Multisensory Processing in Flavour Perception

A satellite symposium of the *9th International Multisensory Research Forum*
Hamburg, Germany

July 15th, 2008 3.00 – 6.00 pm

Sponsored by: Unilever DIAGEO

PROGRAM

3.00 – 3.10 *Introduction*

John Prescott (Chair)
School of Psychology, University of Newcastle, Australia

3.10 – 3.40 *How Cognition and Attention Modulate Affective Responses to Taste and Flavour: Top-down Influences on the Orbitofrontal and Pregenual Cingulate Cortices*

Fabian Grabenhorst & Edmund T Rolls
Dept. of Experimental Psychology, The University of Oxford, UK

3.40 – 4.10 *Olfactory-taste interactions and the role of familiarity and exposure strategy*

David Labbe & Nathalie Martin
Nestle Research Centre, Switzerland

4.10 – 4.40 *Neural encoding of the taste of odor*

Marga Veldhuizen & Dana M Small
Yale University Medical School & The John B Pierce Laboratory, USA

4.40 – 5.10 *Cross-modal capture within flavour*

Garmt Dijksterhuis & Andy Woods □
Unilever Food & Health Research Institute, Vlaardingen, The Netherlands

5.10 – 5.40 *Assessing the contribution of vision (colour) to multisensory flavour perception: Top-down vs. bottom-up influences*

Charles Spence, Maya U Shankar, Carmel A Levitan & Massimiliano Zampini
Dept. of Experimental Psychology, The University of Oxford, UK

5.40 – 6.00 *General Discussion & Closing Remarks*

How Cognition and Attention Modulate Affective Responses to Taste and Flavour: Top-down Influences on the Orbitofrontal and Pregenual Cingulate Cortices

Fabian Grabenhorst & Edmund T Rolls
Department of Experimental Psychology, University of Oxford, UK

How cognition and attention influence the affective brain representations of taste, flavour, and smell is important not only for understanding top-down influences on multisensory representations in the brain, but also for understanding how taste and flavour can be influenced by these top-down signals. We found using functional magnetic resonance imaging that activations related to the affective value of umami taste and flavor (as shown by correlations with pleasantness ratings) in the orbitofrontal cortex were modulated by word-level descriptors, such as “rich delicious flavour”. Affect-related activations to taste were modulated in a region that receives from the orbitofrontal cortex, the pregenual cingulate cortex, and to taste and flavor in another region that receives from the orbitofrontal cortex, the ventral striatum. Affect-related cognitive modulations were not found in the insular taste cortex, where the intensity but not the pleasantness of the taste was represented. Moreover, in a different investigation, paying attention to affective value (pleasantness) increased activations to taste in the orbitofrontal and pregenual cingulate cortex, and to intensity in the insular taste cortex. We conclude that top-down language-level cognitive effects reach far down into the earliest cortical areas that represent the appetitive value of taste and flavor. This is an important way in which cognition influences the neural mechanisms of taste, flavour, and smell, that control appetite.

Olfactory-taste interactions and the role of familiarity and exposure strategy

David Labbe & Nathalie Martin
Nestle Research Centre, Laussane, Switzerland

The role of familiarity and exposure strategy on sensory interactions between olfaction and taste has already been demonstrated in model solutions. The aim of our approach was to investigate the role of these two factors in real food products. First we investigated the impact of olfactory perception on taste in three bitter drinks varying in familiarity with, from the most to the least familiar, a black coffee, a cocoa drink and a caffeinated milk. A vanilla flavouring was added in the three beverages and each flavoured drinks as well as the related unflavoured drinks were characterized by sensory profiling. The vanilla olfactory stimulation led to an increase in sweetness and a decrease in bitterness for both coffee and cocoa drinks. But the effect was more powerful for the most familiar coffee drink. On the contrary when added in the least familiar caffeinated milk, vanilla flavouring did not influence sweetness, but unexpectedly enhanced bitterness. These results suggest the importance of the product familiarity on the expression of sensory interaction. Second, the impact of exposure strategy on coffee odour perception was explored comparing odour characterization of eight coffee drinks done by ten trained subjects according to QDA® and by forty coffee consumers using a sorting task (product grouping according to their similarities with a free description of each group). Results showed that consumers grouped the coffees consensually but differently from the trained panel. This gap may be explained by differences between consumers and sensory panel in terms of evaluation strategy, which may influence coffee perception and related description. Indeed consumers had a holistic approach considering product sensory properties as a whole which may promote the impact of previous food experience on perception, such as odour and taste association constructed during every day coffee exposure. On the contrary, trained panelists evaluated products with an analytical approach since they described individually and independently each attribute. This approach may reduce therefore the impact of food experience on perception and consequently the role of interaction between sensory modalities. To conclude, findings of our

study suggested that the impact of perceptual interactions between olfaction and taste was related to food familiarity and modulated by the applied exposure strategy.

Neural encoding of the taste of odor

Maria G. Veldhuizen & Dana M. Small
The John B. Pierce Laboratory and Yale University School of Medicine, New Haven, USA

Odors are often described as having taste-like qualities, and experiencing an odor in solution with a taste has been repeatedly demonstrated to enhance the intensity ratings of that taste-like quality in the odor [1, 2]. We have performed a series of fMRI studies investigating the possibility that neural processes in the insula encode the taste-like properties of odors. We chose to focus on the insula because neuroimaging studies consistently show that the insular cortex is activated by the perception of taste and the perception of smell [3, 4], and because damage to the insula leads to changes in both taste and smell perception [5, 6]. Collectively, the series of studies we have performed show that: 1) the anterior ventral insula, which receives projections from primary taste and primary olfactory cortex, responds supra-additively to taste-odor mixtures [7], suggesting that this region is important for flavor learning; 2) that several regions of insula and operculum respond more to food compared to equally pleasant and intense non-food odors; and 3) that attention to odors activates the piriform cortex and the ventral insula, and that the magnitude of the response in the ventral insula, but not the piriform cortex, correlates with the sweetness ratings of odors. Taken together, these findings suggest that the insula encodes the taste of odors.

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3. Verhagen, J.V. and L. Engelen, Neurosci. Biobehav. Rev., 2006. 30(5), 613-50.
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Cross-modal capture within flavour

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Unilever Food & Health Research Institute, Vlaardingen, The Netherlands

Food flavour often takes time to develop, varies over mouthfuls and indeed over inhalation and exhalation. Despite this, we rarely acknowledge or even perceive such variation. Somehow, a contiguous food flavour is experienced despite obvious variation in sensory signals. Related processes act in a similar fashion in other modalities (perceptual constancy, *e.g.* in vision) and across modalities (the unity assumption). It was hypothesised that a food which is *assumed* to be consistently flavoured will be tasted to be so, despite some variation in actual flavour. A cookie model-food-stimulus was developed, whose two halves sometimes differed in levels of sugar but were visually indistinguishable (to ensure the assumption of a contiguous cookie). Sweetness ratings for the different cookie halves were indistinguishable for early trials; for later trials the low sugar cookie halves were rated differently in terms of sweetness from each other. The high sugar cookie-halves were always rated differently in terms of sweetness. Our findings provide support for the existence for a contiguity effect which can mask some flavour variation, but whose effects seem to be modulated by increasing exposure to discrepant stimuli.

Assessing the contribution of vision (colour) to multisensory flavour perception: Top-down vs. bottom-up influences

Charles Spence, Maya U Shankar, Carmel A Levitan, & Massimiliano Zampini,
Department of Experimental Psychology, University of Oxford. U.K.

Although researchers have known for more than 80 years that colour has the capacity to influence people's flavour perception (see 1 for early work in this area), surprisingly little is known about the specific conditions under which such crossmodal effects occur. Often, it seems as though researchers have assumed that they are always driven in a relatively 'bottom-up' manner. However, it is important to note that the crossmodal effect of colour on multisensory flavour perception has frequently been found to operate in a relatively top-down manner as well (as, for example, when specific food colours come to signify a brand or provide a semantic cue as to the identity of the food or beverage concerned - as when the red colouring of a drink reminds one participant of strawberries and another of watermelon). We review the experimental literature demonstrating top-down influences of vision (specifically colour) on multisensory flavour perception. We will also highlight the latest research from our own laboratory that has attempted to quantify the effect of colour on people's perception of both drinks and branded chocolate products (2). Finally, we show how findings from the laboratory relating to the colouring, labelling, and branding of foods are currently being used in commercial settings.

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