Organoleptic and Sensory Ontology

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Abstract. This abstract presents a conceptual understanding of Organoleptic ontology and outlines the properties of food that act as stimuli evoking sensory response; and the Sensory Ontology of the perceptions caused by the stimulus.

Keywords: Food Phenotype, Organoleptic, Sensory, Multimodal Stimulus, Computational framework

1. Introduction

Across the world much work has been done to create food composition databases and ontologies, often with the end goal in mind of producing a queryable data set for meeting nutritional needs of a population [11]. At the same time, it is well established that dietary behavior change is more likely to succeed if diet interventions provide tasty, aromatic, and delightful alternatives. [1 2 6] Yet scant attention has been paid to developing computable vocabularies about food capable of delineating expected sensory experiences originating from food organoleptic properties. Organoleptic properties of any food are best explained in the context of the Food Phenotype.

To justify the proposed relationship of Organoleptic Properties as a subset of Phenotypic properties a brief definition is provided. Phenotype data has three main classes: Biological, Chemical, and Physical. Biological components and properties characterizing biological structures present in the food, as well as the physiological and molecular bioactivity roles these ingredients may play in the organism consuming the food, Chemical properties and components characterizing the reactability, and aroma etc, Physical properties can be divided into several classes including Rheological Properties, Morphological Properties, Surface Properties, Acoustic Properties, Volumetric Properties like density, surface area, porosity and volume, Reflective/Refractive properties like colour and transparency, Electromagnetic properties, Thermal properties, Water Activity and absorption properties, State properties. A detailed examination is of out of scope of this abstract. Organoleptic properties are the characteristics resulting from the intersection of the aforementioned Phenotypic classes detectable by electrical, mechanical, chemical, and temperature bio-mechanisms and felt as the sensation of touch, sight, smell, taste, sound, inflammation, and lacrimation. Hence the Organoleptic Ontology has relevance to the consumption of food.

A basic principle in creating Ontologies is to consider existing ontologies and harmonize with new work. As the ontologies proposed in this abstract are merely

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conceptual, a thorough review of existing ontologies and vocabularies is a necessary pre-requisite to formalizing the concept.

2. Background of Existing Food Ontologies

A brief review is provided to point out that the proposed Ontologies do not overlap with either of the two existing Food ontologies namely; FoodON and FoodOntology. Other Food domain ontologies and vocabularies will also be examined similarly.

FoodON [3] is a base ontology for human foods and currently covers raw ingredients, food products and product types specifically intended to address semantic applications in food safety, food processing and agricultural and animal husbandry practices. In regards to food safety it covers the natural encasing of food and food packaging. Regarding food processing it has sub classes that enumerate various heat treatments, cooking methods, preservation techniques. A complete review of FoodON is not in scope of the abstract but it is essential to point out the overlapping nodes with Organoleptic properties will be considered and mapped to.

FoodOntology [11] lists the ingredients in a prepared dish. It also gives the nutritional properties namely the vitamins, minerals and salts in a given ingredient. Hence this Ontology does not detail the Organoleptic properties, though it is possible that some of the Nutritional composition may have an organoleptic impact.

The Organoleptic property must be interoperable with the above ontologies as well as PATO, Crop Ontologies, Vocabularies developed by GODAN, AGROVOC, UN's FAO to name a few [4].

3. Organoleptic Ontology

This Ontology details all possible organoleptic traits of an edible substance. This can be a molecular level entity such as a protein molecule or an aromatic molecule or a singular food like an apple or a composite food like apple pie. Hence while it may be accepted that regardless of category, any edible entity possesses organoleptic properties, the properties are not additive. Hence the sum of all properties of molecular compounds in an Apple will not be the same as the organoleptic properties of an Apple and the sum of all properties of individual ingredients in Apple Pie will not be the properties of Apple Pie. This abstract does not attempt to explain that combinatorial process.

The Ontology has seven top level classes of stimuli corresponding to the sensory reaction.

- Appearance is the response to visual stimuli and includes texture, colour, surface reflectance, size and shape.
- Touch - These are the properties of the food which can be felt by receptors in the skin and mucous membranes. Lacrimation may occur in the presence of syn-propanethial-S-oxide, which may be undetectable by smell or any of the other senses. Inflammation: Similarly, the trigeminal nerve may become inflamed for instance, from peppers when the TRPV1 responds to capsaicin, a

molecule found in varying quantities in almost all peppers. This ‘spiciness’ is neither an odor nor a taste.

- Smell - Any food has hundreds or thousands of odor molecules of different kinds and in different concentrations.
- Taste is the sensory experience of the taste buds and is of 5 types - Sweet, Sour, Bitter, Salty and Spicy. A food is usually a blend of tastes, each in different concentrations.
- Sound is the acoustic effect produced when the food is subjected to a variety of mechanical forces.

A given stimuli might affect more than a single sense but the sensory reaction evoked will differ. For example the texture is a physical attribute and triggers several sensors; Chocolate mousse has the physical properties which may collectively be termed as ‘soft’ or ‘ smooth”. It appears visually as having a soft form, it is spongy to touch and the mouthfeel is creamy. Hence the property “Smooth” appears at three places in the Ontology tree in Figure 1. This depiction thus presents a combinatorial effect of stimuli as a formulaic approach to composing multisensory desired characteristics in food. Ideally a holistic approach must also consider nutrition. However, the compelling desire for taste has been exploited by the mass food industry to produce food with greater emphasis on lowering costs than on nutrition. [5] reported on the traits of taste, texture and aroma as being most influential for the decision panel when comparing the use of egg powder as a substitute for fresh eggs in baked goods. The motivation was to provide nutrition, lower costs, increase shelf life while catering to a poor population not having access to fresh ingredients. Organoleptic properties of doughnut prepared from egg powder were superior compared to fresh egg which had better sensory traits for coconut macaroon. Another study addressing the malnutrition of infants and young children in Indonesia analysed how the addition of *Taburia*, a micronutrient powder, to foods affects the acceptability based on organoleptic properties. [6]

4. Sensory Ontology

Sensory perception is a complex neurophysiological process which involves detection of the stimulus and subsequent recognition and characterization of it. Flavor perception arises from the central integration of peripherally distinct sensory inputs; taste, smell, texture, temperature, sight, and sound of foods. This neurophysiological integrative process is governed by factors like the physical, psychological, emotional condition of the individual and the environmental condition in which the individual is. Additionally, every perception is accompanied by a feeling of like or dislike which is a constant and continuous feedback loop that updates the individual factors mentioned previously thereby influencing future perception.

Level 1	Level 2	Level 3
Food Sound	Eating Sound	Crunch
		Slurp
		Crackle
	Cooking Method Sound	Pop
		Boil
		Sizzle
	Preparation Sound	Crush
		Blend
		Chop
Food Taste	Measure	Scale
		Intensity
	Category	Sweet
		Salty
		Bitter
Food Visual Appearance	Surface Appearance	Surface reflectance
	Volume	Shape
	Texture	Coarse
		Smooth
Food Tactile Sensation	Tactile property at all nerve endings	Coarse
		Smooth
	Pungency	Pepper-type
		Lacrimal
	Mouthfeel	Tannic
Aroma	Category	Burnt
		Caramel
		Grassy
	Measure	Concentration
		Odor Recognition Value
		Odor Recognition Threshold

Table 1: Schematic tabular representation of Organoleptic ontology.

The Sensory Ontology proposed here is an enhancement of the original presented at International Conference for Biological Ontology [4]. The first version covers perceived aroma, flavor, mouthfeel, tactile stimulus, auditory stimulus, visual stimulus, elasticity, viscosity, electromagnetic radiation, and spiciness, and breaks these down to the component parts. While these are the outcomes of the multimodal sensory process and can be grouped as such, the additional high level class added to the Ontology is to represent the affective factors; individual factors and environmental factors. The exact relationship of the factors in determining the perception is not in scope of this paper and neither is it fully discovered or known but it is an active area of contemporary research and investigation and some examples are provided later in this section. At a later stage, it would be interesting to create algorithms that combine these sensory stimuli, sensory factors and sensory responses. Further the inverse relationship is the objective of studies; the extent to which sensory reactions are able to provide give clues to the well-being of the individual or the environment the individual is in.

The study conducted by Small et. al, [8] compared the responses to two solutions delivered retronasally- a congruent and familiar Sweet Vanilla tasting solution and an incongruent and unfamiliar Salty Vanilla solution and regions of the brain responsible for flavor perception were observed. The perception of the congruent flavor revealed superadditive responses compared with the sum of its constituents whereas the similar analysis for the incongruent flavor compared negatively with the sum of its constituents. This experiment confirmed that delivery of an unfamiliar taste-odor combination may lead to suppressed neural responses. The paper also reported supportive findings that odors can enhance the perceived intensity of a taste but only if the odor is perceptually similar to the taste. Finally, odors can acquire "taste-like" properties after repeated pairings with a taste [i.e., strawberry odor is often described as sweet even though the odor does not activate taste receptors. Together these observations underscore the role of experience in forming the neural representation of flavor. Another study [6] seeking to find a strategy to reduce salt intake, reported the same finding through their experiments, and proposed as solution the addition of salty-congruent aroma to sodium reduced food. An example of the influence of environment on perception is easily noticed in the case of an airplane where food tastes different because the environment is more arid than most eating environments; the effect being that extremely cold cider will taste sweeter, yet aromatic compounds related to quintessential "apple" flavor will not be as easily released and not as noticeable to the consumer, as if the cider is warmer [4].

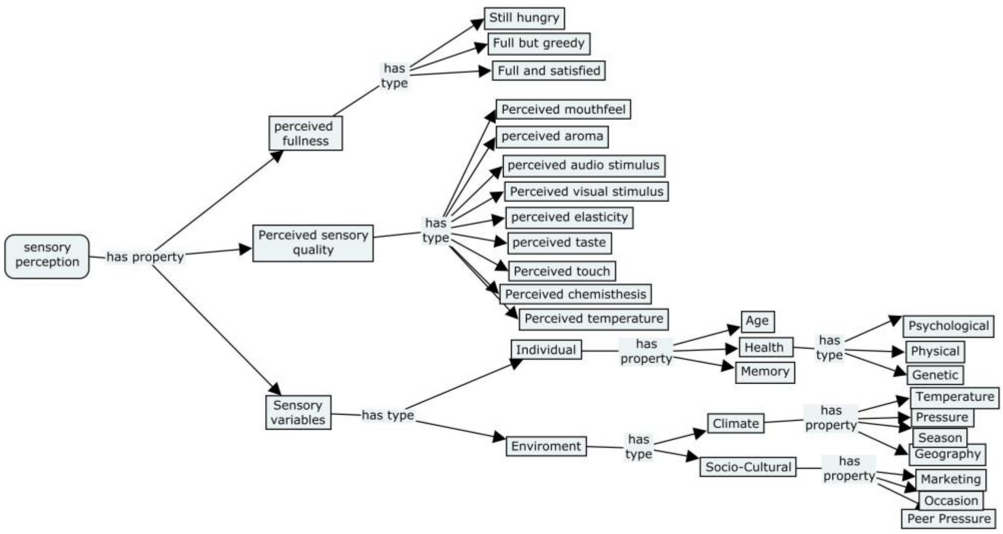

Figure 1: Schematic diagram of sensory ontology.

Chefs have particularly explored the Sensory Ontology creatively and purposefully for recipe development and skillfully manipulated the experience of the diner. The trend of "Molecular Gastronomy" has demonstrated the need to understand the phenomena and "real kitchen problems" that are empirically observed by chefs, from a deeper scientific point of view. [10]

5. Conclusion and Future Work

The knowledge on the flavour of food has been proprietary to businesses and has been therefore been exploited in the mass food processing industry for so long that consumers are habituated to enjoying created flavors over the natural flavor of more healthy foods and enjoying a greater diversity of foods. This has not only an impact on the health of individuals but also on the economy and sustainability of specialised agriculture. This project aims to create a multi-ontology framework connecting health and taste, capable of delineating objective measurable characteristics of food from the sensory experience. Specifically, the organoleptic ontology based on the molecular structural and functional properties of food, is an endpoint for recipe creation, while being mapped to existing ontologies that addressing health characteristics. The Ontologies presented here will be formalised with persistent URLs and will be published in greater detail in a subsequent paper.

References

[1] Farooqui AA, Farooqui T. Garlic and its Effects in Neurological Disorders. Neuroprotective Effects of Phytochemicals in Neurological Disorders. John Wiley & Sons, Inc.; 2017.

[2] Bagchi D, Swaroop A, Bagchi M. Genomics, Proteomics and Metabolomics in Nutraceuticals and Functional Foods. John Wiley & Sons; 2015.

[3] Griffiths EJ, Dooley DM, Buttigieg PL, Hoehndorf R, Brinkman FSL, Hsiao WWL. FoodON: A Global Farm-to-Fork Food Ontology - Semantic Scholar.

[4] Boulos MNK, Yassine A, Shirmohammadi S, Namahoot CS, Brückner M. Towards an "Internet of Food": Food Ontologies for the Internet of Things. Future Internet. Multidisciplinary Digital Publishing Institute; 2015.

[5] Chauhan VS, Sharma A. Studies on organoleptic properties of food products from fresh egg and egg powder through principal component analysis. Nahrung. 2003;47: 102–105.

[6] Sutrisna A, Vossenaar M, Izwardy D, Tumilowicz A. Sensory Evaluation of Foods with Added Micronutrient Powder (MNP) "Taburia" to Assess Acceptability among Children Aged 6–24 Months and Their Caregivers in Indonesia. Nutrients. Multidisciplinary Digital Publishing Institute; 2017;9: 979.

[7] Baer A, Lange M. Uc_Sense: An Ontology for Scientifically-based Unambiguous Characterization of Sensory Experiences.

[8] Small DM, Voss J, Mak YE, Simmons KB, Parrish T, Gitelman D. Experience-dependent neural integration of taste and smell in the human brain. J Neurophysiol. 2004;92: 1892–1903.

[9] Seo H-S, Iannilli E, Hummel C, Okazaki Y, Buschhüter D, Gerber J, et al. A salty-congruent odor enhances saltiness: functional magnetic resonance imaging study. Hum Brain Mapp. 2013;34: 62–76.

[10] Caporaso N, Formisano D. Developments, applications, and trends of molecular gastronomy among food scientists and innovative chefs. Food Rev Int. Taylor & Francis; 2016;32: 417–435.

[11] http://data.lirmm.fr/ontologies/food