# Uc_Sense: An Ontology for Scientifically-based Unambiguous Characterization of Sensory Experiences

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***Abstract*— Recent efforts in biological ontology go to great lengths to unambiguously categorize biological entities and phenomena of the natural world, as well as their relationships with each other. This paper illustrates the importance of unambiguously characterizing the perception of entities relative to biological apparati required for specific modes of sensing, physiological conduction of sensed experiences, along with subjective interpretation and communication of sensed experiences. In addition to building a computable knowledge base around existing sensory science, ontological modelling of this aspect of biology will enable an increased understanding about alternate perceptions of identical stimuli. Leveraging this understanding to modulate desired behavior toward increased health and happiness outcomes is a fundamental goal of this project.**

**Introduction**

*"A whiff of lilacs presents a particular sweet odour. The warmth of the rising sun yields certain tactile sensations. Bees' honey has a specific taste. The qualities that characterize the smell of the lilacs, sensation of the sun, or taste of the honey are all what I will call sensory qualities" (2).* When Austin Clark wrote those words in his book on sensory perception little was known about the topic of sensory perception. uc_Sense is an ontology for unambiguous characterization (UC) of sensory experiences and their descriptive terms. Until now, there has been no standardized vocabulary for describing sensory experiences or events. As a result, there are difficulties in sharing sensory data between scientists, ascribing quality attributes to consumer research, and for consumers to share sensory experiences with one another. These difficulties arise due to the differences in sensory perception between individuals, for example, inflammation of the trigeminal nerve leads to the sensory experience of spiciness. Responses elicit different levels of reaction between individuals with preferences for spicy food and those who do not enjoy spicy foods. Construction of the ontology provides an organization for terms that commonly describe tastes, smells, sounds, textures, etc.

The uc_Sense ontology provides terms gathered from food and beverage flavor wheels in order to provide a vocabulary that will distinguish how a sensory event is perceived and how the same event is processed by an individual. Stimuli are also perceived by more than one biological mechanism, the same way that receptors in nasal passages react to aromatic compounds which then influence the taste, or flavor, of the substance being consumed. Classes like aromas and flavors appear similar but react with one another to elicit unique responses, this is also true for the perceived texture of the food. As demonstrated in the uc_Eating ontology, the sensory response to a substance changes as mastication and enzymatic action breaks down the substance. Similarly, biological processing of food (amylose activity in saliva) and industrial processing affects the sensory events involved in consumption of a product. Individual differences in physiology, mood, or bias also have an influence on how similar stimuli are interpreted. This same concept applies to food processing as well. The uc_Processing ontology unambiguously characterizes alternate methods for processing and packaging foods, for example, humidification, drying, and pH modification have different effects on the product. These methods alter the organoleptic properties of the food. Environmental and temperature effects also alter organoleptic properties of foods, and concomitant sensory experiences. Examples of these phenomena include the fact that food tastes different on an airplane partially because the environment is more arid than most eating environments; likewise, extremely cold cider will taste sweeter, yet aromatic compounds related to quintessential "apple" flavor will not be as easily released, nor as noticeable to the consumer, as if the cider is warmer.

## I. Design and Methods

First, data on a variety of sensory experiences and stimuli were gathered from various food and beverage flavor wheels that account for more than just flavor (i.e. aroma, mouthfeel, etc.), these wheels contained the names used to design classes of perceived stimuli that an individual experiences. The perceived stimuli are logically grouped via subclassing. uc_Sense leverages conceptual entities from several other ontologies in related domains. The Uberon ontology provides a foundation for the anatomical structures important in food, beverage and aroma sensory experiences. The GO Biological Process ontology provides foundational structures for unambiguously characterizing the biological processes used by these structures. Protege, with the streamlined interface and the program's ability to add changes and import existing ontology files improves the flow of

classification and improves the reproducibility of uc_Sense. These classes are not limited to the traditional five human senses because there are some sensations that do not fall into a single category as it may be a product of multiple types of sensation simultaneously.

The ontology covers perceived aroma, flavor, mouthfeel, tactile stimulus, audio stimulus, visual stimulus, elasticity, viscosity, electromagnetic radiation, and spiciness, and breaks these down to the component parts. uc_Sense reveals relations between compounds and sensory events, for example, elasticity is generally a trait shared between gums, while hardness relates to crystalline molecular structures of food. The ontology also reveals the effects of freezing on food, the composition is altered as the water forms crystals, this leads to a different stimuli, eliciting alternate sensory experiences. Changes brought on by processing or changes to the cell structure play an integral role in the perception of stimuli, making it essential to the ways in which these can affect sensory perception processes and alter sensory experiences. This format enables sensory stimuli modeling since the perceived stimuli can be described with general terms or identified specifically as a subset of other perceived stimuli that may or may not be related. This method of ontology modeling is analogous to the modeling of a gene product as part of a biological process like a protein involved in a metabolic pathway, a location in the cell (ie in the nucleus, in the cytoplasm, in the mitochondria), or a function as a regulatory protein. To better account for the dynamic nature of our understanding of sensory perception, uc_Sense is a dynamic, living ontology capable of being changed and updated as new information is discovered regarding sensory processing.

http://www.semanticweb.org/mateolan/ontologies/2016/3/untitled-ontology-5

## II. Results

uc_Sense applies to how humans perceive stimuli, while some of the categories included could apply to other organisms, the focus of the ontology remains consistent with ways to characterize how people perceive stimuli. uc_Sense provides a novel way to classify perceived stimuli and to tie together the various biological pathways that lead to organoleptic interpretation, for example, the ontology reveals how effervescence can relate to stimulation of olfactory receptors as well as visual stimulus of bubbles on the surface of a beverage. The unambiguous terms obtained from uc_Sense allows for more streamlined research into the field of sensory perception and processing which, in turn allows for rapid advancement in designing products based on perception of a sensory product. From uc_Sense, conclusions about relatedness of foods and beverages can be drawn and used to develop products that appeal to particular consumers. Focusing on a particular organoleptic trait that appeals to certain customers gives companies an advantage when marketing products. It is conceivable that uc_Sense will be used to determine products and product features most appropriate for consumers' personal biases against and proclivities toward particular sensory experiences. At an aggregate level, this holds potential to improve product formulation and marketing strategies for businesses in addition to helping individuals understand their own preferences regarding food and beverage preparation and consumption choices. This would lead to both more successful targeted advertisement, as well as reduction of wasted food wasted from food not consumed because of undesirable sensory experiences, as well as making it easier for consumers to know what products they prefer to buy. These decisions could relate to the types of foods purchased, appearance of foods, or the cost of the food, in any case the individual will make the decision based off of sensory perception. This would allow for more success when marketing and selling a product that reflects the sensory desires of the consumer as opposed to the current strategy of gathering information about the demographic.

uc_Sense is also a novel construct in the field of biological ontology research because it is the only ontology that attempts to categorize sensory perception of a stimulus into a hierarchical ontology with links between sensory experiences. While data on the anatomical structures involved in organoleptic pathways are described in other ontologies (GO) no standardized vocabulary for describing sensory perception exists. The connections drawn from the creation and analysis of the ontology reveal that it is possible to classify sensory stimuli into categories and relate them to each other using the traditional human senses even though the five classical senses do not fully encompass all of the ways stimuli can be interpreted.

Moving forward, we envision connections between artificial intelligence and an explanation of differential response to sensory stimuli. More detailed modelling of the differences in physiological sensory processing in combination with quantifiable external stimuli giving rise to differential sensory perceptions between individuals will be a key enabler of this functionality. This would then allow for the construction of a database that can process stimuli based on the differences in sensory processing that results from unique decision making patterns similar to sensory processing and interpretation.

## References

For this paper the reference section has been broken into two categories, first is the traditional references section for scientific papers, journals, and books used as primary sources for this research paper, the second category is for the food and beverage flavor wheels that were used to format the ontology and fill the categories of sensory stimuli. The flavor wheels were cited using the URL where the wheel was found during the course of research for this paper.

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