Genetic Variations, “Taste” and Dietary Behaviors

Valerie B. Duffy
The Omics of Eating Behaviors:
December 9, 2010

Genetics
← Environment

Oral Sensory Function

Food/Beverage Sensation

Food/Beverage Preference (intake)

Diet-related Health Outcomes
**Taste is Tops**

IFIC 2007 Food & Health Survey—representative US sample of 1000

**Figure 49: Factors Influencing Purchasing Decisions**

<table>
<thead>
<tr>
<th>Factor</th>
<th>2007 Impact</th>
<th>2006 Impact</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taste</td>
<td>Great: 53%</td>
<td>Great: 54%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Some: 35%</td>
<td>Some: 31%</td>
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<tr>
<td></td>
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</tr>
<tr>
<td>Price</td>
<td>Great: 37%</td>
<td>Great: 35%</td>
<td>Increase</td>
</tr>
<tr>
<td></td>
<td>Some: 35%</td>
<td>Some: 28%</td>
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<tr>
<td></td>
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</tr>
<tr>
<td>Healthfulness</td>
<td>Great: 25%</td>
<td>Great: 26%</td>
<td>Increase</td>
</tr>
<tr>
<td></td>
<td>Some: 40%</td>
<td>Some: 32%</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Convenience</td>
<td>Great: 23%</td>
<td>Great: 19%</td>
<td>Increase</td>
</tr>
<tr>
<td></td>
<td>Some: 32%</td>
<td>Some: 30%</td>
<td></td>
</tr>
</tbody>
</table>

*Great impact = 2007 Impact - 2006 Impact*  
*Some impact = 2006 Impact - 2007 Impact*  
*↑ Significant increase from 2006  \*  ↓ Significant decrease from 2006*
Main Points

• History
• Multiple “taste” phenotypes/genotypes
• Taste pathology influences on oral sensation
• Taste as a biomarker; dietary preference as a behavioral endophenotype
• Recommendations and research needs
PTC/PROP Phenotype

SCIENCE NEWS LETTER for April 18, 1931

CHEMISTRY
Six in Ten "Tasteblind"
To Bitter Chemical

"TASTEBLINDNESS" is the only term that can be found to describe the reaction of a fortunate forty per cent. of folk who cannot taste para-ethoxy-phenyl-thio-urea. For the other sixty per cent. find it intensely bitter - bitter as gall, bitter as quinine, bitter enough to make them go round sticking out their tongue and making wry faces for an hour.

This curious difference in perception has been discovered by Dr. Arthur L. Fox, of the laboratories of E. I. du Pont de Nemours and Company at Wilmington, Del. He has tried this very complex organic compound on everybody who would volunteer to taste it, and has found that approximately three-fifths of his "victims" declare it intensely bitter, while the rest say that it "has no more taste than sand."
In “Gustatory Chemoreception in Man: Multidisciplinary aspects and perspectives,” Fischer et al (1966) state: “extremely sensitive tasters of both quinine and propylthiouracil can be classified as Kretschmerian leptosomes or Sheldonian ectomorphs, whereas the extremely insensitive tasters of both compound conform to the Kretschmerian pyknic or Sheldonian endomorph type.”
Oral Sensory Function—PROP Phenotypes

Historically—Threshold

Tasters

Nontasters

Identifying supertasters and nontasters with appropriate scaling (Bartoshuk)

PROP tasting: Outdated scaling techniques misidentify nontasters and supertasters
Oral Sensory Function
PROP Phenotype: Associations with Taste Intensity

Magnitude Estimate of Taste Intensity
(normalized to tones)

<table>
<thead>
<tr>
<th>Substance</th>
<th>Correlation (r)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>QHCl</td>
<td>0.62</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Sucrose</td>
<td>0.46</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>NaCl</td>
<td>0.49</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Citric Acid</td>
<td>0.22</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

Magnitude Estimation Normalized to tones
N=100

PROP Tasting --->
Measure of Oral Sensory Variation?
Time courses of variation in concentration of haemoglobin (Hb) in the unit of mM*mm representing the flow of statistical analysis, during PROP administration in the 2 groups.


“the PROP phenotype is associated with fundamental differences in cortical taste processing”
Oral Sensory Function: Papillae Number (proxy for receptor density)

Nontaster Tongue

Supertaster Tongue
Taste System is Redundant

Taste buds in Throat—CN X

Circumvallate papillae

Foliate papillae

Lateral Rugae

Fungiform papillae

Palate

GSP Br. of CN VII

Glossopharyngeal Branch of CN IX

Chorda Tympani Branch of CN VII

Ligual Branch of CN V

Somatosensory

Total Ageusia Very Rare
Potential Oral Sensory Changes with Chorda Tympani Damage

Pathogen Damage—Fairly Common
- Otitis Media, upper respiratory tract infections
- Physical damage
- Head Trauma, T&A surgeries, middle-ear surgeries

Back of Oral Cavity:
- Elevated bitterness & dysgeusia
- Heightened bitterness from foods/beverages.

Whole mouth:
- Intensified bitterness
- Intensified tactile/irritation
- Preference changes

Tongue Tip:
- Diminished bitter (severe - all qualities)
- Heightened touch/pain sensations (taste - somatosensory interactions)
Oral Sensory Function: Nerve damage can dissociate taste and anatomy

Perceived Bitterness of Quinine (Fungiform Papillae)

Density of Fungiform Papillae (per cm$^2$)

strongest imaginable sensation of any kind

very strong

strong

moderate

weak

barely detectable

At risk of taste and oral pain phantoms

Fast, Duffy & Bartoshuk, 2002
A Brief History of Genetic Variation in Taste

In 1931, A.L. Fox, a DuPont chemist, discovered that some individuals found phenylthiocarbamide (PTC) to be bitter while others found it tasteless[3]. At the 1931 meeting of the American Academy for the Advancement of Science, Fox collaborated with Blakeslee (a geneticist) to have attendees taste PTC: 65% found them bitter, 28% found them tasteless, and 6% described other taste qualities. Subsequent work revealed that the ability to taste PTC was genetic in nature. In the 1960s, Roland Fischer was the first to link the ability to taste PTC, and the related compound propylthiouracil (PROP), to food preference and body type. Today, PROP has replaced PTC in taste research due to a faint sulfurous odor and safety concerns with PTC. As described above, Bartoshuk and colleagues discovered that the taster group could be further divided into medium and supertasters. Most estimates suggest 25% of the population are nontasters, 50% are medium tasters, and 25% are supertasters. 5% of supertasters can fly, unaided, at heights of up to seventy-five feet, merely by flapping their tongues.

Oral Sensory Intensity

Taste

oral somatosensation

retronasal olfaction

Supertasters

Nontasters

Taste Intensity

Neon Food World

Pastel Food World
Supertasting – More than TAS2R38 Genotype

Another receptor?

Bitterness: Genotype & FP

PROP supertasters

Suprathreshold v. Threshold by Genotype

Hayes et al, 2007
Fig 1. Effect of A49P genotype on sensitivity to the bitter taste of PROP

A. Children

B. Mothers

Mennella, J. A. et al.
Pediatrics 2005;115:e216-e222
• haploblock across TAS2R3, TAS2R4, and TAS2R5 explained some bitterness in coffee (TGAG>CCGT).
• TAS2R19 was associated with increased grapefruit bitterness and increased disliking (Cys299>Arg299 homozygotes or hets).

Hayes et al, Chem Senses in press.

<table>
<thead>
<tr>
<th>Gene</th>
<th>SNP</th>
<th>Association and possible mechanism, if known</th>
<th>Taste quality affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAS1R1</td>
<td>A372T(^{(50)})</td>
<td>T associated with high sensitivity. Mechanism unknown</td>
<td>Umami</td>
</tr>
<tr>
<td></td>
<td>G1114A(^{(95)})</td>
<td>A associated with high sensitivity. Mechanism unknown</td>
<td>Umami</td>
</tr>
<tr>
<td></td>
<td>C329T(^{(95)})</td>
<td>T associated with low sensitivity. Mechanism unknown</td>
<td>Umami</td>
</tr>
<tr>
<td>TAS1R3</td>
<td>R757C(^{(30,43)})</td>
<td>C associated with lower sensitivity. Mechanism unknown</td>
<td>Umami</td>
</tr>
<tr>
<td></td>
<td>R247H(^{(30)})</td>
<td>H associated with increased sensitivity. Possibly influences binding with L-glutamate resulting in stronger activation of taste system.</td>
<td>Umami</td>
</tr>
<tr>
<td></td>
<td>A5T(^{(43,95)})</td>
<td>A associated with heightened perception.</td>
<td>Umami</td>
</tr>
<tr>
<td></td>
<td>C2269T(^{(96)})</td>
<td>T more frequent in nontasters. Mechanism unknown</td>
<td>Umami</td>
</tr>
<tr>
<td></td>
<td>C1266T(^{(41)})</td>
<td>T alleles result in reduced promoter activity</td>
<td>Sweet</td>
</tr>
<tr>
<td></td>
<td>C1572T(^{(41)})</td>
<td>T alleles also result in reduced promoter activity in this mutation</td>
<td>Sweet</td>
</tr>
<tr>
<td>TAS2R16</td>
<td>G516T(^{(98)})</td>
<td>G associated with low sensitivity</td>
<td>Bitter</td>
</tr>
<tr>
<td>TAS2R38</td>
<td>P49A(^{(44,51)})</td>
<td>P associated with high sensitivity, possibly through increased G-protein activation rather than ligand binding(^{(97)})</td>
<td>Bitter</td>
</tr>
<tr>
<td></td>
<td>A262V(^{(44,51)})</td>
<td>A associated with high sensitivity possibly through increased G-protein activation</td>
<td>Bitter</td>
</tr>
<tr>
<td></td>
<td>V296I(^{(44,51)})</td>
<td>V associated with high sensitivity</td>
<td>Bitter</td>
</tr>
<tr>
<td>TAS2R43</td>
<td>W355(^{(60)})</td>
<td>W associated with high sensitivity</td>
<td>Bitter</td>
</tr>
<tr>
<td>TAS2R44</td>
<td>W35R(^{(60)})</td>
<td>W associated with high sensitivity</td>
<td>Bitter</td>
</tr>
</tbody>
</table>

Feeney et al, 2010
Survey Liking/Disliking: Association with Receptor Genetics

Connecting Chemosenses with Health

ENTR2R16  CHRM2

149 cM  170 cM

7q31  7q34

Fungiform Papilla
PROP and quinine bitterness

Genetic

Environment

Preference/Intake Patterns
Diet-related diseases & conditions

Chorda Tympani Nerve

Quinine Bitterness
Individuals differ in tastes and oral sensations from foods and beverages; differ in likes/dislikes.

- Philosophical question
  - Do you believe that individuals can tell you their behaviors and what they perceive?
  - In dietary assessment, we ask people what they eat and how much they eat (ie, judging portion size).
  - Can we ask people how intense or how liked or disliked?
    - or can we only ask forced choice responses (this is stronger than that, I like this more than that)?

- We believe that people can tell you how intense or how liked, but you have to be careful with the instructions.
PROP phenotype associations missed with inappropriate scaling

NaCl (Sip and Swallow)

Unconstrained vs. constrained to taste and oral sensation

Perceived Bitterness of 3.2 mM PROP
Labeled Scales - Adjectives Describe Something

S.S. Stevens (1958)

“Mice may be called large or small, and so may elephants, and it is quite understandable when someone says it was a large mouse that ran up the trunk of the small elephant.”
We learn the meanings of adjectives and we learn that adjective scales are elastic. We can stretch or compress it to fit the domain of interest. Thus we can speak of small or large mice and small or large elephants with no difficulty.

But what if the interest was to compare the relative size of mice, elephants in comparison to other sizes?
Studying Differences in “Taste”

Nontasters and supertasters live in different “taste” worlds.

Intensities of adjectives applied to taste and oral sensations are much greater to the supertaster than to the nontaster.

The key is to apply the adjective labels to all kinds of sensations to be able to assess differences in taste and oral sensations.

Perceived intensities indicated by intensity descriptors

Data collected by Susan Marino

Bartoshuk Lab
Ratings on the gLMS

Strongest imaginable sensation of any kind

strongest taste rating

strongest taste rating

soy sauce

grapefruit juice

lemonade

quinine

PROP

Erroneous assumption that the "strongest taste rating" reflects the same intensity to NTs and STs

soy sauce

grapefruit juice

lemonade

quinine

PROP
Green's Labeled Magnitude Scale
(Green et al, 1993)

- Tell the participant that the scale applies to any kind of sensation.
- Ask them to think about the strongest sensation of any kind.
- Practice rating the intensity of light in room, dim restaurant, brightest light.
- Have participant rate tastes in reference to lightness ratings.

Very Strong

Strong

Moderate

Weak

Barely Detectable

Strongest Sensation of Any Kind

Bartoshuk
Intensity of Remembered Non-Oral Sensation

- general Labeled magnitude scale for practice and standards
For supertasters,

<table>
<thead>
<tr>
<th>Vegetable bitterness ↑</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetable preference &amp; intake ↓</td>
</tr>
<tr>
<td>Vegetable-related cancers ↑</td>
</tr>
</tbody>
</table>

For low tasters,

| Alcohol bitterness, irritation ↓ |
| Alcohol palatability ↑ |
| Alcohol intake ↑ |

| Fat tactile sensations ↓ |
| Fat, sweet preference & intake ↑ |
| Greater energy intake? |
| adiposity, serum lipids ↑ |
Taste as a Diet and Health Biomarker?

- Big taste effect – alcohol and vegetable intake
- Taste and/or preference endophenotype is a superior indicator of health indicators
- Taste as an indirect effect on health indicator through dietary preference.
- The taste effect doesn’t work just through diet.
PROP, TAS2R38 and Vegetable Intake

Duffy Lab
60 Adults
EB, 2004;
Duffy et al,
2010

Italian branch of the
European Prospective
Investigation into Cancer
and Nutrition
(Sacerdote et al, 2007)

TAS2R38 variants are good
candidates for Mendelian
randomization studies of cancer
and other health outcomes.

* SD, standard deviation.
† p value from Wilcoxon’s two-sample test.
Variability in a taste-receptor gene determines whether we taste toxins in food

Mari A. Sandell and Paul A.S. Breslin

2007
PROP and quinine bitterness, vegetable sensation, preference & intake: Structural equation modeling

Structural Equation Model Fit
$X^2(13)=11.08$, $p=0.604$
TLI=1
RMSEA=0.000, 90% C.I. 0.000-0.081

Dinehart et al, 2006
Multiple trait interactions can hide single trait effects

FP number moderates the nontaster effects on vegetable intake

Duffy et al, 2010
PROP bitterness and Colon Cancer Risk in Men: Preliminary Findings

Basson, Bartoshuk, DiChello, Panzini, Weiffenbach, & Duffy, 2005
Can We Block Vegetable Bitterness to Improve Palatability?

Adding Light Sweetness

* p<0.05
** p<0.01

FNCE 2007
Added Sweetness—Just Right for the Medium Tasters

Nontasters - Too sweet—not enough natural bitterness to block the sweetness

Supertasters - Too sweet—they taste the sweetener too intensely

FNCE 2007
Supertasters—sensory hindrance to consuming alcoholic beverages

Duffy et al, 2004

Duffy et al, 2004

PROP bitterness

TAS2R38 genotype

\[ r = -0.33, p < 0.004 \]

Hayes et al, Chemical Senses in Press, different SNP
Lack of LD – both could exert unique effects on alcohol intake
PROP bitterness, alcohol sensation, preference & intake

Laboratory-study, of-age undergraduates
Lanier, Hayes, Duffy, 2005
“However, it appears that the protective effect of TAS2R38 * 1 somewhat overrides the risk conferred by ADH1B * 1, similar to our hypothesis; individuals are not likely to develop AD [Alcohol Dependence] if they rarely drink, despite any metabolic predisposition they may have.”
Summary and preference to link taste and health

**Oral Sensory Function**
- Multiple markers to capture variation
- Emerging genotypes

**Matching foods/beverages with oral sensory variation**

Include preference evaluation to assess diet-health relationships

**Preference**

**Adiposity**

**Reported Intake**

Risk of Energy Overconsumption

Genetics → Environment

- Oral Sensory Function
- Food/Beverage Sensation
- Food/Beverage Preference
- Food/Beverage Choice

Include preference evaluation to assess diet-health relationships
Addressing the Obesity Epidemic: A Genomics Perspective

Examples of Genes Involved in Obesity and Their Associated Phenotypes

<table>
<thead>
<tr>
<th>Gene</th>
<th>Associated Phenotype (Characteristic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leptin</td>
<td>Satiation, metabolism</td>
</tr>
<tr>
<td>Melanocortin</td>
<td>Feeding behavior, binge eating</td>
</tr>
<tr>
<td>Ghrelin</td>
<td>Appetite stimulation</td>
</tr>
<tr>
<td>Neuromedin β</td>
<td>Feeding behavior, satiety</td>
</tr>
<tr>
<td>PROP</td>
<td>Taste preference</td>
</tr>
<tr>
<td>PPAR</td>
<td>Fat metabolism</td>
</tr>
<tr>
<td>Mitochondrial uncoupling proteins</td>
<td>Energy expenditure</td>
</tr>
<tr>
<td>Melanocortin and MC4R</td>
<td>Energy expenditure</td>
</tr>
</tbody>
</table>

For detailed information about single-gene mutations and their association with obesity, see the Obesity Gene Map Database (9) and CDC’s Obesity and Genetics: A Public Health Perspective (10).
Normal Weight Adults: Fat/Sweet Mixtures Revisited

Response Surface Models (Hayes & Duffy 2008)

10% sucrose
whole milk
(soda 9-10%)
Like ok

15% sucrose
Light cream
(soda 9-10%)
Like > a lot

Drewnowski et al, 1985

University of Connecticut
Variation in the Bitter-taste Receptor Gene \textit{TAS2R38}, and Adiposity in a Genetically Isolated Population in Southern Italy

Beverly J. Tepper\textsuperscript{1}, Yvonne Koelliker\textsuperscript{1}, Liqiang Zhao\textsuperscript{1}, Natalia V. Ullrich\textsuperscript{1}, Carmela Lanzara\textsuperscript{2}, Pio d'Adamo\textsuperscript{2}, Antonella Ferrara\textsuperscript{2}, Sheila Ulivi\textsuperscript{2}, Laura Esposito\textsuperscript{2} and Paolo Gasparini\textsuperscript{2}

Female PROP nontasters heavier than supertastasters

<table>
<thead>
<tr>
<th></th>
<th>Nontaster</th>
<th>Medium taster</th>
<th>Super-taster</th>
<th>( P )</th>
<th>\textit{TAS2R38} haplotype</th>
<th>AVI/AVI</th>
<th>PAV/AVI\textsuperscript{a}</th>
<th>PAV/PAV</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Body Mass Index (kg/m(^2))</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td></td>
<td></td>
<td></td>
<td>0.50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>29.5 ± 0.6\textsuperscript{a}</td>
<td>26.8 ± 0.6 \textsuperscript{b}</td>
<td>26.3 ± 0.7 \textsuperscript{b}</td>
<td>0.001</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Waist Circumference (cm)</strong></td>
<td></td>
<td></td>
<td></td>
<td>0.80</td>
<td></td>
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<tr>
<td>Males</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>90.7 ± 1.6\textsuperscript{a}</td>
<td>85.6 ± 1.5 \textsuperscript{b}</td>
<td>82.7 ± 1.6 \textsuperscript{b}</td>
<td>0.001</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Values are means (\(\pm\) SEM). Values with different superscripts are significantly different at \( P < 0.01\) by Duncan’s Multiple Range Test. \textsuperscript{a}AVI/AVI individuals (\( n = 31 \)) were included with the PAV/AVI group.

Effects modified by dietary restraint and not captured by haplotype
Structural Equation Modeling
Linking Taste Markers with central adiposity thru survey
fat/sweet liking

Quinine

Fat/Sweet Preference

Fat Intake Frequency

Saturated Fat Intake

Age

Waist Circumference

+ .21

- .16

- .20

+ .21

- .15

+ .23

- .16

+ .39

.30

8%

Model Fit
Chi Sq = 8.8, df=11, p=0.64
TLI = 1
RMSEA = 0, 90% CI 0 - 0.084

Hayes et al, Pangborn 2007
### Predicting WC in hierarchical regression

<table>
<thead>
<tr>
<th>Step</th>
<th>Predictor</th>
<th>total $R^2$</th>
<th>delta $R^2$</th>
<th>$p$ change</th>
<th>final sr</th>
<th>final $p$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.290</td>
<td>.001</td>
</tr>
<tr>
<td>Model 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.188</td>
<td>.030</td>
</tr>
<tr>
<td>1</td>
<td>Age</td>
<td>8.6%</td>
<td>-</td>
<td>.004</td>
<td>.290</td>
<td>.001</td>
</tr>
<tr>
<td>2</td>
<td>Saturated Fat</td>
<td>18.5%</td>
<td>9.8%</td>
<td>.001</td>
<td>.188</td>
<td>.030</td>
</tr>
<tr>
<td>3</td>
<td>Liking/disliking</td>
<td>33.0%</td>
<td>14.5%</td>
<td>&lt;.001</td>
<td>.381</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Model 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Age</td>
<td>8.6%</td>
<td>-</td>
<td>.004</td>
<td>.285</td>
<td>.001</td>
</tr>
<tr>
<td>2</td>
<td>Liking/disliking</td>
<td>29.5%</td>
<td>20.8%</td>
<td>&lt;.001</td>
<td>.374</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>3</td>
<td>Saturated Fat</td>
<td>32.7%</td>
<td>3.3%</td>
<td>.037</td>
<td>.181</td>
<td>.037</td>
</tr>
</tbody>
</table>

L/D as a value-added measure

L/D as an alternative predictor

Liking/Disliking for high-fat and sweet foods explains greater variance in adiposity
Response to a Buffet Meal – Nontaster women consume more

Fig. 1. Mean differences (±SEM) in energy intake (kcal) between the control meal and the buffet meals in non-taster (n = 14) and super-taster (n = 18) women. Energy intakes differed between groups for the pizza buffet lunch and the average of the three buffet lunches. *p < 0.0.

Tepper et al, 2010 – Appetite, in press
<table>
<thead>
<tr>
<th>Dietary Risk</th>
<th>AHA Guidelines 2007</th>
<th>Orosensory Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturated fat, trans fat and</td>
<td>High intake can elevated LDL-cholesterol</td>
<td>Low tasters like and consume more fat</td>
</tr>
<tr>
<td>cholesterol</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Added Sugars</td>
<td>Elevated intakes, especially as liquids, increases risk of energy over-consumption and obesity</td>
<td>Low tasters like and consume more sweets</td>
</tr>
<tr>
<td>Salt</td>
<td>Elevated intakes, especially in salt-sensitive individuals, can elevate blood pressure</td>
<td>Supertasters like and consume more</td>
</tr>
<tr>
<td>Alcohol</td>
<td>While moderate intakes can lower CVD risk, high intakes increase blood pressure</td>
<td>PROP nontasters like and consume more</td>
</tr>
<tr>
<td>Obesity</td>
<td>Increases risk of elevated blood pressure and dyslipidemia</td>
<td>Low tasters show greater obesity risk</td>
</tr>
<tr>
<td>Fruits, Vegetables and whole</td>
<td>Low intakes may increase risk of overweight and elevated blood pressure and cholesterol</td>
<td>Supertasters consume fewest vegetables</td>
</tr>
<tr>
<td>grains</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
PROP Bitterness Associates with CVD Risks

Blood Pressure

Systolic Blood Pressure

Diastolic Blood Pressure

3.2 mM PROP bitterness (sqrt)
sr=-.20, p<.05

sr=-.22, p<.05

LDL Cholesterol

Multiple Linear Regression

Non-significant

Total Cholesterol

HDL-cholesterol

TG

Unpublished data, conference presented
Summary
Blood Pressure

Quinine Tongue Tip
Sweet/ Fat Preference (Fat Intake)
Waist Circumference

Taste Receptor Gene (ANCOVA)

PROPP

?? Other regulation

Blood Pressure

Unpublished data, conference presented
Summary

LDL-cholesterol

Quinine Tongue Tip

Sweet/ Fat Preference (Fat Intake)

Waist Circumference

PROP

Taste Receptor Gene (ANCOVA)

LDL-cholesterol

Other regulation

Genetic

Nontaster

Unpublished data, conference presented
Salt Sensation, Liking and Intake: Indirect Taste Genetic Effects

• Sex effects modulate taste genetic effects
• NaCl as a taste and an irritant
• PROP supertasters – more aware of intensity differences in salt concentration
• Effects on food liking are food specific
  – In snack foods, supertasters like the salt more (salt is an important sensation)
  – In cheese, supertasters dislike low sodium cheese as it is more bitter
  – Nontasters add salt more at the table – flavor enhancer?
• PROP bitterness and FP density have indirect impact on sodium intake via liking/preference (Hayes, Sullivan, Duffy, 2010).
Indirect effects of taste genetics

Model Fit
- chi-sq = 8.89, df = 8, p = 0.351
- TLI = 0.979
- RMSEA = 0.036, 90% CI 0 - 0.11
Brand Camp

The Sensory Cafe

Prop Tasting or Non Prop Tasting Section?

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brief measures for the assessment of cognitive, emotional, motor, and sensory function for use in clinical trials, epidemiological and longitudinal studies.

taste perception is assessed as one of six areas of sensory function.

Three taste measures, one for pediatric populations (J. Menella et al) and two for adult populations, were selected by a team of eleven scientists with expertise in taste perception.
Chemosensory Function – Population Based Study

- Anterior tongue and whole mouth

- 3.2 mM PROP bitterness

- Data treatment – PROP, PROP ratio, quinine tip/whole mouth, salt tip/whole mouth, quinine/PROP concordance and discordance

- Brief odor identification taste
Summary of Need

• Phenotypes or genotypes that are markers for dietary intake and/or differential risk of chronic conditions (susceptibility biomarker)
  – chemosensory-related genotypes
  – chemosensory phenotypes
  – preference phenotypes

• Consistent measures of phenotyping for multi-center clinical studies

• Measures that have utility, validity, and feasibility for epidemiological studies.

• Intervention studies that consider variation in taste and oral sensation
Research Support / Grants
– USDA NRI and Hatch
– American Diabetes Association Foundation
– NIH DC00283 and NIH Chemosensory Research Project
– NIH Toolbox
– NIDCD/Westat

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