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Contribution of genes and experiential factors to individual differences in taste preferences and eating behaviour among children

Julie A. Mennella, PhD
Monell Chemical Senses Center
Philadelphia, PA USA

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Perspective

- Unhealthy eating habits that plague many adults – too few fruits and vegetables, too many salty, sweet and fatty foods – are rampant in the youngest members of society.
- Although health professionals recommend a reduction in intake of sweet and salty foods and an increase in intake of grains, fruits and bitter-tasting vegetables, this advice is difficult for adults, let alone children to comply with.
- How can we account for these patterns of food choice and the difficulties in changing them?

Perspective

- Several factors conspire to predispose children to consume diets that may lead to obesity:
  - innate, evolutionarily driven flavor preferences;
  - genetic predispositions for heightened sensitivity to bitter and preferences for sweet and salt
  - negative consequences of not being exposed to flavors of healthful foods early in life;
- Evolution has shaped the type of foods initially preferred or rejected by infants and children. The child's basic biology, a consequence of long evolutionary history, does not predispose the child to favor low-sugar, low-sodium foods.

Objective

- Define chemical senses and basic biology of child;
- Use the bitter taste receptor TAS2R38 gene to highlight the effects of age on genotype-phenotype relationships;
- Highlight developmental and biological imperatives that help shape food preferences.

Chemical Senses

- Powerful stimulus domains for eliciting affective responses because they are primary signals of food- a basic biological commodity.
- Serve as gatekeepers to ensure that animals correctly make one of the most important decision it faces
  - whether to take a foreign substance into the body or reject;
  - And if it gains admission to the digestive tract, to warn the gastrointestinal system of impending rush of nutrients
- Source of extreme pleasure and pain;
- Innate responses yet inherent plasticity

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Chemical Senses

- Retronasal Olfaction: encoded by the largest gene family in mammalian genomes (~900 OK genes but half are pseudogenes; 2004 Nobel Prize);
  - Experience is the means by which system is tuned to respond more strongly to stimuli relevant to an individual's environment.

- Taste: Sweet, umami, sour, salty, bitter (~25 T2Rs)
  - Substantial degree of sequence diversity and variation that exists in taste receptor genes.
  - Taste receptors located in oral cavity and gastrointestinal tract.

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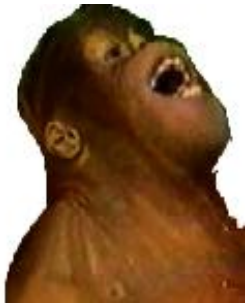
Biological Substrates

- Chemical senses are functioning *in utero*.
- Children live in different sensory worlds than adults
  - Heightened preference for sweet, salts, fats, sour
  - Heightened sensitivity to some odors
  - Heightened rejection of bitter
- Substantial degree of sequence diversity and variation exists in taste receptor genes..

From the perspective of the ontogeny of taste development, what children are eating isn ť surprising and reflects their basic biology.

Sweet Taste:

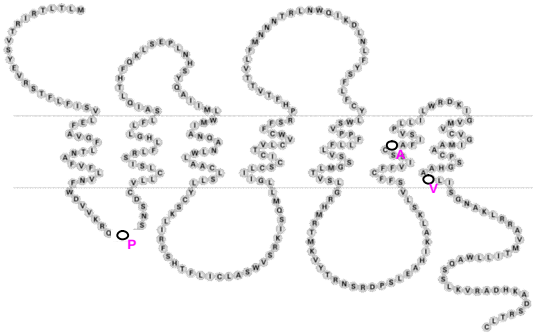
Bitter Taste:



- In nature, sweetness is associated with readily available calories from carbohydrates:
  - Fruits
  - Mother ṡ milk
- Salt is associated with needed minerals; reduces bitter.
- Bitterness is associated with toxins and poisons. Hence, preferences for bitter-tasting foods (e.g., coffee, dark green vegetables) is learned.

from Neurosci Biobehav Rev 25: 53-74, 2001

Genotype-Phenotype Relationships

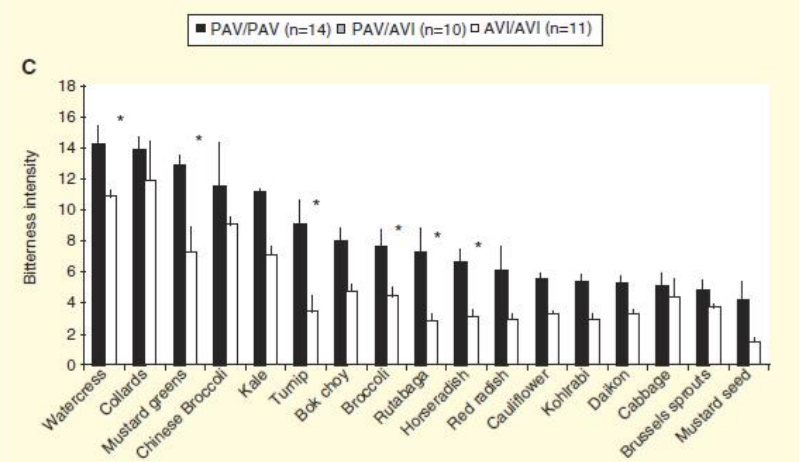


- From birth to old age, the ability to taste compounds containing a N-C=S (thiourea) group (e.g., phenylthiocarbamide: PTC and its chemical relative, propylthiouracil: PROP), is evident in human populations.
- The gene, which accounts for this taste polymorphism, is now known to be *TAS2R38* on chromosome 7q, a member of the family of taste receptors that respond to bitter stimuli (Kim et al., 2003; Bufe et al., 2005).
- Age-related changes in genotype-phenotype relationship for bitter perception for at least one gene.
  - Alleles of TAS2R38 gene are associated with sensitivity to PTC and related bitter compounds such as PROP in adults and children.
  - Heterozygous children were more sensitive to PROP than heterozygous adults (Mennella et al., 2005).

Comments

- What causes the developmental shift in taste sensitivity remains a mystery.
- We hypothesize that the age and diplotype interaction may be due to preferential allele expression, with children over-expressing the ‘taster’ form rather than the ‘nontaster’ form of the receptor early in life and then losing this tendency as they age.
- Age-related changes in taste sensitivity are likely to have a broad impact because many people in the population are heterozygous (57% of White subjects, ~70% percent of Black subjects).

- Adults with ‘taster’ alleles report certain vegetables (especially glucosinolate (block iodine) producing ones like turnips, mustard greens, broccoli) taste more bitter than do people with ‘nontaster’ alleles (Sandell and Breslin, 2006; Turnbull and Smith, 2002; Bell and Tepper, Keller et al., 2002).
- The possession of even a single allele of a bitter taste receptor gene impacts on perception of an entire family of vegetables. The ~200 TAS2R alleles that humans posses should detect the thousands of toxins in our diet.
- It has been hypothesized that the more sensitive to bitter, the less likely the individual will eat these foods.



Sandell and Breslin (Current Biology), 2006

- We cannot easily change the basic ingrained biology of avoiding bitterness and liking sweets to get children to prefer broccoli to candy.
- If this is the bad news, the good news arises from knowledge gained from our experimental research on how, beginning very early in life, sensory experience can shape and modify flavor and food preferences.

Learning from Mom

If a calf or lamb see its mother avoiding larkspur, it won't eat it either.

- Fundamental feature of all mammals
- Young animals learn what to eat and how to eat from their mothers
  - What plants to avoid
  - What plants to eat occasionally
  - When plants are at their peak nutritional content

from the research of F. Provenza and colleagues

Learning from Mom

- Flavors from mothers' diets are transmitted to amniotic fluid and breast milk
  - Exposes infants to variety of flavors
- Facilitates the acceptance and enjoyment of similarly flavored foods
  - *Pediatrics* 107: E88, 2001
  - *Pediatrics* 120:1247-54, 2007
- Breastfeeding confers an advantage for initial acceptance of fruits and vegetables.
  - Continuity in flavor experiences
  - But mother has to eat the foods

- Once baby is weaned to solid foods, both formula- and breast-fed infants clearly discriminate flavors. Repeated opportunities to taste a particular or a variety of foods promoted willingness to eat fruits and vegetables.
- 8-9 days of exposure led to increased intake but not always reduction in faces of distaste;15 days lead to liking.
- To promote green vegetables, the exposure requires that some or all of the foods are bitter tasting.

Pediatrics 93: 271-7; 1994
Am J Clin Nutr 73, 1080-5, 2001
Pediatrics 120: 1247-54; 2007
Physiol Behav 94, 29-38; 2008

Social variables are embodied in biology.

Individual experiences, which can be conceived as the mechanism by which one absorbs culture, serve to specify acceptable and preferred foods and perhaps alter the way the brain and the body respond.

Concluding Remarks

- Food habits are an integral part of all cultures that have its beginnings during gestation and breastfeeding.
- Although the inherent plasticity in the system allows for new learning, greatest barrier is that it is difficult to change adults' preferences and eating habits.
- Start Early and Often: By introducing a variety of fruits and vegetables, infants are more accepting of fruits and vegetables, the consumption of which is generally low in the pediatric population and the acceptance of which is difficult to enhance beyond toddlerhood.
- Focus on Infant Behaviors: Innate facial expressions are often misinterpreted by mothers.
- If we are to understand the etiology of over-consumption and to develop evidence-base strategies to improve the diets of our children, one of our gaps in knowledge remains one fundamental mysteries of human behavior – why do we like the things we do.