Cognitive Decision Making
Neuroscience

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Topic: Taste (Gustation)

Sensory processes influence one of the most basic kinds of choices

Article Discussed

Carleton, A., Accolla, R., & Simon, S. A. (2010). Coding in the mammalian gustatory system. *Trends in Neurosciences*, *33*(7), 326–334. https://doi.org/10.1016/j.tins.2010.04.002

Brief summary

The topic of this article is how different aspects of taste experience, or gustation, are encoded in the mammalian nervous system. The critical reading questions focused on topics including the difference between labeled line coding and broad tuning, changes in taste preferences over time, and clinical aspects of taste behavior. The classroom discussion featured topics including the difficulty of bringing specific taste mental images to mind during memory recall, and why humans seek out tastes that are aversive in their basic form, specifically bitter.

This summary includes discussions of two questions that were not answered during the classroom discussion. The first question was about the problems involved with studying anesthetized animals in order to understand behavior and experiences that usually occur when animals are awake. The second unanswered question was about why the temporal response of gustatory neurons is necessary for broadly tuned neurons.

Some of the questions that remain unanswered in this summary include: What is the function of the IP3-reduced transient receptor channel? What are the major similarities and differences between taste codes and the way the taste signals travel? And, How do you gain or lose the different types of TRCs (taste responsive cells)? For example some people like salt more than others, or have an acquired taste for bitter things, do they have more type II TRCs, or G-protein coupled receptors?

Cognitive process neuroimaging analysis

Neurosynth term: “taste”

Top 5 Pubmed articles:

1: Yoshida Y, Kawabata F, Kawabata Y, Nishimura S, Tabata S. Expression levels of taste-related genes in palate and tongue tip, and involvement of transient receptor potential subfamily M member 5 (TRPM5) in taste sense in chickens. Anim Sci J. 2018 Feb;89(2):441-447. doi: 10.1111/asj.12945. Epub 2017 Nov 27. PubMed PMID: 29178505.

2: Choo E, Dando R. The Impact of Pregnancy on Taste Function. Chem Senses. 2017 May 1;42(4):279-286. doi: 10.1093/chemse/bjx005. Review. PubMed PMID: 28334158.

3: Ogawa T, Annear MJ, Ikebe K, Maeda Y. Taste-related sensations in old age. J Oral Rehabil. 2017 Aug;44(8):626-635. doi: 10.1111/joor.12502. Epub 2017 Mar 23. Review. PubMed PMID: 28252186.

4: Green BG, Alvarado C, Andrew K, Nachtigal D. The Effect of Temperature on Umami Taste. Chem Senses. 2016 Jul;41(6):537-45. doi: 10.1093/chemse/bjw058. Epub 2016 Apr 20. PubMed PMID: 27102813; PubMed Central PMCID: PMC4918727.

5: Running CA, Craig BA, Mattes RD. Oleogustus: The Unique Taste of Fat. Chem Senses. 2015 Sep;40(7):507-16. doi: 10.1093/chemse/bjv036. Epub 2015 Jul 3. PubMed PMID: 26142421.

Top 5 Neurosynth articles:

de Araujo, I. E. T., Rolls, E. T., Kringelbach, M. L., McGlone, F., & Phillips, N. (2003). Taste-olfactory convergence, and the representation of the pleasantness of flavour, in the human brain. *The European Journal of Neuroscience*, *18*(7), 2059–2068.

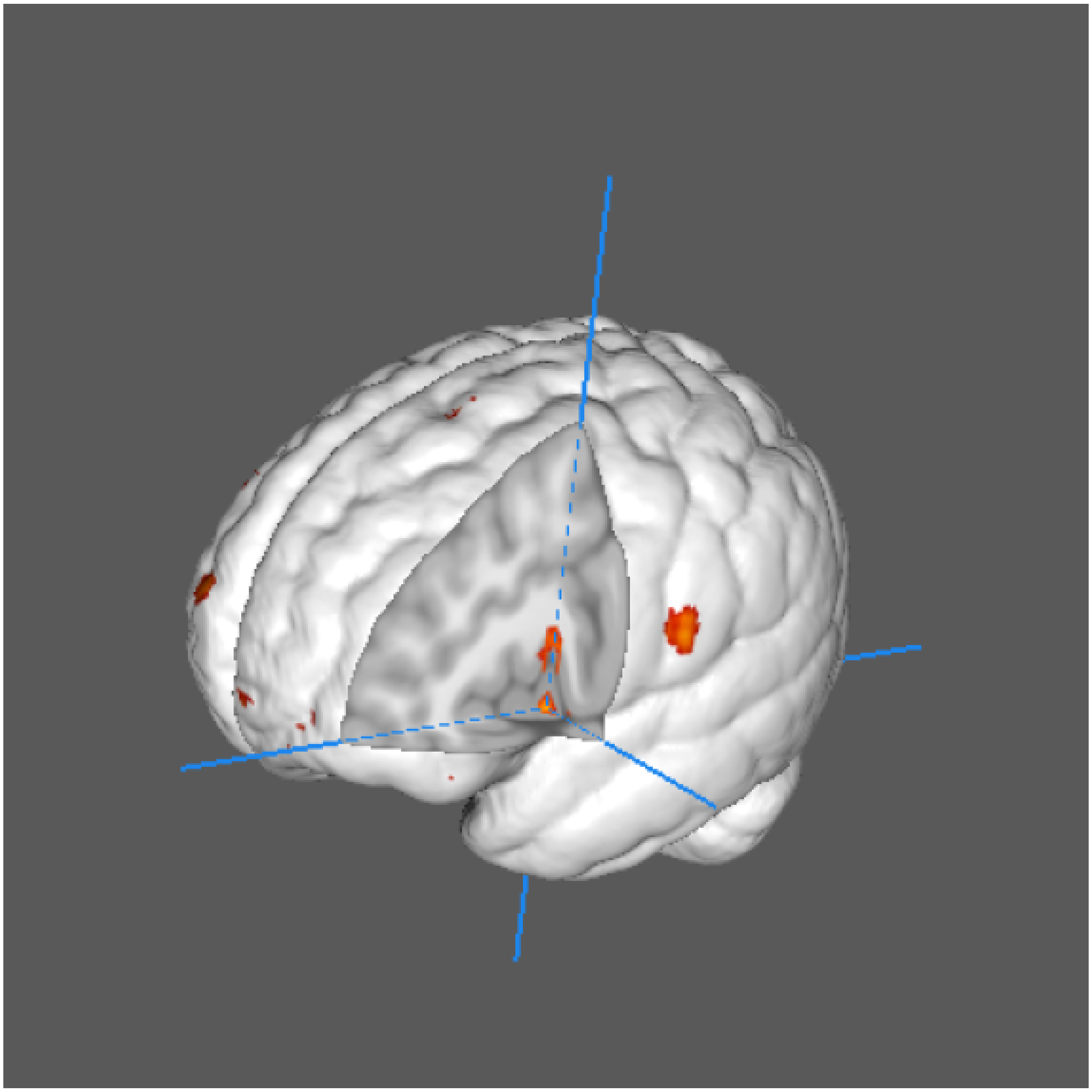
Grabenhorst, F., Rolls, E. T., & Bilderbeck, A. (2008). How cognition modulates affective responses to taste and flavor: top-down influences on the orbitofrontal and pregenual cingulate cortices. *Cerebral Cortex (New York, N.Y.: 1991)*, *18*(7), 1549–1559. https://doi.org/10.1093/cercor/bhm185

Hoogeveen, H. R., Dalenberg, J. R., Renken, R. J., ter Horst, G. J., & Lorist, M. M. (2015). Neural processing of basic tastes in healthy young and older adults - an fMRI study. *NeuroImage*, *119*, 1–12. https://doi.org/10.1016/j.neuroimage.2015.06.017

Nakamura, Y., Goto, T. K., Tokumori, K., Yoshiura, T., Kobayashi, K., Nakamura, Y., … Yoshiura, K. (2011). Localization of brain activation by umami taste in humans. *Brain Research*, *1406*, 18–29. https://doi.org/10.1016/j.brainres.2011.06.029

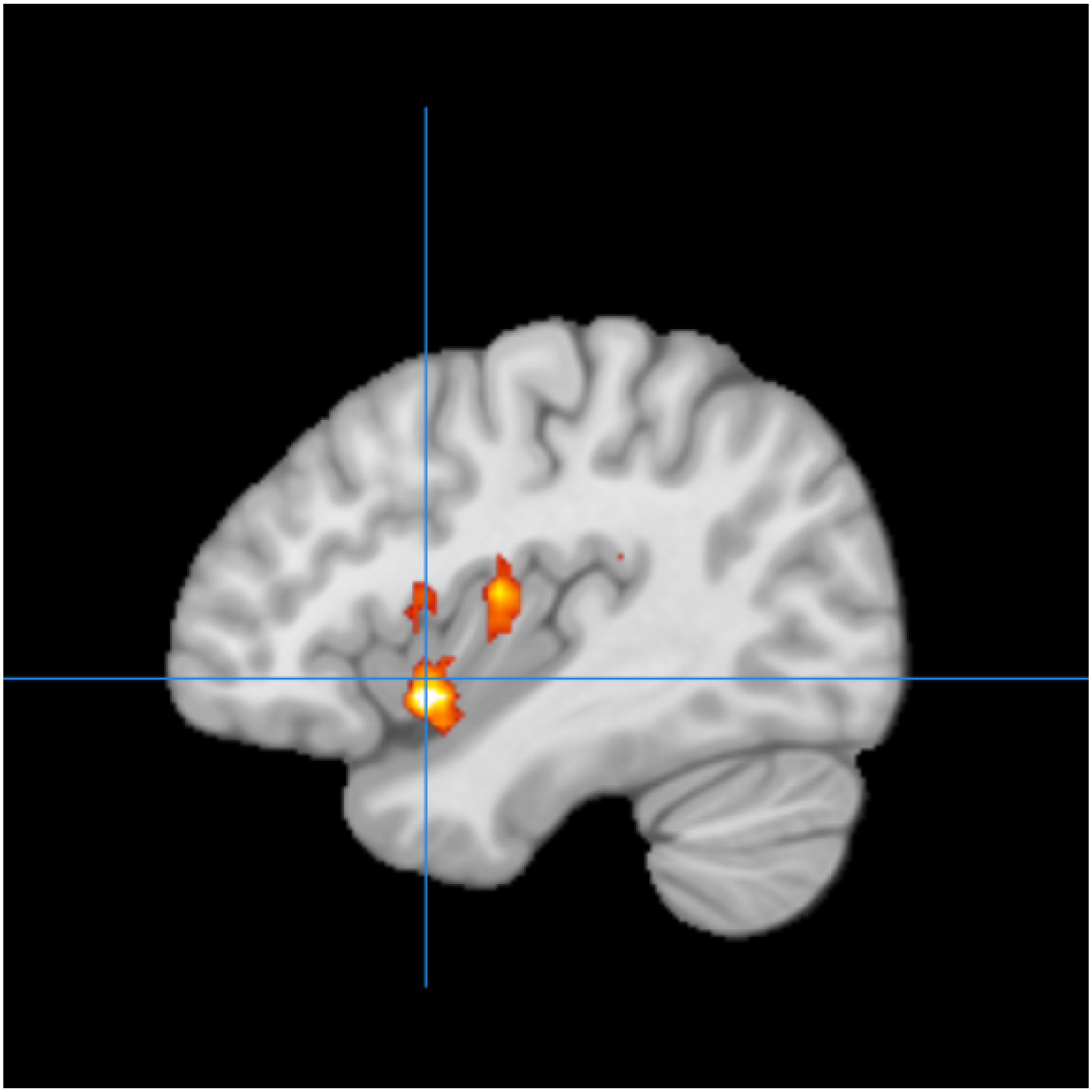
Nakamura, Y., Tokumori, K., Tanabe, H. C., Yoshiura, T., Kobayashi, K., Nakamura, Y., … Goto, T. K. (2013). Localization of the primary taste cortex by contrasting passive and attentive conditions. *Experimental Brain Research*, *227*(2), 185–197. https://doi.org/10.1007/s00221-013-3499-z

Neurosynth map for the term:



Brain region chosen for the term

Brain region “left rostrodorsal insula”



Other Neurosynth terms associated with this brain region:

MNI Coordinates: -40, 8, -7

	Individual voxel	Seed-based network		
Name	**z-score**	**Posterior prob.**	**Func. conn. ®**	**Meta-analytic coact. ®**
insula	13.25	0.8	0.52	0.57
pain	9.7	0.81	0.46	0.41
anterior insula	8.87	0.78	0.43	0.46
taste	7.85	0.88	0.12	0.2
insular	7.66	0.78	0.4	0.46
painful	7.43	0.83	0.43	0.4

	Individual voxel	Seed-based network		
noxious	7.3	0.86	0.28	0.25
insular cortex	6.84	0.81	0.36	0.42
anterior insular	5.8	0.84	0.24	0.26
fear	5.47	5.47	0.21	0.33

Questions posed by students

Background vocabulary

Q: What does “hedonic value” mean?

“Hedonics: the study of pleasant and unpleasant sensations” (Carleton, Accolla, & Simon, 2010). So, the “hedonic value” would be linked to how pleasant or unpleasant the sensation was -VideoSport

Q: What is gustatory?

SodaOxford: The gustatory is responsible for taste.

What Is the Gustatory Cortex? (with pictures). (n.d.). Retrieved January 29, 2019, from http://www.wisegeek.com/what-is-the-gustatory-cortex.htm

“Gustatory” is the technical word for the regular English word “taste.” It comes from the root “*geus-” which etymonline.com describes like this: “Proto-Indo-European root meaning “to taste; to choose.” It forms words for “taste” in Greek and Latin, but its descendants in Germanic and Celtic mostly mean “try” or “choose.””

*geus- | Origin and meaning of *geus- by Online Etymology Dictionary. (n.d.). Retrieved January 29, 2019, from https://www.etymonline.com/word/*geus-

I think it is interesting that “taste” and “choice” are related concepts linguistically.

AnthonyCate

Neuroscience methods

Q: How is data taken in morphological and electrophysiological recordings?

TwinNevada

- electrophysiological recording- The precise techniques employed in the electrophysiology laboratory influence the nature of the electrograms that are recorded during mapping procedures. (Stevenson & Soejima, 2005)
- Morphological recording- Morphological Analysis (MA) can also be referred to as ‘problem solving’. It is visually recorded in a morphological overview, often called a ‘Morphological Chart’. The method was developed in the 1960s by Fritz Zwicky, an astronomer from Switzerland. (Mulder, 2017)

Q: What does the Intrinsic Signal Optical Imaging technique exactly measure on the brain?

SincereZigzag:

- The intrinsic signal optical imaging (ISOI) technique measures cortical reflectance change caused by hemodynamic response (Lu, Chen, Cai, & Roe, 2017).
- It originates from different mechanisms such as changes in the physical properties of the tissue and/or changes of fluorescence or absorption of intrinsic molecules (Carleton et al., 2010).

Q: If most electrophysiological recordings are performed on anesthetized animals, doesn’t this mean that if the same tastant experiments were conducted when the animals are awake that results could be different and produce a different outcome? How do researchers combat this?

The short answer appears to be that researchers need to conduct similar studies with awake animals for comparison. A brief literature review found multiple articles that reported qualitative differences in neuronal activity in awake versus anesthetized animals [REFS]. Some of these studies turned out to be about olfaction, which seems to be a sensory system that researchers study in order to learn about one particular of neuronal function that are thought to apply to all kinds of sensory neurons: synchronous oscillations among sensory neurons that work together to signal the presence of the same odorant (Kay et al., 2009). These oscillations probably occur differently in anesthetized and awake animals, because the oscillations are sensitive to behavioral task demands. Experiments in awake, behaving animals (including both insects and rats) found that olfactory oscillations were stronger when animals had to distinguish two very similar odors compared to two dissimilar odors (Beshel, Kopell, & Kay, 2007), and that disrupting these oscillations with a GABA antagnonist impairs animals from distinguishing similar but not dissimilar odors (Stopfer, Bhagavan, Smith, & Laurent, 1997). Other studies that compared neural responses between anesthetized and awake animals found that there are both similarities and differences in their neural responses to visual (Lamme, Zipser, & Spekreijse, 1998) and tactile (Peeters, Tindemans, De Schutter, & Van der Linden, 2001) stimulation. Sometimes the responses of awake animals are actually less spatiotopically specific, at least in studies using fMRI (Peeters et al., 2001). Finally, a study of tactile stimulation in the cerebral cortex of both anesthetized and awake rats concluded that even though there were differences in the timing of single neuron responses, the responses in anesthetized rats still provided valuable information about how these neurons respond in awake, behaving animals (Simons, Carvell, Hershey, & Bryant, 1992)

AnthonyCate

Nervous system pathways

Q: Is gustatory processing in the periphery considered to be more or less complex in terms of evolution than gustatory processing contained within the CNS?

PolarisUnique: “Therefore, it is not surprising that other oral senses modulate taste sensations and that a particular brain circuit should have evolved to assess the multisensory properties of intra-oral stimuli.”

de Araujo, I. E., & Simon, S. A. (2009). The gustatory cortex and multisensory integration. *International Journal of Obesity (2005)*, *33*(Suppl 2), S34–S43. https://doi.org/10.1038/ijo.2009.70

Q: What are the main functions of each part of the tongue - in relation to

organizing and categorizing tastes?

WindowComrade: There are two cranial nerves responsible for taste perceptions when dealing with the tongue - the glossopharyngeal nerve at the back and the chorda tympani at the front. Taste buds are also important in interpreting taste sensations and sending signals to the brain.

(Center for Smell and Taste » The tongue map you learned in school is wrong. (n.d.). Retrieved January 29, 2019, from http://cst.ufl.edu/that-neat-and-tidy-map-of-tastes-on-the-tongue-you-learned-in-school-is-all-wrong.html)

Q: Neurons that are labelled 'best receptors' can change their tastant selectivity during, or after ingestion? - what does that mean?

Optiontemple: Distinct taste modalities (sweet / bitter) are sent to the brain, but gustatory neurons provide more detail in the food and can change based on appetite and associative learning.

(Carleton, Accolla, & Simon, 2010)

Q: What is a synthetic and normally tasteless ligand? This is in relation to the quote from the article "For example, in mice expressing a receptor activated by a synthetic and normally tasteless ligand in bitter-responsive cells the ligand was found to induce avoidance behavior, whereas when the same receptor was expressed in sweet-responsive cells the ligand provoked acceptance behavior."

- Ligand is a molecule, so for example if you had french fries, you would have some sort of molecule from the french fry that induces a flavor. They used a molecule that is synthetic (aka, made by the researchers and had no flavor) to see if the receptor that the actual molecule binds to is what causes taste. When the "tasteless" molecule bound to the receptor in a bitter-responsive cell, the animal showed "avoidance behavior" aka, confirmed that it most likely experienced a bitter taste. When the "tasteless" molecule bound to the receptor in a "sweet responsive cell" acceptance behavior was observed. When they expressed a "bitter receptor" inside of a "sweet cell" I THINK and I may be reading this wrong, but I think that the animal indicated acceptance behavior. So the bitter receptor was not as important to taste as the actual sweet cell. (Carleton, Accolla, & Simon, 2010) AmbientBenefit
- This supports the labeled line model, which says that individual taste receptor cells "will respond only to a single taste quality" (Firestein, Margolskee, & Kinnamon, 1999) AmbientBenefit

Q: What is the thing that activates the transient receptor channel, the IP3-reduced, and what is its function?

Q: Why doesn't the firing rate decrease for blackcurrant juice?

This is about Figure 4 from the article. My reading of it is this: First, the graph is about a single neuron in orbitofrontal cortex (OFC) that responds with an equally high firing rate to both blackcurrant juice (which I know to be Ribena ®) and glucose. That is, this neuron is selective for the taste of both of those sweet liquids. However, after the animal had drunk a lot of glucose drink, the neuron responded less to glucose but retained its high response to blackcurrant juice. This showed that the neuron's response to sweet things is modulated by how satiated ("sick of") a specific food the animal was. The implication is that the animal would still find blackcurrant juice tasty even after it was sick of glucose drink.

AnthonyCate

Q: Can the separate pathways be simultaneously activated? (e.g. bitter and sweet).

BanditMeter: Different taste receptors need different chemicals to fire. If a food has chemicals that can attach to bitter and sweet taste receptors than they will fire, however, it is rare for a food to have large amounts of both tastes and generally one taste will fire many more receptors and "overpower" the other pathways. But it is common for one food to fire multiple taste receptors.

Informed Health Online. Cologne, Germany: Institute for Quality and Efficiency in Health Care

(IQWiG); 2006-. How does our sense of taste work? 2011 Dec 20 [Updated 2016 Aug

> 17]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK279408/

"a single chemical species may elicit more than one taste (i.e., through the activation of multiple receptors) and may explain the characteristic "aftertaste" associated with these tastants." (Yarmolinsky, Zuker, & Ryba, 2009) -VideoSport

Q: What are the major similarities and differences between taste codes and the way the taste signals travel?

Q: What does the article mean by the phrase “neuronal spike timing”?

- Neuronal Spike Timing is defined as the timing of a neuron’s action potential or “spike.” This is the point that the cell depolarizes (becomes less negative) and leads to a spike in the membrane potential of the cell.
- Izhikevich, E. M., Gally, J. A., & Edelman, G. M. (2004). Spike-timing dynamics of neuronal groups. *Cerebral Cortex*, *14*(8), 933–944.
- ShelfOpus

Q: What does the article mean when it says “gustatory pathways in the brain consist of interacting and dynamic feed-forward and top-down pathways”? More specifically, I am not sure how the feed-forward and top-down pathways come together.

Top-down pathways refer to perception that is driven by cognition. It takes the information that we already have stored in our brain and fills in the blanks of things were are trying to perceive. Feed-forward pathways refer to a neural network that is inspired by classification algorithm consisting of a number of simple neuron-like processing units that process input information in a layered system. In this network, the information moves in one direction until it reaches its target output. I think in a sense, the gustatory pathways are using these two types of networks to relay sensory input from its gustatory receptors and processing the taste and this is how our brain perceives whether we like or don’t like what we are eating. For example, if someone is eating a new food for the first time they might be able to initially see that the item is a vegetable, has a green color, has a rough texture, etc and they are able to put together what they know from previous foods they’ve tried to determine if they enjoy it. The feed-forward pathway is gathering all this input and the information travels to the gustatory cortex, which consist of the the anterior insula on the insular lobe and the frontal operculum on the inferior frontal gyrus of the frontal lobe, to help they store the new information and remember whether they enjoy this food or not.

Jones, L. M., Fontanini, A., & Katz, D. B. (2006). Gustatory processing: a dynamic systems approach. Current Opinion in Neurobiology, 16(4), 420–428. https://doi.org/10.1016/j.conb.2006.06.011

Maffei, A., Haley, M., & Fontanini, A. (2012). Neural processing of gustatory information in insular circuits. Current Opinion in Neurobiology, 22(4), 709–716. https://doi.org/10.1016/j.conb.2012.04.001

RavioliJaguar

Q: What is a segregated pathway?

A segregated pathway is used to carry abundant information to a particular location of the brain via multiple pathways as opposed to only one. This increases efficiency and allows information to be processed and transmitted more quickly and without the risk of all of the information being lost if there is damage to one of the pathways.

Cloutman, L. L., Binney, R. J., Morris, D. M., Parker, G. J. M., & Lambon Ralph, M. A. (2013). Using in vivo probabilistic tractography to reveal two segregated dorsal 'language-cognitive' pathways in the human brain. *Brain and Language*, *127*(2), 230–240. https://doi.org/10.1016/j.bandl.2013.06.005

DecimalSponsor

Q: What is the difference between labeled line and ensemble code?

- Labeled-line implies that the neurons are sensitive to a narrow range of receptors (one neuron type, such as NaCl best or sugar best) and that the response from these specific receptors determines the sensory response (taste) (Purves et al., 2001) AmbientBenefit
- Ensemble code otherwise known as "across neuron hypothesis" says coding for taste comes from a response from ALL cells involved, not just those with the biggest response (Purves et al., 2001) AmbientBenefit

Q: Why does the temporal response need to be able to distinguish between two tastes more specifically than the broadly tuned neuron if the overall purpose is to distinguish between harmful and helpful substances? Based on Page 5 of the PDF, "Coding in the brainstem and thalamus".

Q: What exactly is the role of the 'pontine parabrachial nucleus (PBN)', and specifically, how does it project signals to the various areas of the brain used in "feeding and/or taste memory formation"

"Neurons in the pontine parabrachial nucleus (PBN) transduce signals for the general visceral sensory, somatic sensory, gustatory, and autonomic nervous systems, and the various PBN neurons that perform these functions are intermingled." (Maeda, N, et al. "Spatial Differences in Molecular Characteristics of the Pontine Parabrachial Nucleus." *Current Neurology and Neuroscience Reports.*, U.S. National Library of Medicine, 3 Nov. 2009, www.ncbi.nlm.nih.gov/pubmed/19664607.). Essentially the PBN takes physical energy, converts it into nervous signals and is sent to various sensory systems. -(ZeroCanary)

Cortical representation of taste

Q: What does “taste maps for saccharin are plastic” mean?

SodaOxford: This means that they can easily be changed according to the hedonic value that is present at the time.

> Gutierrez, R., & Simon, S. A. (2011). Chemosensory processing in the taste – reward pathway. *Flavour and Fragrance Journal*, *26*(4), 231–238. https://doi.org/10.1002/ffj.2050

Q: What is chemotopic organization? (Binder, Hirokawa, & Windhorst, 2009)

Representation indicates an orderly spatial arrangement of olfactory glomeruli (or other neural elements in a chemosensory system) that is related to the chemical attributes of the effective sensory stimuli.

Mobilesuper

Q: What type of graph is a “topographical representation”?

WindowComrade: a topographical representation shows the anatomical location of a part/parts of the body in respect to a specific region (topography. (n.d.). *The Free Dictionary*. Retrieved from https://medical-dictionary.thefreedictionary.com/topography)

IsotopeNirvana: A topographical representation is an orderly projection of the sensory surface and can be found in all sensory systems and some motor systems. (“Topographic map (neuroanatomy),” 2018)

Topographic maps, as referred to in the olfactory system, refer to the way that stimulus are recognized and organized by the brain to be laid out in the physical environment. The stimuli are processed by the brain, and they are then understood to be in a specific position in the environment. Taste and smell are very closely related, and it’s understood that taste greatly relies on smell. As individuals get older, the ability to smell diminishes, and so also does the ability to taste, as well.

> Auffarth, Benjamin. “Understanding Smell—The Olfactory Stimulus Problem.” *Neuroscience & Biobehavioral Reviews* 37, no. 8 (September 1, 2013): 1667–79. https://doi.org/10.1016/j.neubiorev.2013.06.009.
>
> –AgentCharter

Q: What role does the somatosensory system play in the analyzing different types of food?

TwinNevada - oral-somatosensory attributes carbonation, oral texture, and mouth-feel (Spence & Ngo, 2012)

BanditMeter: The somatosensory system analyzes the touch, proprioception, temperature and trigeminal chemical sensitivity

Barbara Cerf-Ducastel, Pierre-Francois Van de Moortele, Patrick MacLeod, Denis Le Bihan,

Annick Faurion; Interaction of Gustatory and Lingual Somatosensory Perceptions at the

> Cortical Level in the Human: a Functional Magnetic Resonance Imaging Study, Chemical
>
> Senses, Volume 26, Issue 4, 1 May 2001, Pages 371–383,

https://doi.org/10.1093/chemse/26.4.371

Q: can we point of the area in the brain in Mango where gustation occurs? (“Gustatory Cortex,” n.d.)

Since the gustatory cortex is made up of two smaller substructures, the anterior insula and the frontal operculum. These substructures are found in the insular and the frontal lobes of the brain. When inputting gustation into mango view then the insular and the frontal lobes of the brain should light up on the brain.

Mobilesuper

Q: Why does the temporal response need to be able to distinguish between two tastes more specifically than the broadly tuned neuron if the overall purpose is to distinguish between harmful and helpful substances? Based on Page 5 of the PDF, “Coding in the brainstem and thalamus”.

Answer: Basically, the extra information conveyed by the timing of action potentials allows broadly-tuned neurons to signal basic tastes more specifically than they would otherwise. Research cited in the main article supports the idea that the temporal responses form part of the code that signals the different basic tastes (sweet, sour, salty, bitter, and umami). These studies were conducted on neurons in the nucleus of the solitary tract (NST or, confusingly, also NTS) in rats. One study quantified how much information for discriminating basic tastes was transmitted by the specific timing of NST neuron spikes, above and beyond the average spike rate (Lorenzo, Chen, & Victor, 2009). It found that the more broadly tuned a neuron was (i.e. the more it responded equally to the different basic tastes), the more information was transmitted by spike timing. Other studies stimulated these neurons instead of just recording their respones, which made the neurons respond with the pattern that they showed during stimulation by a specific tastant, even if there was no tastant present (Hallock & Di Lorenzo, 2006). It was found that stimulating rats with this kind of artificial spike train did not produce taste-related behavior if the timing of the artificial spikes was randomly perturbed (Di Lorenzo, Hallock, & Kennedy, 2003). Together these studies make a good case that the precise timing of action potentials in NST neurons is critical for enabling rats to identify specific tastes.

AnthonyCate

Cognitive implications of taste coding

Q: Do people get a similar memory recall from taste as people do with scent? Or are they different in that regard?

- "On the contrary to the visual and auditory memory, the taste memory (although very well developed in the humans, e.g., 8]) is not readily available for on demand recall, unless there is present taste stimulus. This could be partially explained by one kind of specific poison protective reflex known as conditioned taste aversion reaction" ((Zach, Zimmelová, Mrzílková, & Kutová, 2018)
- So basically they are the same in that they are both "wet senses"; The signal molecule has to interact with the chemical receptor in order to make "taste" or "smell" occur. They are the two senses that cannot be recalled into memory unless you experience them again. (Zach et al., 2018) AmbientBenefit
- If you are referring to remembering something from a smell based on associative learning, the same thing can sort of happen with taste**:** "Learning through the taste system is intimately allied with GI consequences. The animal knows two facts: what the chemical was (taste), and what it did (GI). This information permits it to tailor its chemical selection to full individual advantage over a lifetime." (Scott, 2011) AmbientBenefit

Q: How do you gain or lose the different types of TRCs? For example some people like salt more than others, or have an acquired taste for bitter things, do they have more type II TRCs, or G-protein coupled receptors?

Q: If most electrophysiological recordings are performed on anesthetized animals, doesn’t this mean that if the same tastant experiments were conducted when the animals are awake that results could be different and produce a different outcome? How do researchers combat this?

Q: Is the gustatory system and the somatosensory system the only thing involved in analyzing food features?

(CoolActive) The receptors found in the gustatory and somatosensory system are also found in the stomach, pancreas, and intestines. Cells in the digestive tract have taste receptors that “taste the sugar a second time”. “This 'second tasting' triggers glucose transport into the cells and bloodstream, and the faster this happens, the more insulin will be released”.

https://www.nature.com/articles/486S7a

> Trivedi, B. P. (2012). Neuroscience: Hardwired for taste. *Nature*, *486*, S7–S9.

https://doi.org/10.1038/486S7a

Q: Why does the peripheral gustatory processing have a much simpler mechanism over the central nervous system gustatory processing?

I don’t have any information on the scientific functional reason why this is but simply said Peripheral means on the side/ secondary and Central means primary/ main. Hence why the processing in Peripheral Gustatory System is simpler compared to the processing in the Central nervous gustatory system. -(ZeroCanary)

Q: Do people like sour candies (even though sour tastes are generally unpleasant) because the sweet flavor overpowers the sour? So why do some prefer sour candy over other candy?

Socialanvil: It seems like preference correlates to the amount of receptors present in the individual. This can be dependent on sex and age. For example in the research article I found, women had a more acute taste for sour then did men. Also, younger people has a stronger sense of taste to sour than did older people.

Barragán, R., Coltell, O., Portolés, O., Asensio, E., Sorlí, J., Ortega-Azorín, C., . . . Corella, D. (2018). Bitter, Sweet, Salty, Sour and Umami Taste Perception Decreases with Age: Sex-Specific Analysis, Modulation by Genetic Variants and Taste-Preference Associations in 18 to 80 Year-Old Subjects. Nutrients, 10(10), 1539. doi:10.3390/nu10101539

RespondLlama: children tend to prefer sour tastes more than adults. ⅓ of 5-9 year old children, and virtually none of their mothers prefered the extremely sour taste in this study:

> Liem, D. G., & Mennella, J. A. (2003). Heightened Sour Preferences During Childhood. *Chemical Senses*, *28*(2), 173–180.

https://doi.org/10.1093/chemse/28.2.173

Q: With so much biological and evolutionary support for how and why human gustation works the way it does, why do humans still find food that is very unhealthy, and that the body does not need, so appealing?

- “The evolved taste abilities of humans are still useful for the one billion humans living with very low food security by helping them identify nutrients. But for those who have easy access to tasty, energy-dense foods our sensitivities for sugary, salty and fatty foods have also helped cause over nutrition-related diseases, such as obesity and diabetes.”
- Sweet sensations are innately attractive in adults and children. When habits are formed as a child to eat sweet, unhealthy foods it can lead to obesity.
- From an evolutionary standpoint, our closest relatives, the chimpanzees main diet is fruit which we retained , high in sugars and acids,
  - Breslin, P. A. S. (2013). An Evolutionary Perspective on Food Review and Human Taste. *Current Biology : CB*, *23*(9), R409–R418.
  - https://doi.org/10.1016/j.cub.2013.04.010DivideSegment

Q: Under the assumption that taste preferences change with age, especially considering differences between children and adults (like how most kids normally hate the taste of vegetables that adults may otherwise enjoy), how does the taste encoding differ in children versus adults? Does associative learning play a larger role in one group versus the other?

WindowComrade: Adult taste buds contain many small receptor cells which process taste. This means that adults have the capacity to handle stronger, sweeter, saltier flavors than children. It could be said that children do learn through associative learning because they develop taste according to taste buds, food aroma, appearance, and even previous experiences with foods. Taste develops in a more social way in children. They learn taste preferences based on their other senses, as do adults - but it is more prominent in children as they are growing and learning. (Are kids’ taste buds different from adults’?

(2009, September 21). Retrieved January 29, 2019, from https://recipes.howstuffworks.com/menus/kids-taste-buds.htm)

WelcomeSoda: There is not a huge difference in sucrose taste thresholds between younger adults and older adults but there is a difference. This is because adults constantly have new taste buds being made so the difference is not as great as one may think. This means that there could be associate learning at play as well but most of the information I could find focuses on actual biological reactions to food chemistry rather than other psychological factors. Moore, L. M., Nielsen, C. R., & Mistretta, C. M. (1982). Sucrose Taste Thresholds: Age-related Differences. *Journal of Gerontology*, *37*(1), 64–69. https://doi.org/10.1093/geronj/37.1.64

Q: Why is it that some medicine injections to other areas of the body result in a patient tasting something?

TelecomElegant: The medicine is injected into the bloodstream, and then certain chemicals within are released via the respiratory system into the surrounding air. The olfactory system detects these chemicals. Due to the close relations of the olfactory and gustatory systems, people assume they are tasting something when in fact this is more so due to smelling the components of the medicine via the respiratory system.

> Kongsgaard, U. E., Andersen, A., Øien, M., Oswald, I.-A. Y., & Bruun, L. I. (2010). Experience of unpleasant sensations in the mouth after injection of saline from prefilled syringes. *BMC Nursing*, *9*, 1.

https://doi.org/10.1186/1472-6955-9-1

Q: Does the release of neurotransmitter dopamine playing into the frontal cortex and reward value?

IsotopeNirvana: Dopamine neurons encode an alerting signal for cues, such as motivational value, where certain neurons are excited by appetitive stimuli. (Love, 2014)

PaintLevel: Dopamine is a catecholamine synthesized in the VTA and SNc with axons that project to the striatum, limbic area, and cortex. Dopamine release in the brain and subsequent activation of the mesolimbic pathway mediates reward processes as related to detecting cues that predict reward and regulating neural response to reward itself. This sensation of reward can come from natural rewards, like food, or chemicals that stimulate reward neural circuits, like cocaine. As a result, stimulation of D1 receptors plays a role in the molecular changes associated with addiction.

Nestler, E. J. & Carlezon, W. A. (2006). The mesolimbic dopamine reward circuit in depression. *Biological Psychology, 59*(12), 1151-1159. https://doi.org/10.1016/j.biopsych.2005.09.018

Implications for health and clinical disorders

Q: Can this science be used to help with dieting or health benefits? Reduce the type II TRCs that respond to sweets, or reduce the ENaCs to reduce attraction to salt for those with high blood pressure?

MileImport:

A significant portion of the research on dietary/health benefits tend to focus on replacement of the foods that release dopamine, rather than reducing dopamine in general. Protein rich, energy dense foods that are not high in fat or salt content can release similar neurotransmitters, in turn replacing negative benefits associated with poor foods.

> “Epigenetic Dysregulation of the Dopamine System in Diet-induced Obesity - Vucetic - 2012 - Journal of Neurochemistry - Wiley Online Library.” Accessed January 29, 2019. https://onlinelibrary.wiley.com/doi/full/10.1111/j.1471-4159.2012.07649.x.

Q: I wonder how the sensory-specific satiety in the OFC would be affected by people with eating disorders. With binge eating disorder, people eat much more past the point of simply gaining nutritional value, or with anorexia, people don’t eat nearly enough. However, people with both kinds of disorders are somehow satisfied with their abnormal eating habits. Is this a change that affects the OFC or is it more strictly psychological?

- “in comparison to healthy and bulimic subjects, patients with anorexia nervosa have alterations, specifically, lowered olfactory and gustatory functions”
- Aschenbrenner, K., Scholze, N., Joraschky, P., & Hummel, T. (2008). Gustatory and olfactory sensitivity in patients with anorexia and bulimia in the course of treatment. *Journal of Psychiatric Research*, *43*(2), 129–137. https://doi.org/10.1016/j.jpsychires.2008.03.003
- ShelfOpus

Q: Can certain types of brain trauma affect the functioning of the gustatory system?

Taste Perception: The primary taste cortex is located in the rostrodorsal insula. Damage to the right insula caused ipsilateral taste recognition and intensity deficits. Damage to the left insula caused ipsilateral deficit in taste intensity and a bilateral deficit in taste intensity. Taste information from both sides of the tongue goes through the left insula, based on the testing done with left-hemisphere stroke patients.

Taste perception in patients with insular cortex lesions. Retrieved January 29, 2019, from

https://psycnet.apa.org/fulltext/1999-03910-002.html

-PoloBravo

- “Olfactory dysfunction is common following traumatic brain injury, occurring in approximately 20% of patients depending on the mechanism of injury… In contrast, gustatory disturbances are infrequent, occurring in less than 1% of cases;” “With the higher prevalence of traumatic injuries to the olfactory system than the gustatory system, it follows that patients with brain injury reporting taste disturbances more likely have olfactory deficits.”
  - Reiter and Costanzo, “Chemosensory Impairment after Traumatic Brain Injury.”
  - https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3798071/ –RespondLlama

> Reiter, E. R., & Costanzo, R. M. (2012). Chemosensory Impairment after Traumatic Brain Injury: Assessment and Management. *International Neurotrauma Letter*, *23*, 3.

“Therefore, it is clear that alterations in digestive physiology have a significant effect on taste responses in neurons located at the first synaptic relay along the taste system.”

This states that digestive physiological changes in an individual can affect the ability of that individual to process taste stimuli. This could extend beyond just brain trauma, but I think that the gustatory system in the body is complex and involved enough that even subtle, seemingly unrelated systems in the body really could affect taste responses in neurons.

“Better control of dietary compensation is highly desirable and needed.”

Individuals’ bodies will naturally attempt to develop a proper healthy dietary system, and trauma to these processes within the body effect large portions of bodily functions as a result. Trauma to the body greatly affects the body’s ability to properly and efficiently process taste stimuli, and this includes trauma to the brain.

Hill, David L. “Neural Plasticity in the Gustatory System.” *Nutrition Reviews* 62, no. 11 Pt 2 (November 2004): S208–41.

Karasov, William H., and Angela E. Douglas. “Comparative Digestive Physiology.” *Comprehensive Physiology* 3, no. 2 (April 2013): 741–83. https://doi.org/10.1002/cphy.c110054.

Morais, S., L. E. C. Conceição, I. Rønnestad, W. Koven, C. Cahu, J. L. Zambonino Infante, and M. T. Dinis. “Dietary Neutral Lipid Level and Source in Marine Fish Larvae: Effects on Digestive Physiology and Food Intake.” *Aquaculture*, Larvi 2005, 268, no. 1 (August 22, 2007): 106–22. https://doi.org/10.1016/j.aquaculture.2007.04.033.

–AgentCharter

Directions for future research

Q: How would future experiments delve into the other parts of the food stimulus?

ExactTulip: "Gustatory dysfunction may indeed be related to the normal ageing process. However, in many cases, what is perceived as a taste defect is truly a primary defect in olfaction. Other than smell dysfunction, the most frequent causes of taste dysfunction are prior upper respiratory infection, head injury, drug use, and idiopathic causes."

Boyce, J. M., & Shone, G. R. (2006). Effects of ageing on smell and taste. *Postgraduate Medical Journal*, *82*(966), 239–241. https://doi.org/10.1136/pgmj.2005.039453

Hunger triggers endocannabinoid receptors, making your olfactory system more sensitive and more active, to salt and sugar in particular. Future experiments could study how the increased activity of the endocannabinoid receptors affect binge eating and/or how its effects vary by culture. (CoolActive)

> Why Does Food Taste Better When You Are Hungry? (2018, June 1). Retrieved January 29, 2019, from

https://www.discoverydcode.com/dcode/articles/food-taste-better-hungry/This research article analyzes the changes of olfactory and gustation processes with age, and findings seem to support that taste is incredibly dependent on smell. This opens the door to different types of future experiments, such as observing patients with a lessened sense of smell and analyzing the correlation between their olfactory strength and how stimulating certain food aromas or tastes may be in comparison to a controlled group, or those considered to have an average sense of smell.

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