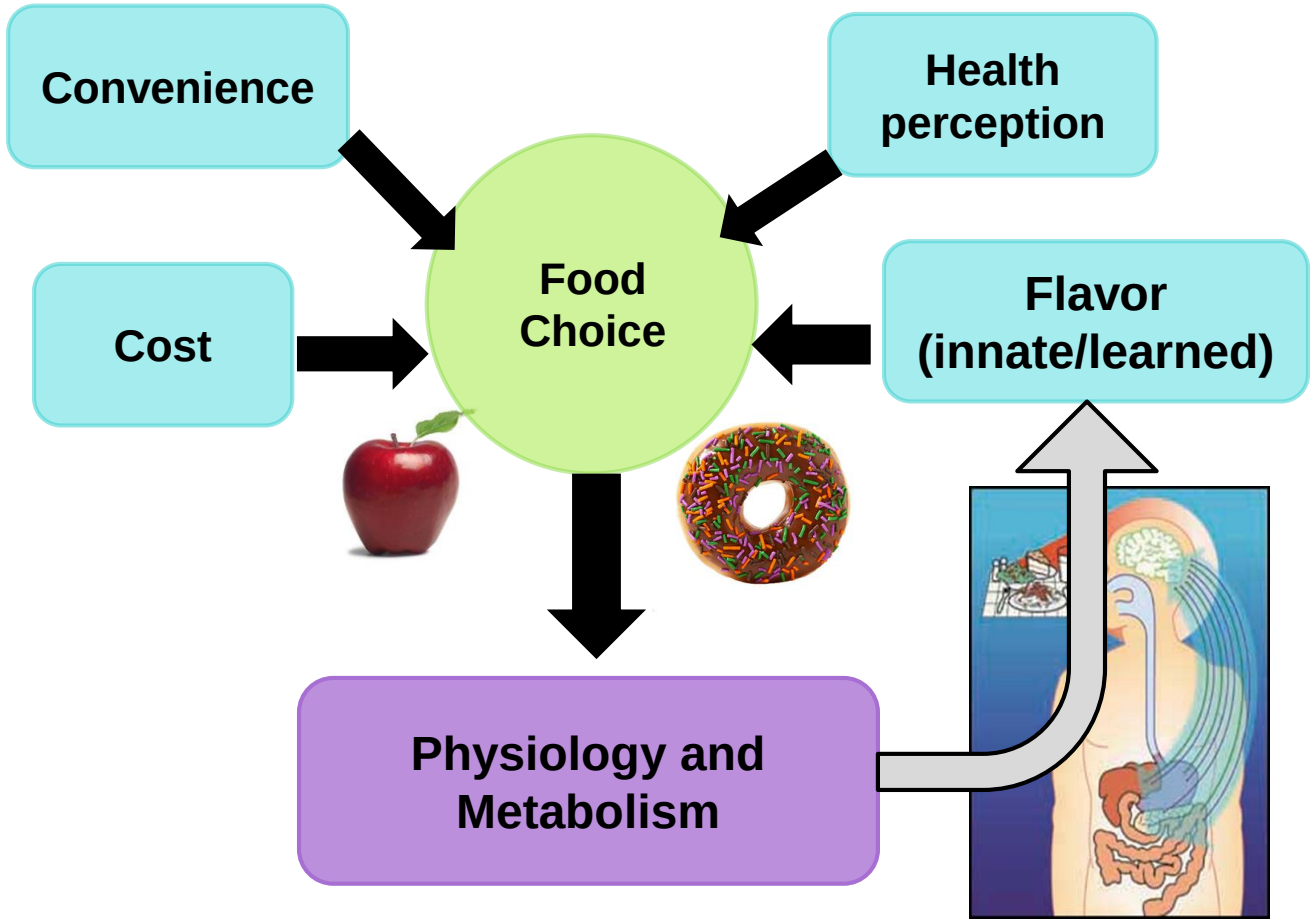
M. Yanina Pepino

M. Yanina Pepino

Department of Food Science and Human Nutrition, College of ACES

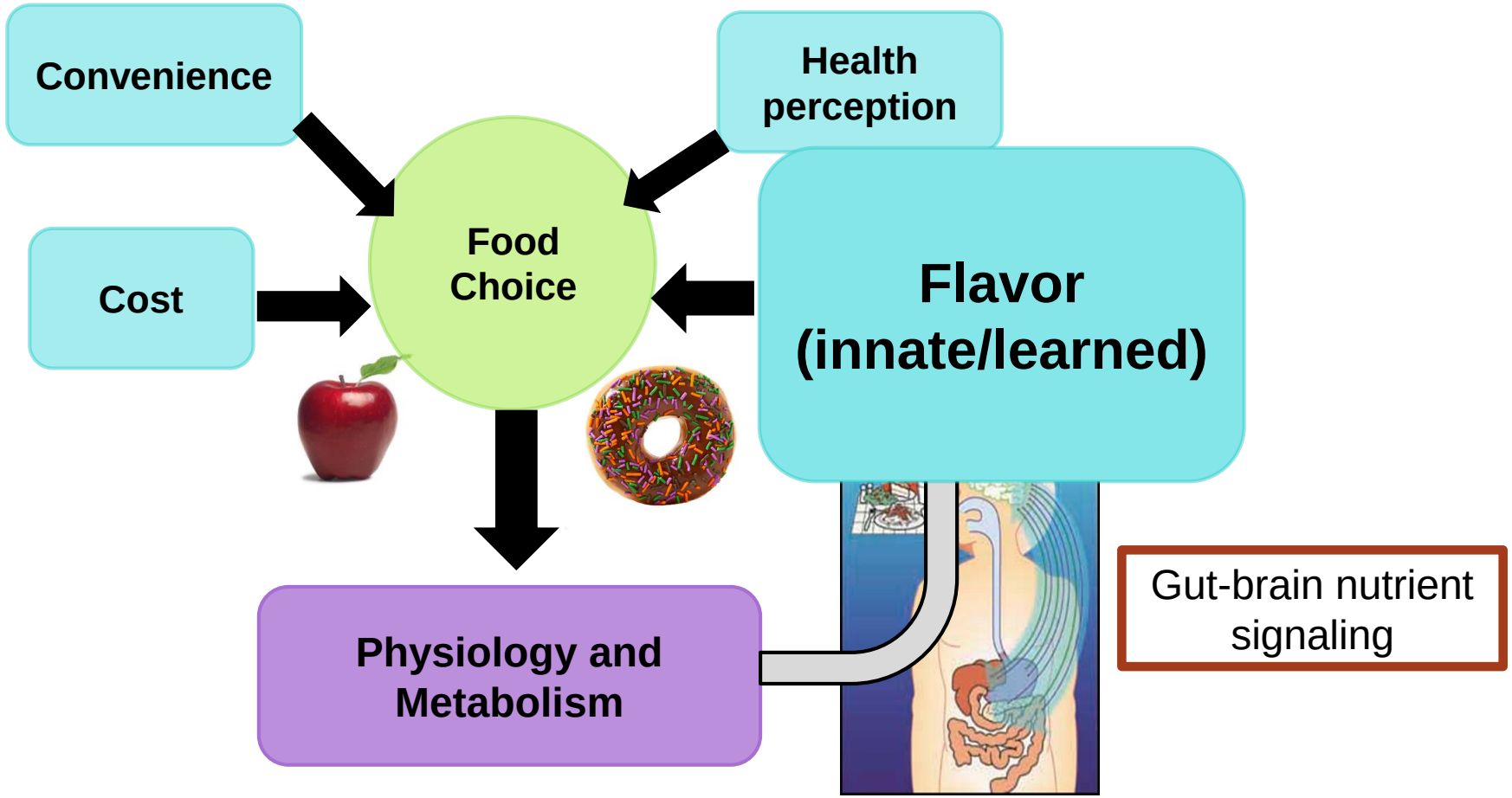
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Food preferences and diet choices are fundamentally affected by how food tastes



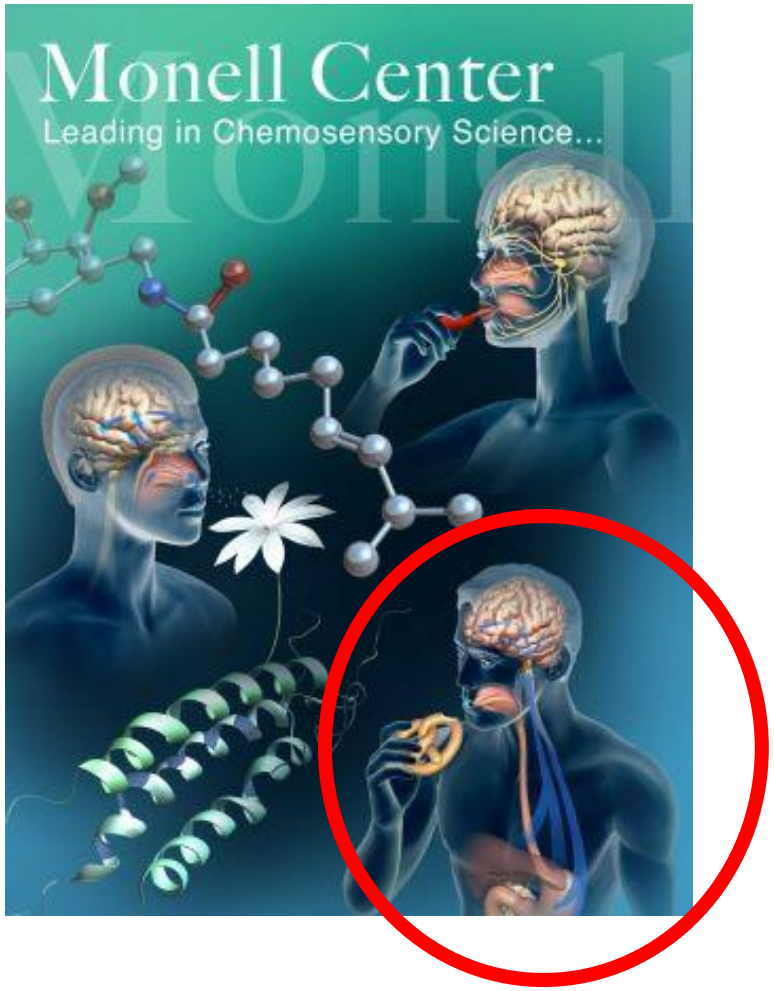
Modified from Drewnowski, Taste, Genetics and Food Choice. In Food Selection: From Genes to Culture, 2002

Food preferences and diet choices are fundamentally affected by how food tastes



Modified from Aggarwal, Rehm, Monsivais, Drewnowski, Prev Med 2016

Chemosensory perception and body weight: is there a link?

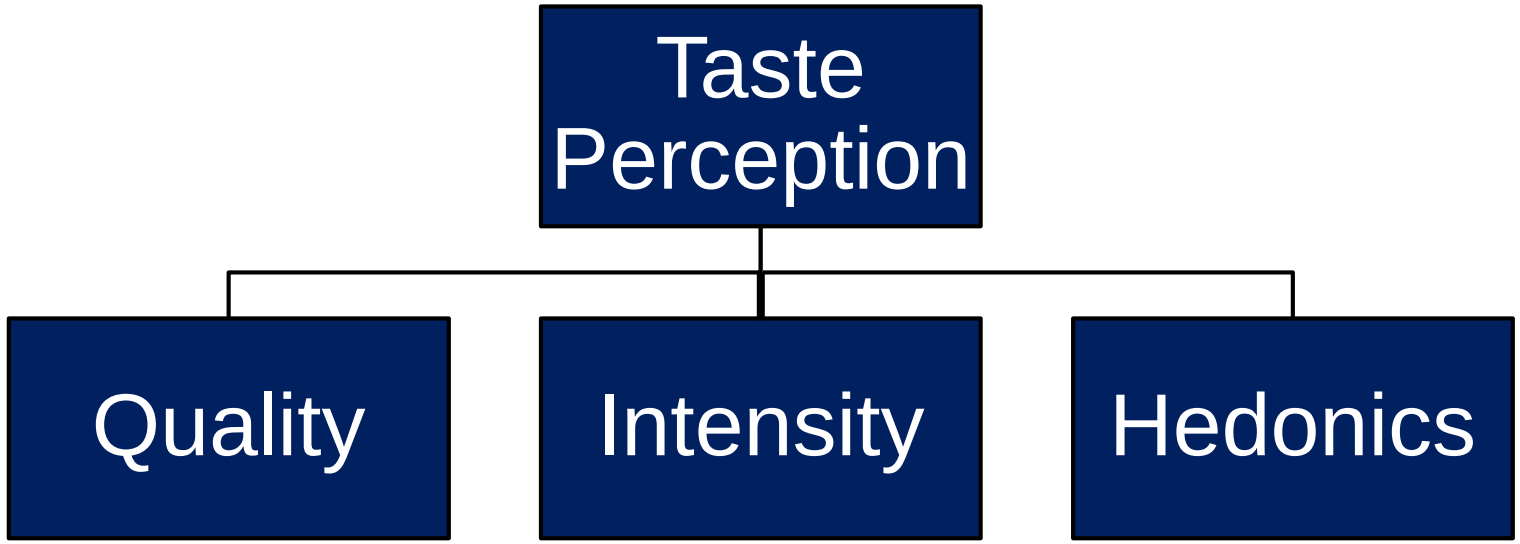


Disclosure:

- Psychophysical measurements of human taste function: changes associated with obesity and with weight-loss surgeries

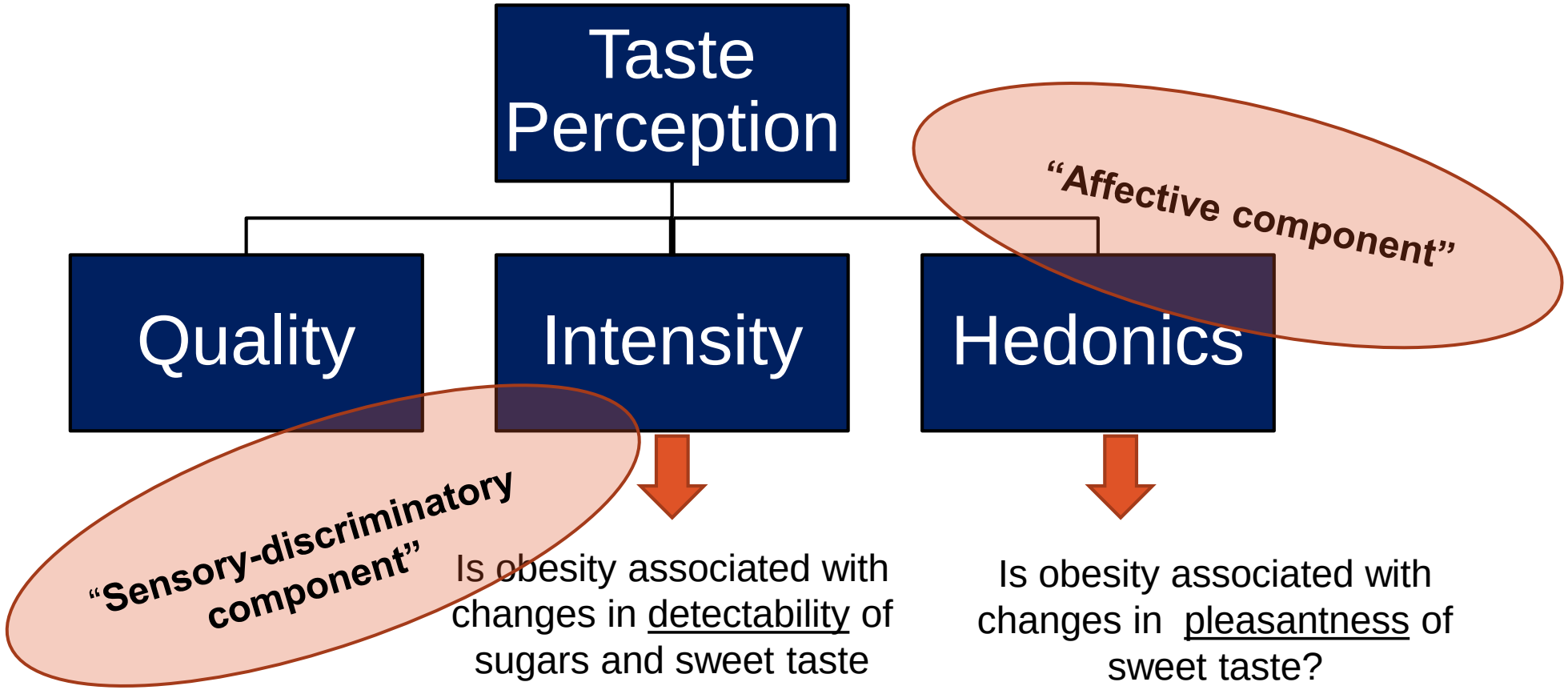
- Review of the literature shows discrepant results: Inappropriate sensory methods?

The psychological attributes of taste



Modified from Breslin & Spector, Current Biology, 2008

Obesity and taste function



Modified from Breslin & Spector, Current Biology, 2008

Taste perception range

~5,800 mM (saturated solution)

~300 mM (6 tsp in 8 oz)

~35 mM (1/2 tsp in 8 oz)

~8 mM (1/7 tsp in 8 oz)

0 mM

Perceived Intensity Region (above-threshold)

Undetectable no perception (below-threshold)

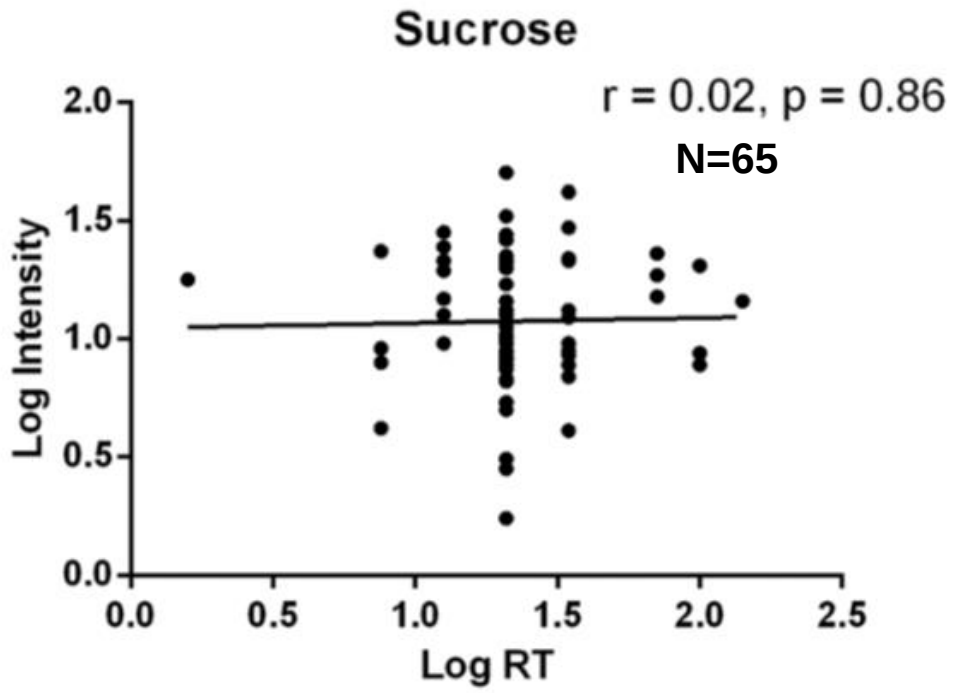
Maximal intensity

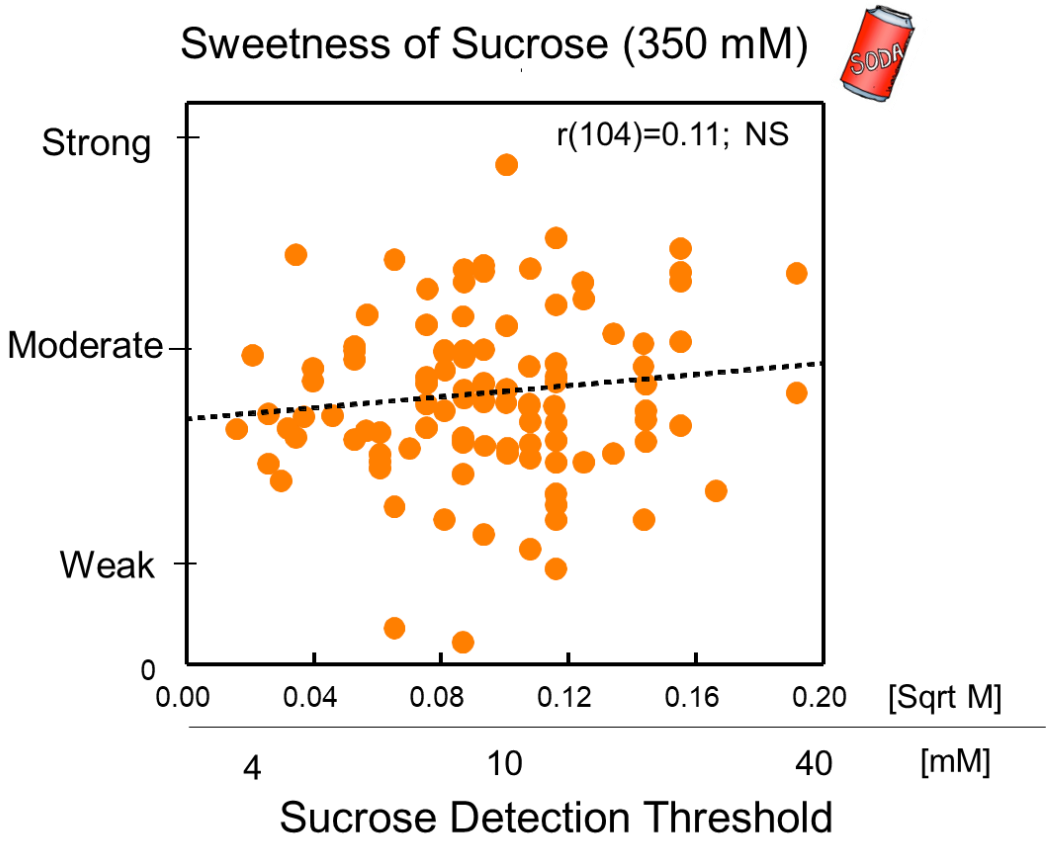
Recognition threshold **(SWEET!)**

Detection threshold **(DIFFERENT!)**

adapted from Keast & Roper; Chem Senses 2007

Sucrose thresholds do not predict perception of intensity of above threshold concentrations



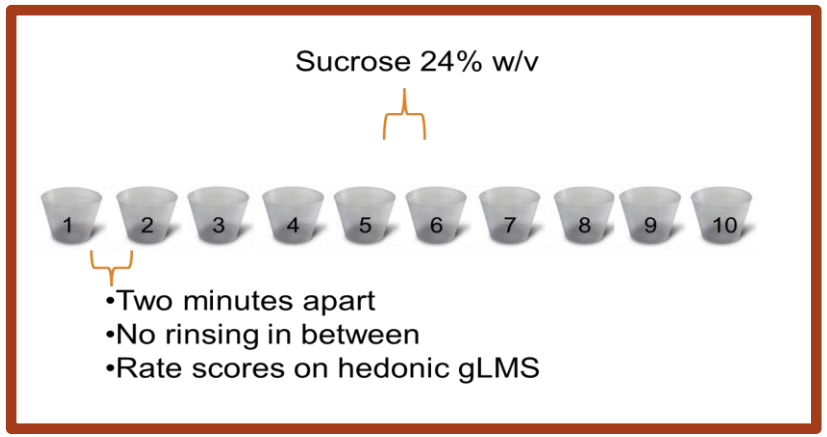


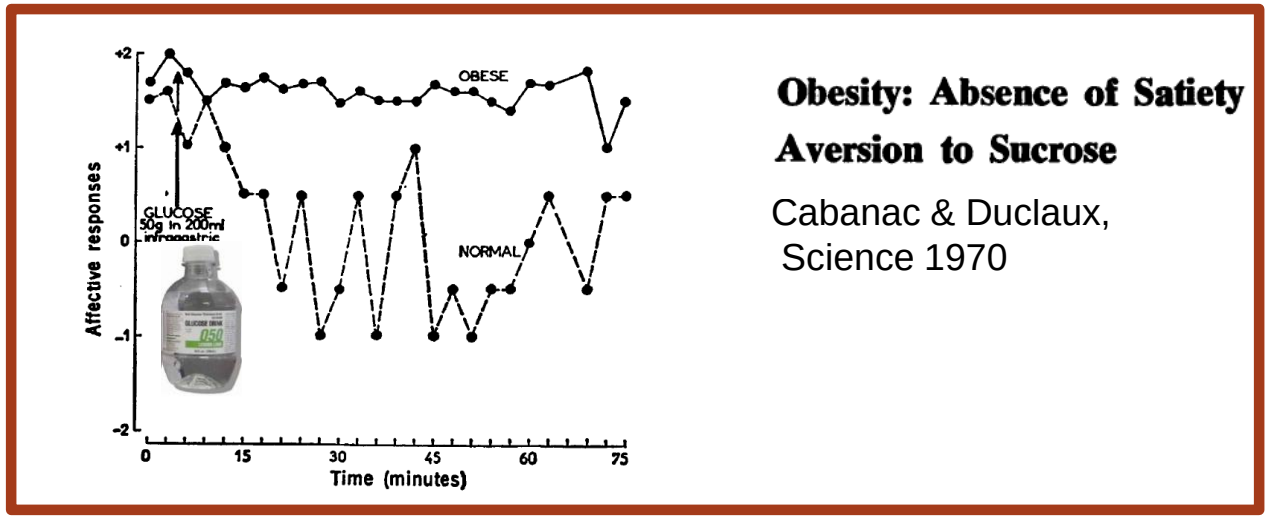
Webb, Bolhuis, Cicerale, Hayes and Keast, Chemosens Percept. 2015
(Consistent with Bartoshuk, AJCN, 1978; Jayasinghe et al., Nutrients 2017)

Pepino et al., unpublished

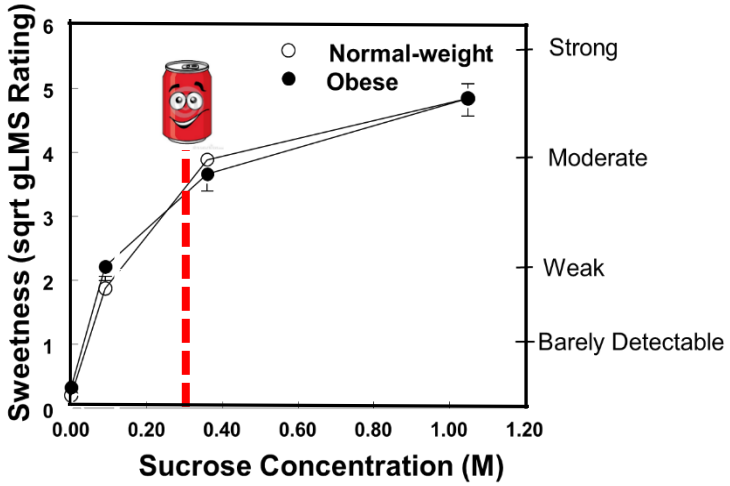
Methods

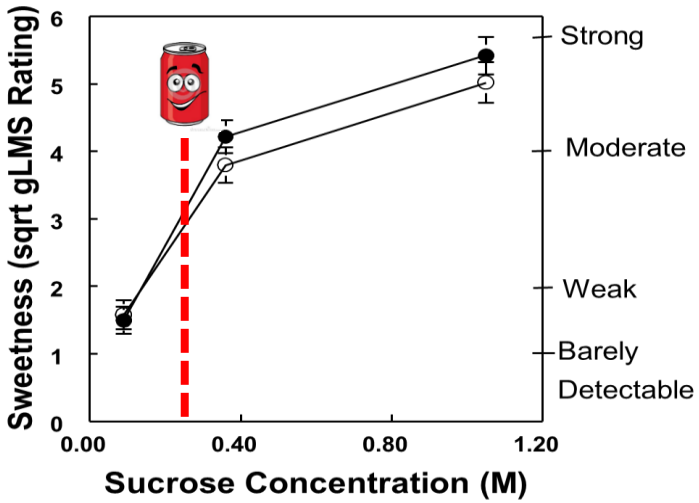
- **Using "sip-and spit" technique:**
  - Taste sensitivity (glucose, sucrose, NaCl, MSG)
    a. Detection thresholds: 2 alternative force choice procedures (Pribitkin et al., Ann Otol Rhinol Laryngol. 2003)
    b. Intensity at above-threshold concentrations general Labeled Magnitude Scale (Bartoshuk et al., Phil Trans R. Soc. B., 2006)
  - Hedonic value of sweetness
    a. Sucrose preferences (Monell tracking technique)
    b. Sweet taste reactivity taste: changes in hedonic value with repeated experience (Pepino and Mennella, Appetite, 2012)

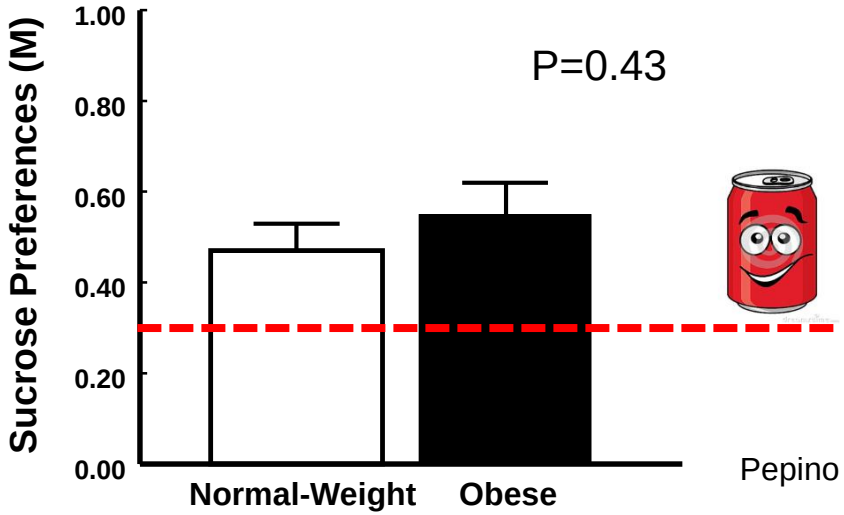




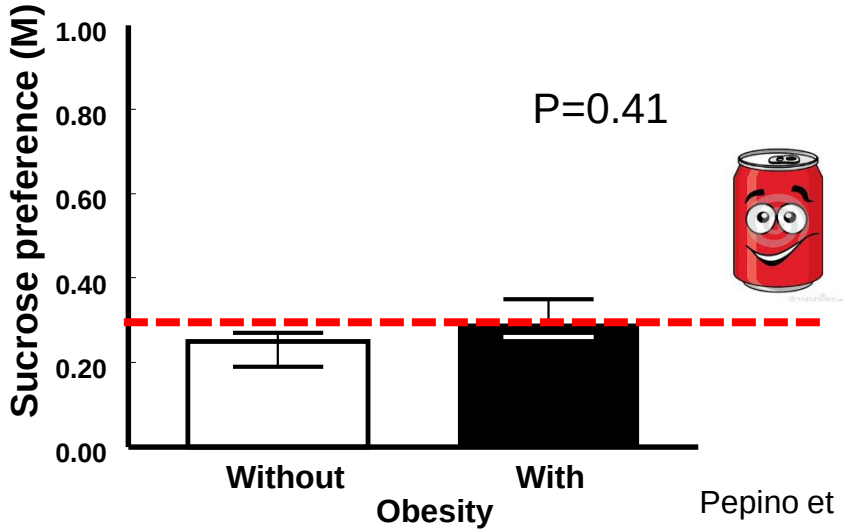
Obesity is not associated with changes in perceived sweetness of sucrose or sucrose preferences





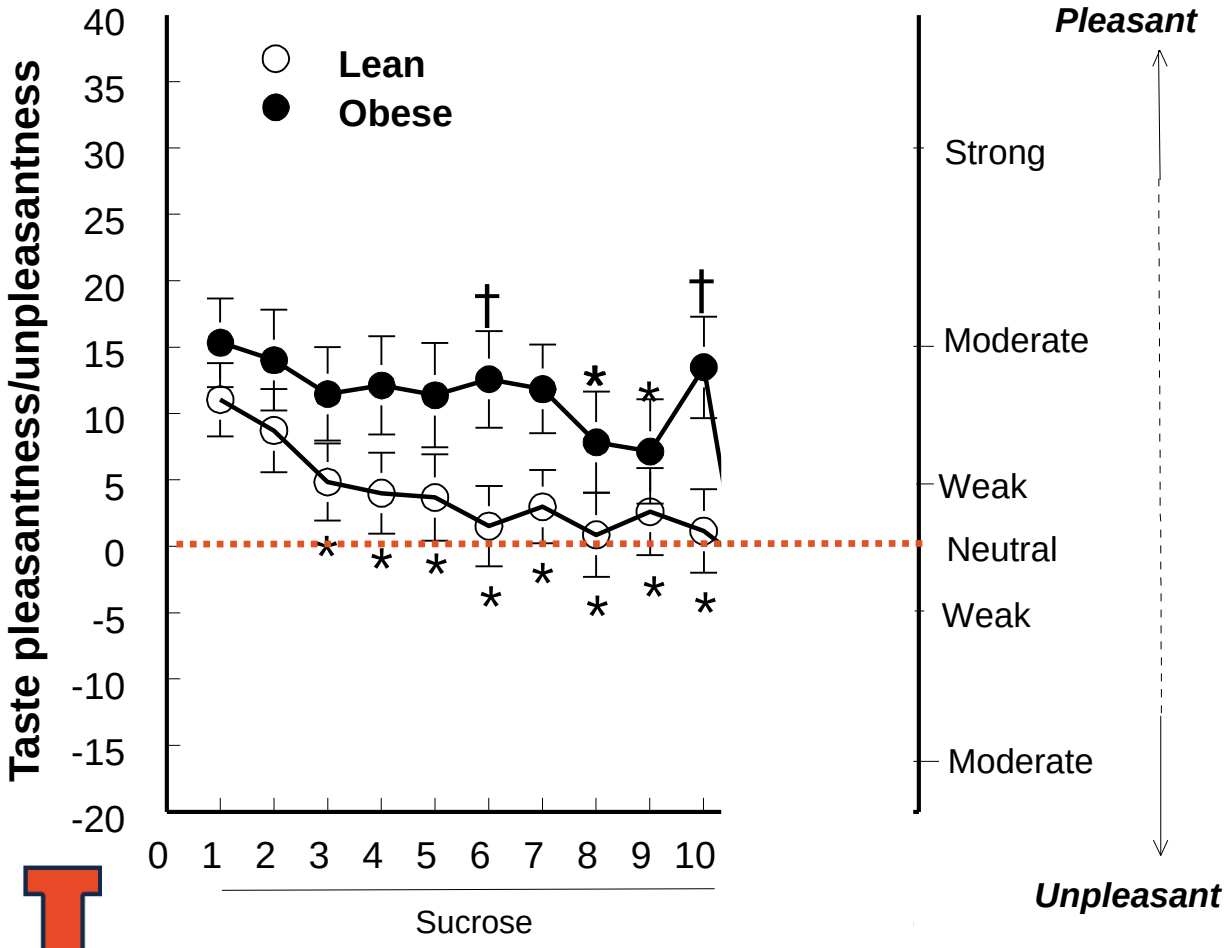


Pepino et al., Obesity (2010)

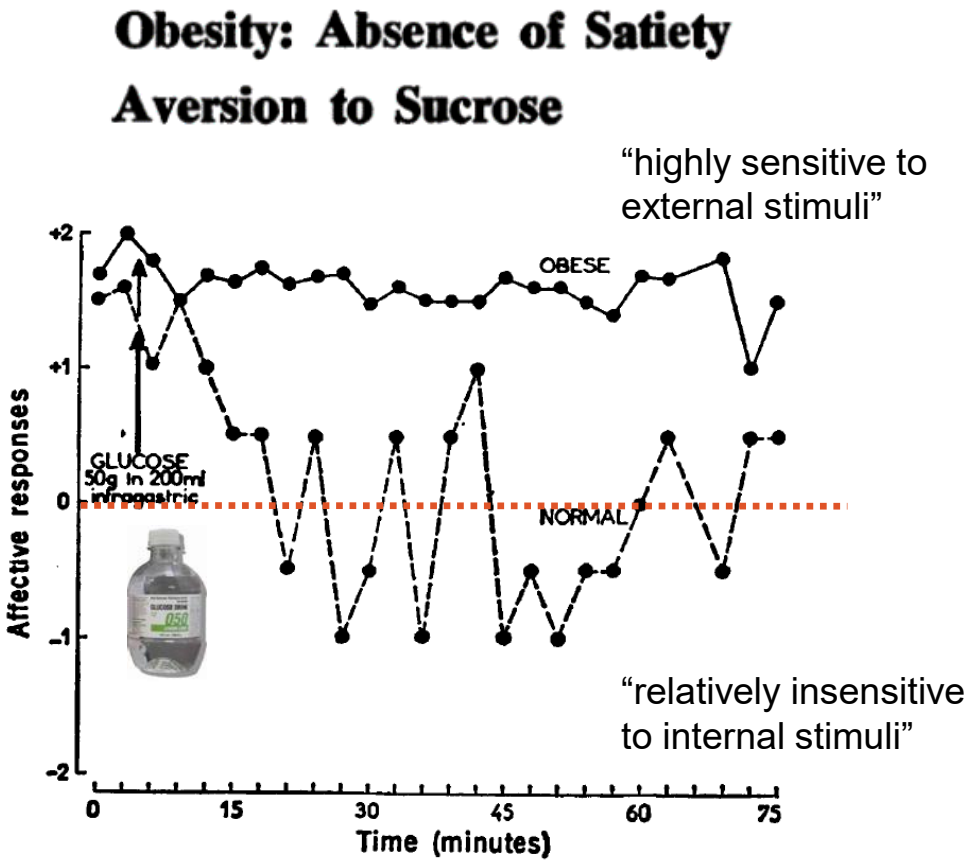


Pepino et al., Diabetes (2016)

Compared to lean peers, women with obesity perceive more pleasure when repeatedly tasting sweetness

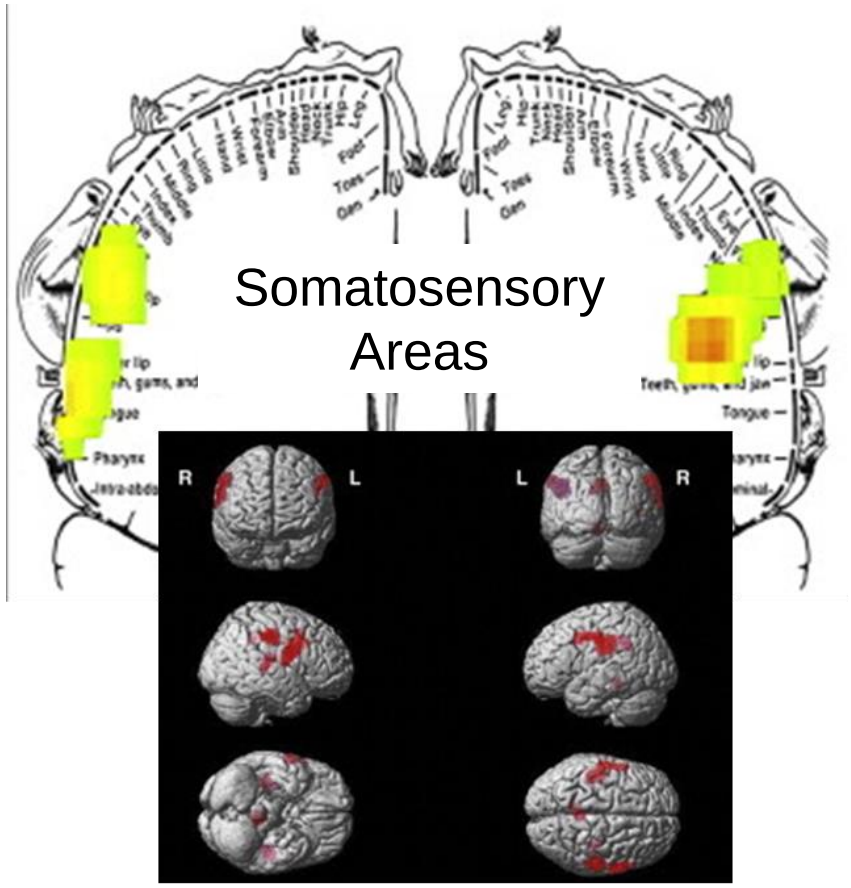


Pepino & Mennella, Appetite, 2012

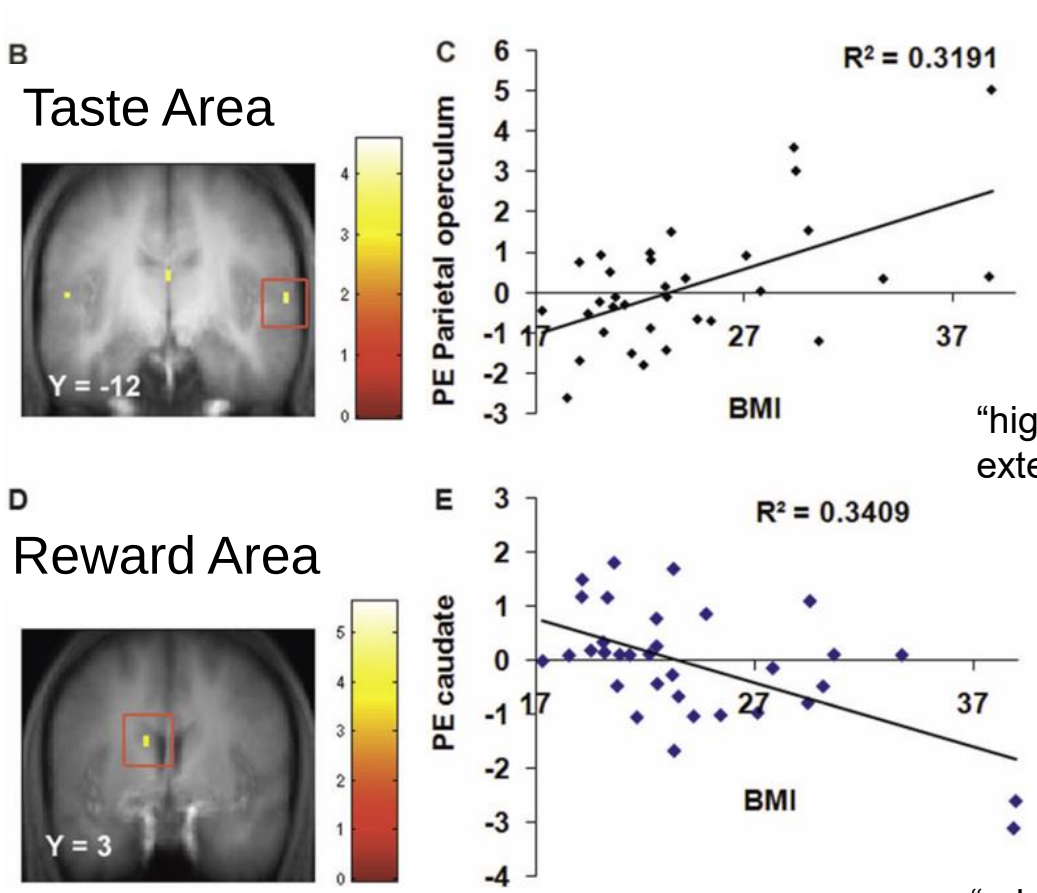


Cabanac & Duclaux, Science 1970

Brain activation to palatable food (and in resting state) in subjects with obesity is different from lean subjects



Wang et al., Neuroreport, 2002

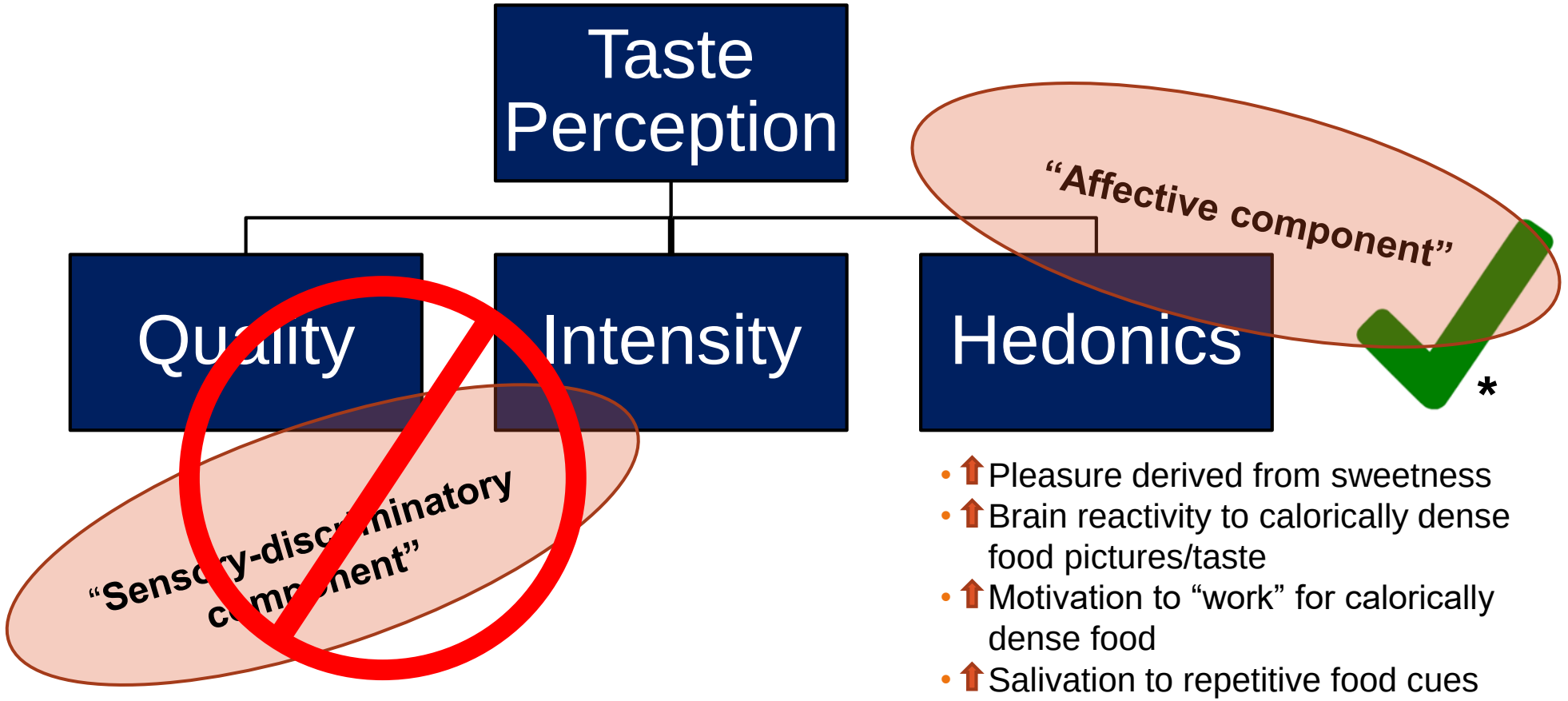


"highly sensitive to external stimuli"

"relatively insensitive to internal stimuli"

Stice et al., J Abnorm. Psychol. 2008

Summary (1): Obesity and taste perception

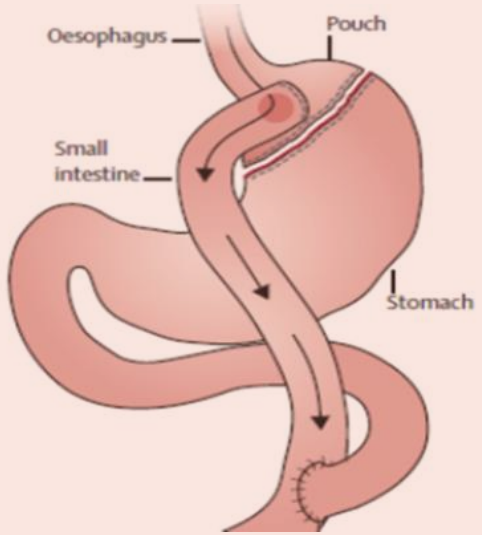


- ⬆ Pleasure derived from sweetness
- ⬆ Brain reactivity to calorically dense food pictures/taste
- ⬆ Motivation to "work" for calorically dense food
- ⬆ Salivation to repetitive food cues

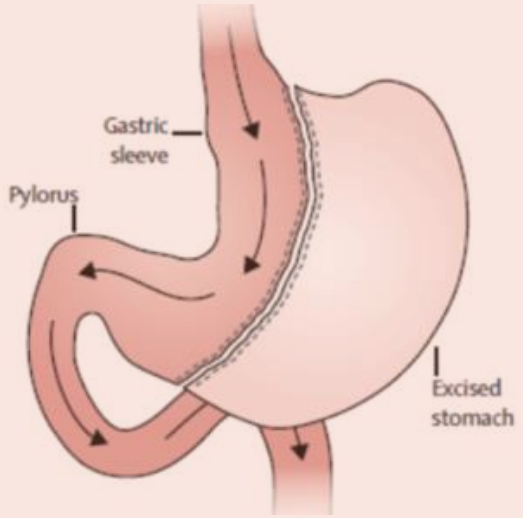
(*Consistent with: Epstein et al., 1996; Wang et al., 2002; Stice et al., 2008; Epstein et al., 2008; DelParigi et al., 2004)

Bariatric surgery and taste perception

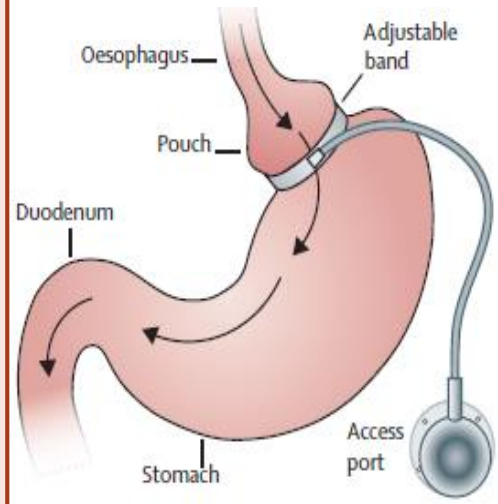
Roux-en-Y gastric bypass (RYGB)



Sleeve gastrectomy (SG)

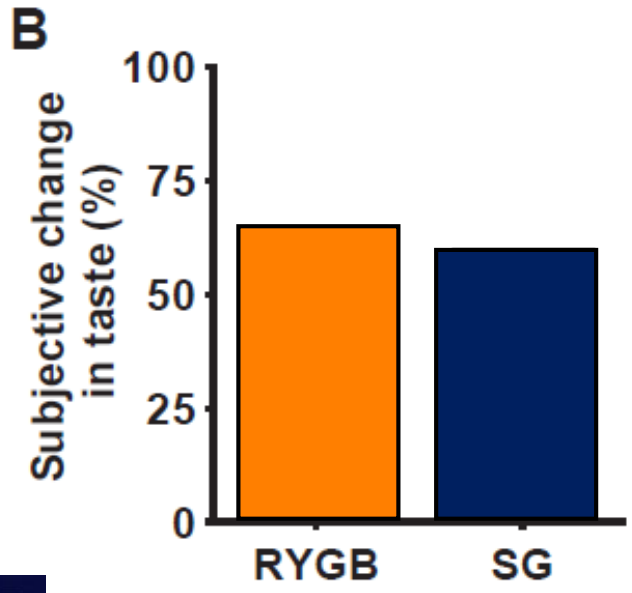


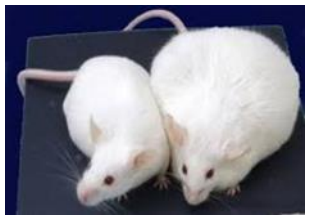
Laparoscopic Gastric banding (LAGB)



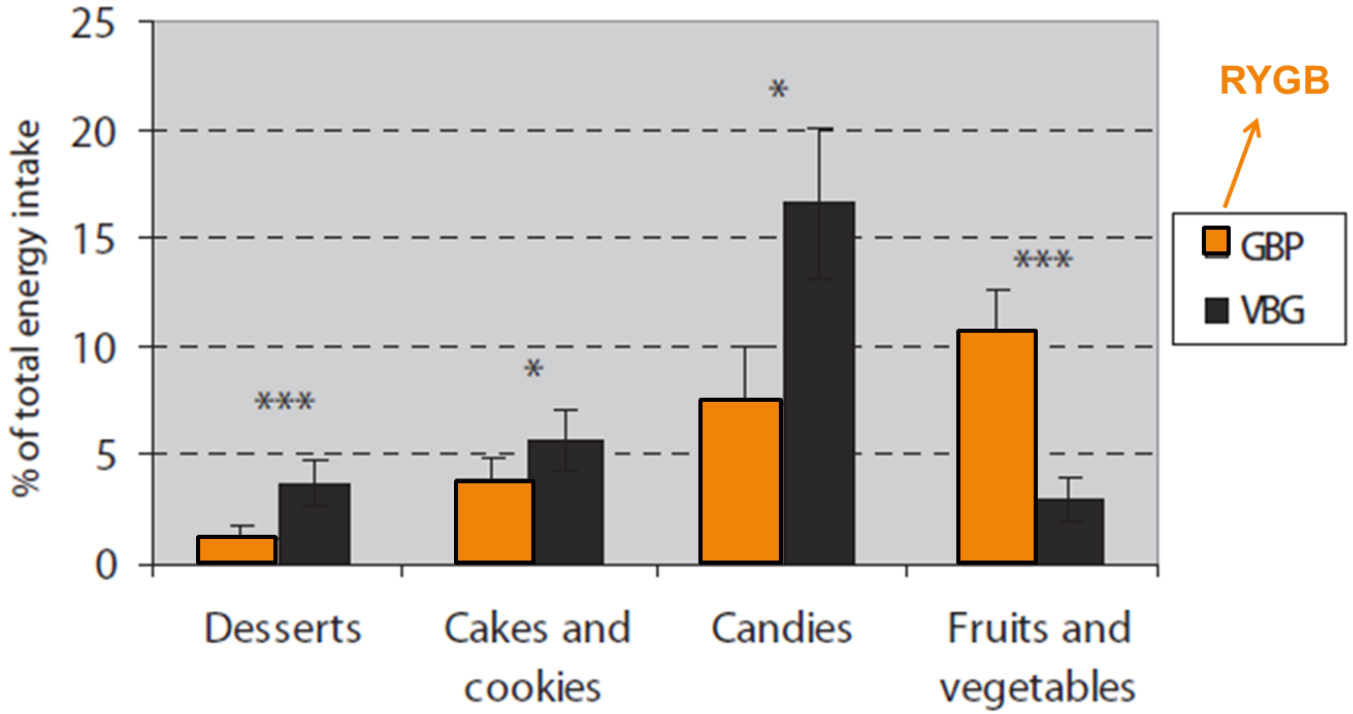
- People lose ~30% body weight, ~60-70% excess body weight and keep it off in the long term (Chang et al., JAMA Surgery, 2014)

Following RYGB and SG, the majority of patients report changes in “taste”





Makaronidis et al., Appetite, 2016



Pre-clinical data: Sclafani et al., Physiol. & Behav. 1985; Hajnal et al., AJPGLP, 2010; Shin et al., IJO, 2011; Berthoud et al., Ann N Y Acad Sci, 2012; Mathes et al., AJPREG 2015

Olbers et al., Annals of Surg 2006

Studies on RYGB and taste sensitivity

Study	Subjects	Methods	Finding
Scruggs et al., Obes Surg, 1994	6 before-after RYGB 10 lean	Taste thresholds	Increased bitter and sour sensitivity after RYGB
Burge et al., J Am Diet Assoc, 1995	14 before - after RYGB 4 in very-low-calorie diets	Taste thresholds	Increased sweet, sensitivity after RYGB
Bueter et al., Phsysiol Behav, 2011	9 before-after RYGB 9 lean	Taste thresholds	Increased sweet sensitivity after RYGB

Studies on SG and taste sensitivity

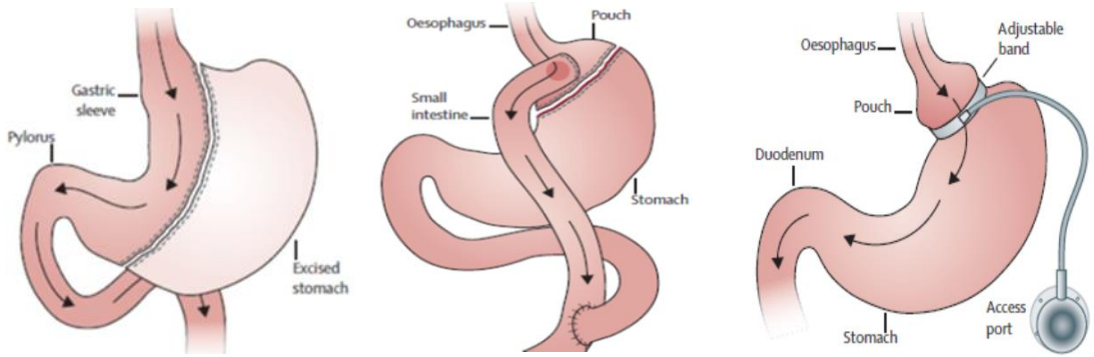
Study	Subjects	Methods	Finding
El Labban et al., Nutrition, 2016	9 RYGB; 12 SG (post surgery)	Detection thresholds Sucrose acceptability	~ sweetness, saltines, bitterness sensitivity (sourness < in RYGB) ~ sucrose acceptability
Altun et al., Ann Otol, Rhin & Laryng., 2016	52 SG (pre-, 1m & 3 m post- surgery)	Taste strip test	Improvement in taste acuity

Study Design

20-70 year old scheduled to undergo bariatric surgery

Taste Test + Eating Behavior (3 separate visits)

Nance et al., Nutrients, 2017



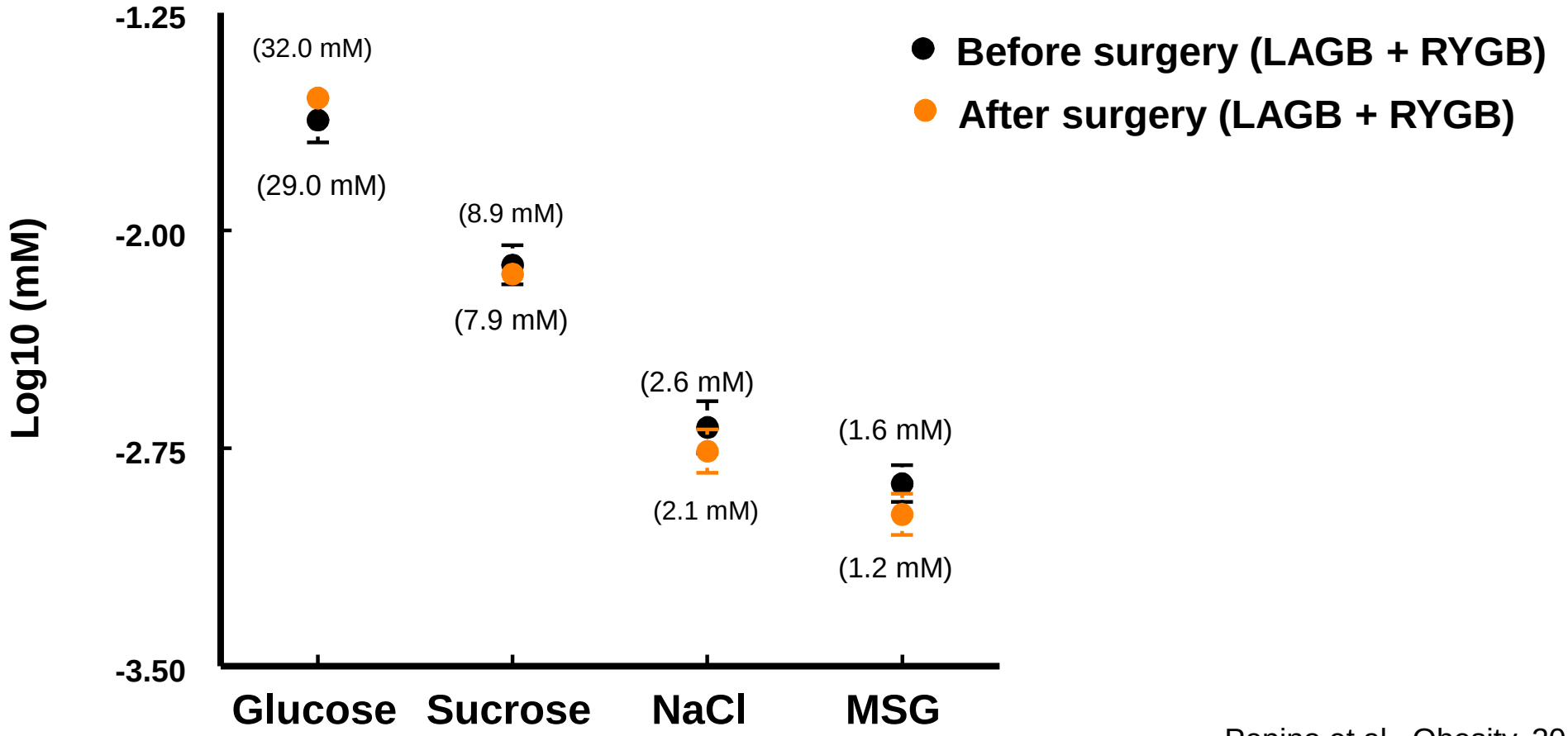
Pepino et al., Obesity, 2014

Individual supervised weight management program (20% weight loss)

6 to 12 months

Taste Test + Eating Behavior (3 separate visits)

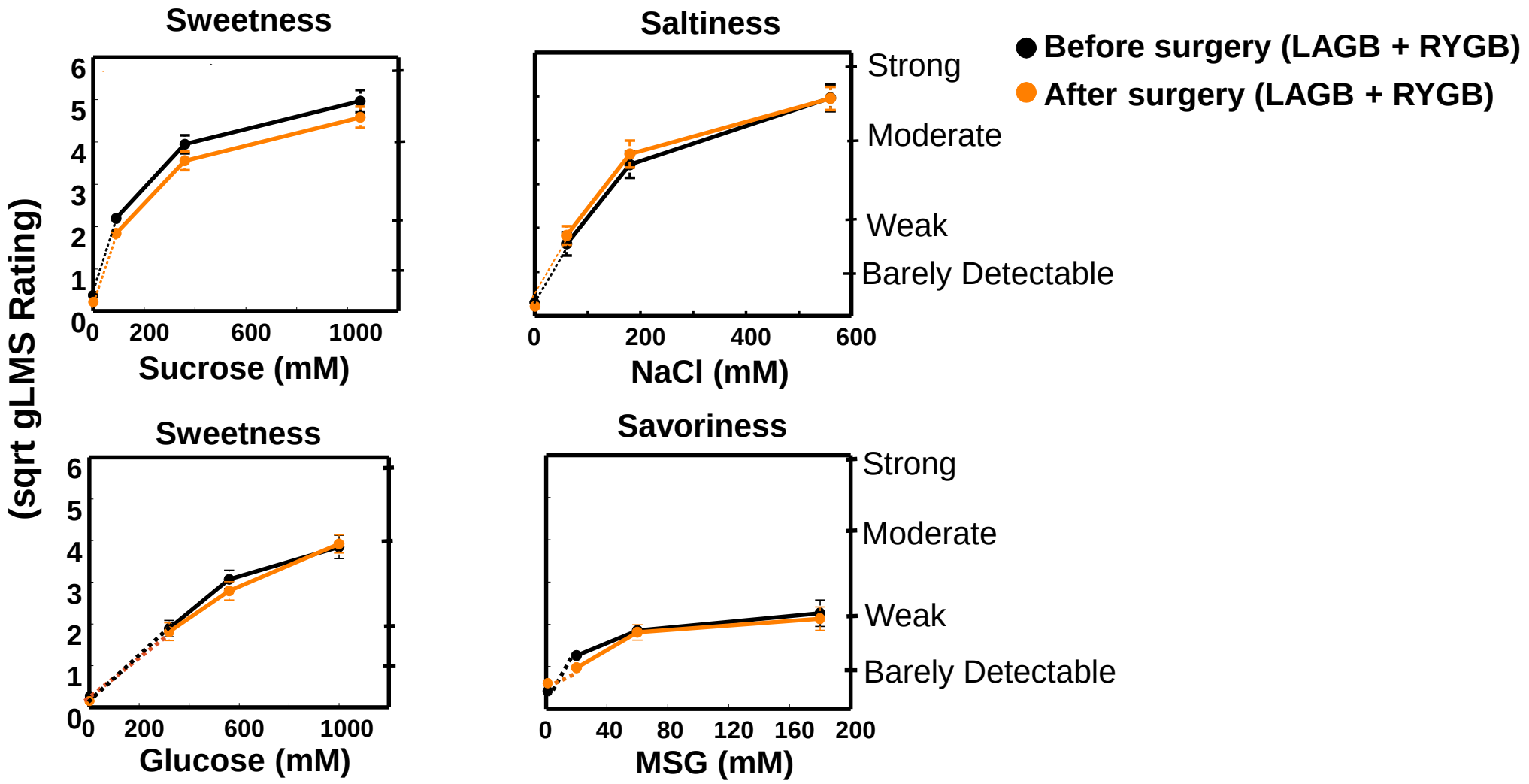
Taste detection thresholds: unchanged



Pepino et al., Obesity, 2014

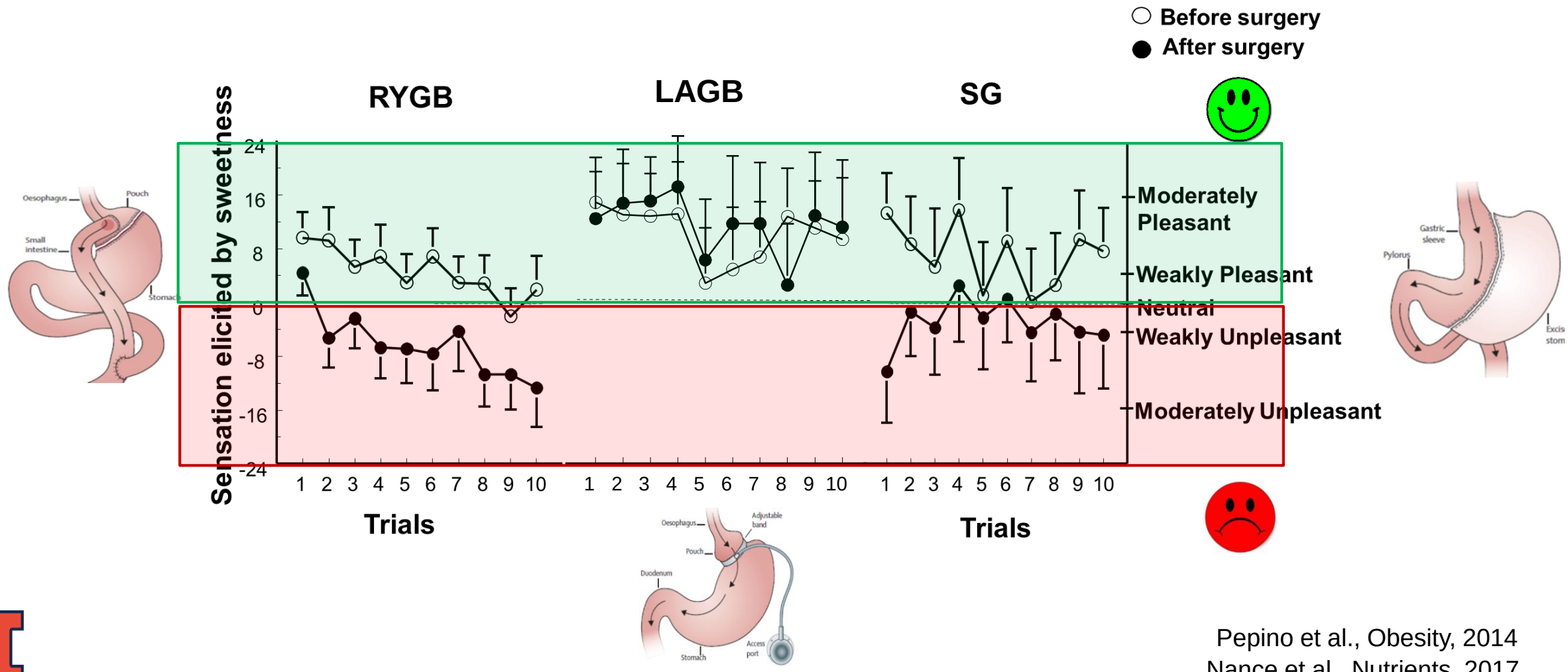
Nance et al., Nutrients, 2017

Taste intensity remained unchanged



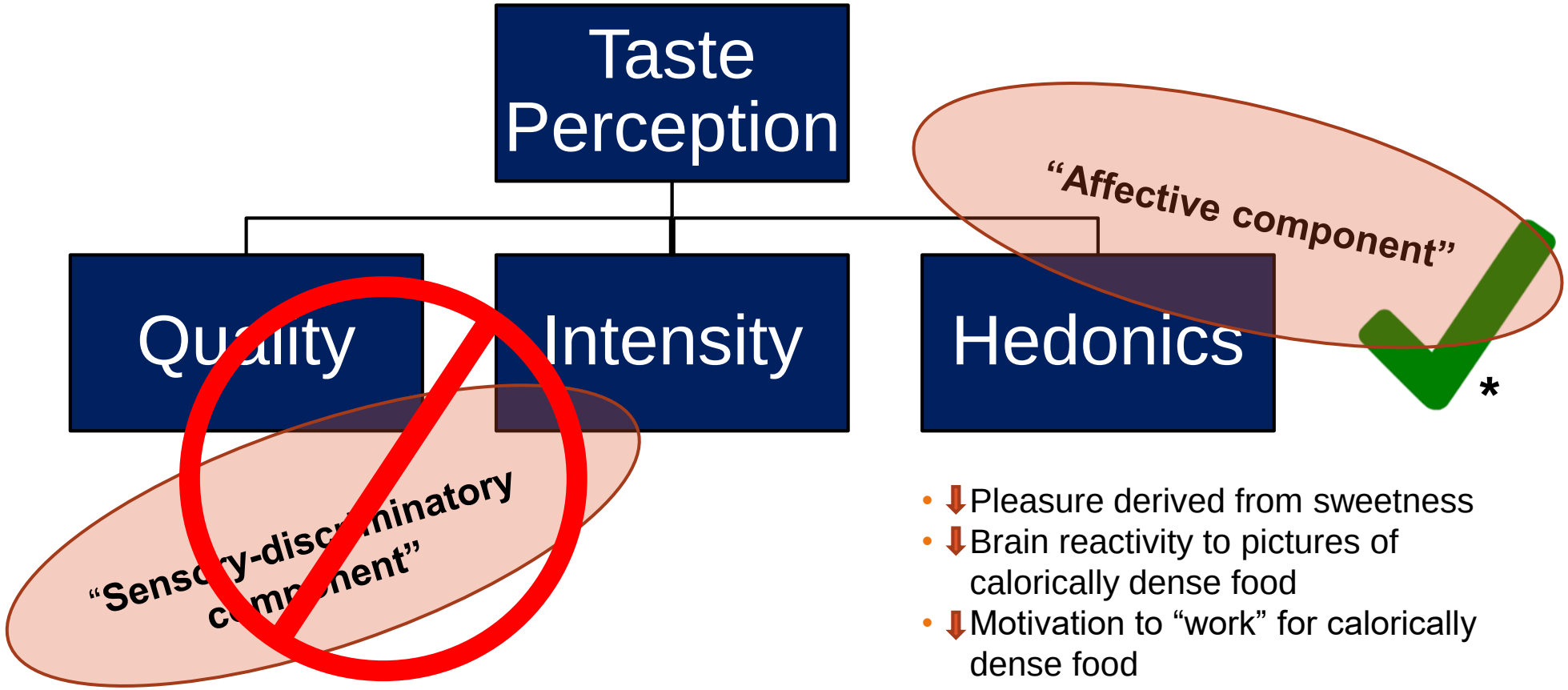
Pepino et al., Obesity, 2014; Nance et al., Nutrients, 2017; Consistent with Hubert et al., Nutrients, 2019

Sweet taste pleasantness decreased after both SG and RYGB but not after LAGB



Pepino et al., Obesity, 2014
Nance et al., Nutrients, 2017

Summary (II): Metabolic surgery and taste perception



- ⬇Pleasure derived from sweetness
- ⬇Brain reactivity to pictures of calorically dense food
- ⬇Motivation to "work" for calorically dense food

(*Consistent with: Ochner et al., Ann Surg, 2011; Miras et al., AMJCN, 2012; Scholtz et al., Gut, 2013; Goldstone et al., JCEM, 2016; Hubert et al., Nutrients 2019)

Future studies

- Patients report dramatic changes in “taste” perception: changes in “flavor” perception? Retronasal smell? Texture? Fat sensory perception?

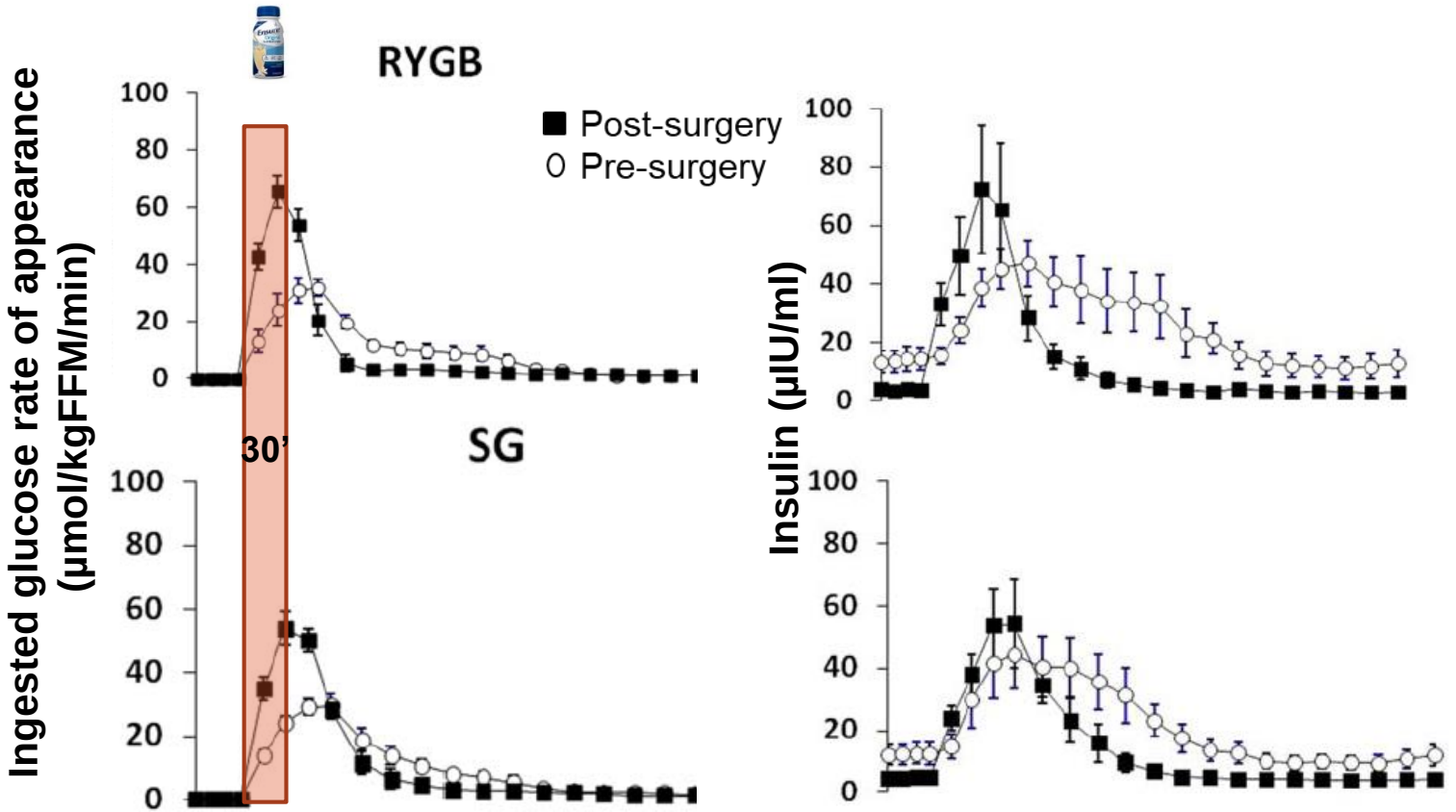
- Do the observed changes in the affective component of sweetness last beyond the first-year post surgery? Can this sweetness response explain variation in weight-loss/regain trajectories?

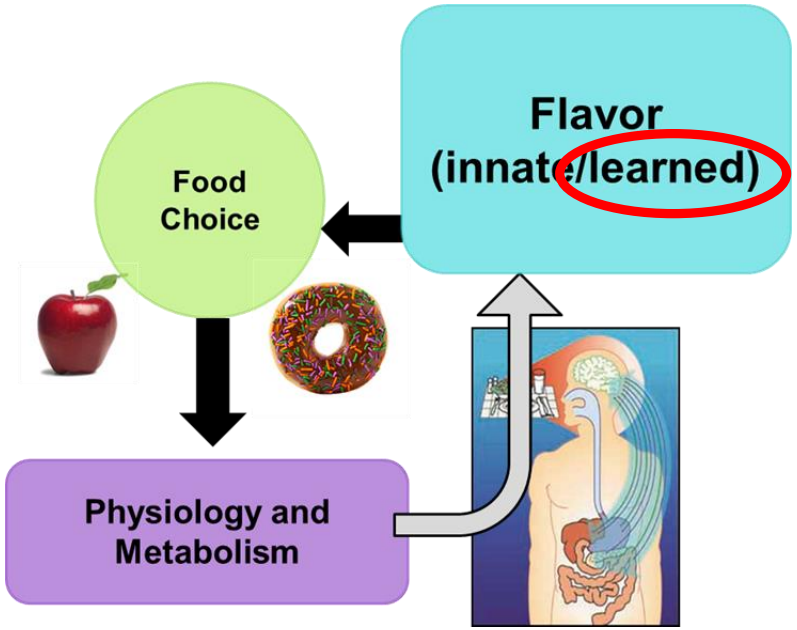
- **Potential mechanisms?**

  Changes in gut-brain nutrient signaling

Potential mechanisms

- **Enhanced conditioned satiety?** (Asarian and Geary, Appetite 2019)
- **Condition avoidance?** (Mathes et al., AJPR 2015)



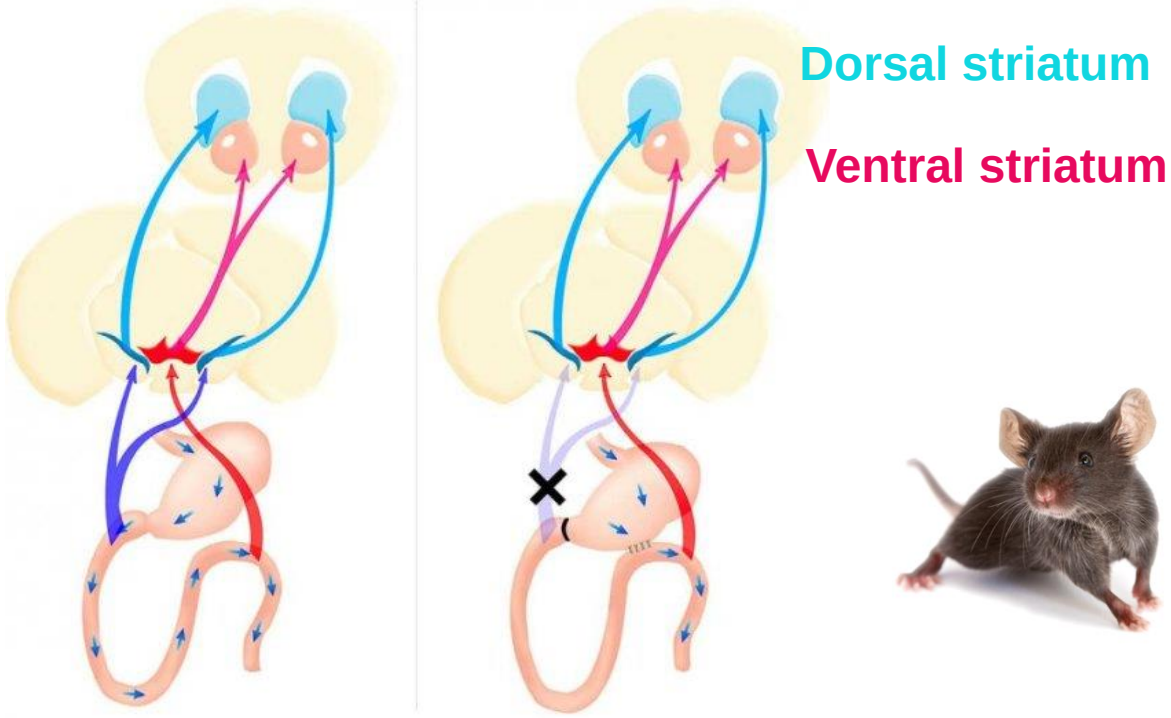


Bradley et al., Obesity, 2014

Potential mechanisms (II)

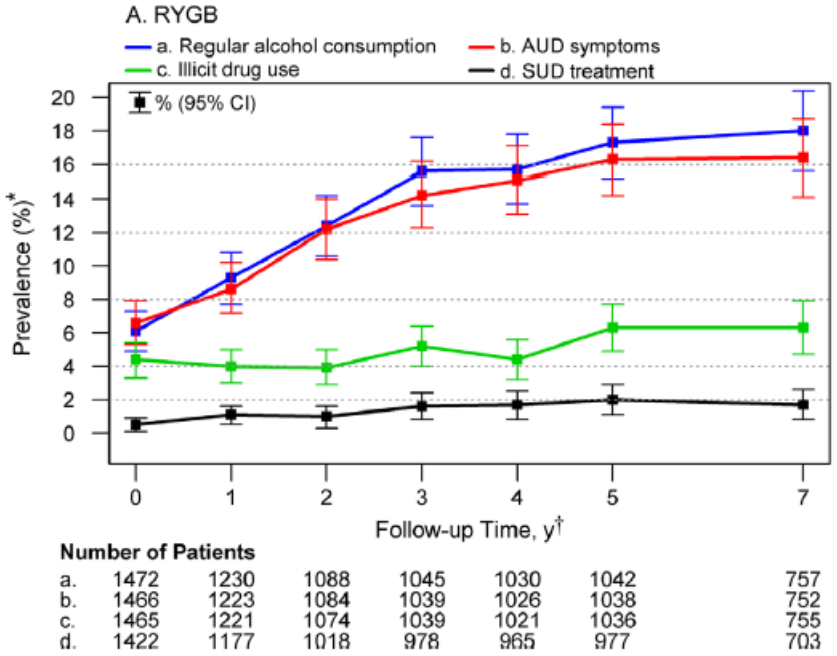
- Decreased “**appetition**”?
  Preclinical data suggest the gastrointestinal rerouting plays a critical role for sugar-induced dopamine release in dorsal striatum (Han et al., Cell Metabolism, 2016)

“Intestinal sugar sensing has an appetite-stimulating action that enhances preferences for sweets” (Sclafani, Cell Metab. 2016)



Han et al., Cell Metabolism, 2016

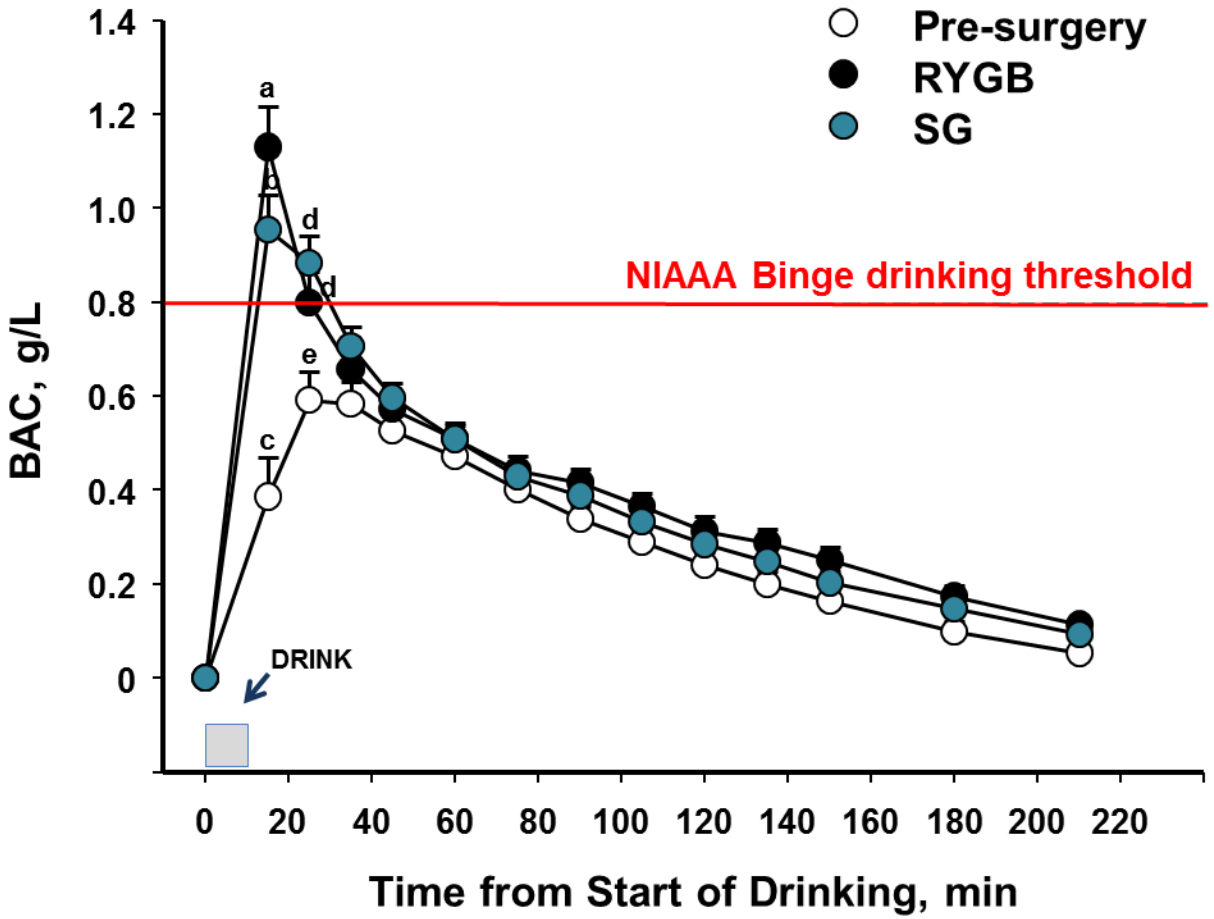
The dark side of metabolic surgeries



W. King et al. / Surgery for Obesity and Related Diseases ▮ (2017)

- 2-fold increase in likelihood to develop an alcohol use disorder (AUD) after RYGB compared to banding procedures (King et al., 2012, JAMA; Ostlund et al., JAMA Surg, 2013, King et al., SOARD 2017).
- Similar prevalence of AUD following SG and RYGB (Ibrahim, et al., Surg Endosc 2018).

SG and RYGB convert 2 drinks to ~4



Pepino et al., JAMA Surgery, 2015; Acevedo et al., SOARD, 2018

Thanks

Pepino Lab

Belén Acevedo

Raul Alfaro Leiva

Rafael Troconis

Clara Salame

Sara Petty

Molly Black

Undergraduates

Ying Yang

Jennifer Zeng

Daphne Vahlenkamp

Katie O'Hara

Alumni

Alex Nichol

Katie Nance

Carle Foundation Hospital

- Blair Rowitz
- Christine Canfield

Washington University

- Samuel Klein
- Kathleen Bucholz
- Chris Eagon
- Bruce Patterson
- Tamara Hershey

Funding

NIH NIAAA (R01 AA024103-02)

USDA NIFA Hatch Project # 698-921

United States Department of Agriculture
National Institute of Food and Agriculture