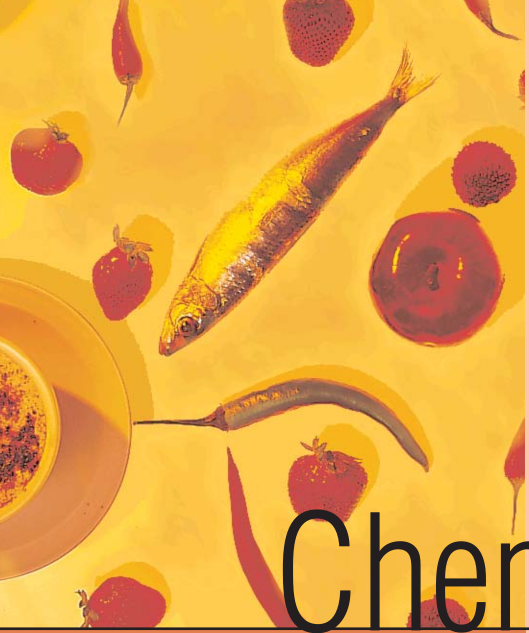


Vol. 9 No.3 June 2007

Chemo sense

EDITORIAL

Olfactory Breakthroughs and Breakdowns

By Graham Bell
g.bell@atp.com.au

Progress in understanding any process of the central nervous system tends to be slow and difficult. However, Don Wilson's review of research on the role of the piriform cortex in chemosensory functions shows we are close to a breakthrough in knowledge and understanding.

In their recent review on aging and flavour perception, Bell and Strauss fell into an old time trap: the field has moved on. A rejoinder, by Sari Mustonen and Hely Tuorila, cites several new papers from the European HealthSense project, and some currently in press. They argue that flavour enhancement of food is not a solution to

cont. pg 2

What's new in the Olfactory Cortex?

Donald A. Wilson

Neurobehavioral Institute
Department of Zoology
University of Oklahoma, USA
dwilson@ou.edu

Contrary to the thrilling world of continual new discoveries and advancement that characterizes science in the mass media, research may more accurately be described using Stephen Jay Gould's evolutionary terminology of "punctuated equilibrium". Advances can be very slow within a particular field for years, hindered by conservative thought and technical limitations ("equilibrium"), until a conceptual or technical breakthrough allows sudden ("punctuated") change. Our understanding of the role of the olfactory cortex in odor perception may be approaching just such a punctuation point. As our knowledge of olfactory receptor mechanisms has improved, attention is shifting toward that appendage attached to the back of the nose called the brain.

As shown in Figure 1, in 1991, the year that Buck and Axel's seminal and ultimately Nobel Prize winning work on the olfactory receptor gene family was published (Buck & Axel, 1991), no paper was published that matched the PubMed search for ["piriform cortex" odor]. Research on piriform cortex as a model system for understanding synaptic physiology and plasticity was rich at that time (Neville & Haberly, 2004), but there was an extreme dearth of work on piriform cortex as a primary sensory structure. Ten years later, the count was up to 11/year. In

cont. pg 2

INSIDE:

E-Nose Pty Ltd
Graham Bell and Associates Pty Ltd
Centre for ChemoSensory Research
www.chemosensory.com
ISSN 1442-9098

EDITORIAL CONTINUED

Olfactory Breakthroughs and Breakdowns

continued

chemosensory deficits in aging.

This issue carries a mini-review by psychologist Jenni Ibrahim, on the role perfume has played in Islamic culture and its contribution to modern perfumery.

This year, July in Australia will be scientifically "hot" and the chemical senses will be "bubbling". Meetings include AIFST (food) in Adelaide; the International Brain Research Organisation (IBRO) in Melbourne; avian brain (including olfaction) on Heron Island; chemical senses (AACSS) in the lovely Barossa Valley, followed by AWRI's national wine technical meeting in Adelaide. If you wish to attend any of these, see our list for dates and contact details, and act now ■

Heron Island

What's new in the Olfactory Cortex?

continued

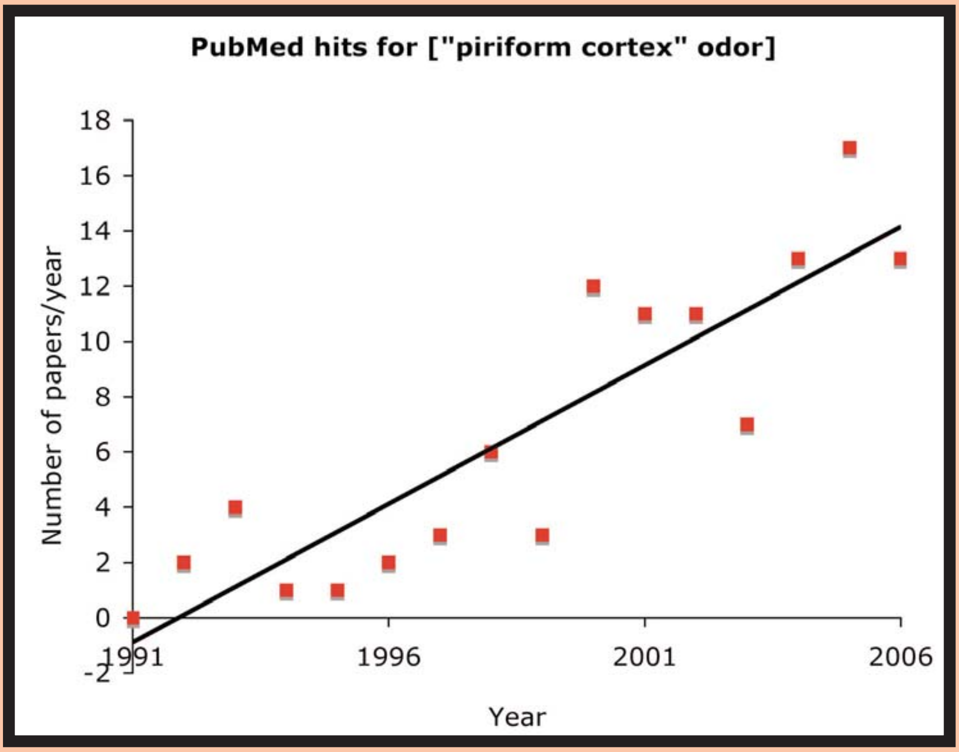


Figure 1. Rise in publications directly exploring the sensory physiology of the piriform cortex over the last 15 years. The long history of work on circuit anatomy and synaptic physiology of the piriform cortex has laid a very strong ground work for this new work on the role of piriform cortex in olfactory sensation and perception.

the last couple of years, however, 15 years after Buck and Axel, the number of papers published per year examining the piriform cortex as sensory cortex is approaching 20. In addition, Richard Stevenson and I published a book in 2006 that expands on previous work (Haberly, 2001), to place the olfactory cortex and cortical plasticity in the center of a perceptual object oriented olfactory system (Wilson & Stevenson, 2006). This review will be a short summary of only some of the highlights from 2006-2007's bounty of piriform cortical work addressing "how does the piriform cortex contribute to odor perception?" Apologies to authors of those other exciting papers not included here.

In most terrestrial vertebrates, including reptiles, birds and mammals, the piriform (or primary olfactory) cortex is a three layered structure (paleocortex instead of neocortex) that receives direct input from the olfactory bulb. In reptiles, birds and mammals such as rodents, the piriform cortex lies along the ventral-lateral edge of the brain, while in higher mammals with larger neocortex, it has been pushed more medially, along the medial edge of the anterior temporal lobe. The organization and location of the piriform cortex are mentioned here, because they may provide clues as to the role the piriform plays in odor perception. For example, the piriform cortex not only receives input from the olfactory bulb, but is intimately and reciprocally interconnected with the similarly evolutionarily old limbic system. Thus, when we explore the role of piriform cortex in olfactory perception, it must be kept in mind that the piriform listens and talks to circuits involved in memory, emotion and homeostasis.

At its most basic, odor perception involves detection and discrimination of odorant molecules. Of course odor perception in its full glory is a much richer experience, involving synthetic or configural experience of complex mixtures, recognition of odors despite smelling them in the presence of background odors, categorization of

cont. pg 3

What's new in the Olfactory Cortex?

continued

individual odors into quality groupings such as food odors or floral odors, visceral/emotional responses that may be learned or innate, and modulation of perception based on context, familiarity, expectation and internal state. The piriform cortex, as a central interface between primary olfactory input, higher cortical structures (such as orbitofrontal cortex) and the limbic system, may play a role in all of these "higher-order" olfactory processes. Work published over the last year, in fact, has begun to provide evidence for this.

Odor discrimination

Given that the piriform cortex is the largest component of the olfactory cortex, and has traditionally been seen as primary sensory cortex for olfaction, it seems logical to assume it may be involved in basic odor discrimination. Several studies published in the past year support this view, and strongly support previous notions that the piriform can be functionally divided into at least two components. Odor discrimination, much like discrimination in other sensory systems, can occur at several different conceptual levels. For example, a subject may not only discriminate isoamyl acetate and nonane on the basis of perceptual characteristics (e.g., banana odor vs. gasoline), but also in terms of qualities such as fruity vs. oily, or even edible vs. not edible. New work in both humans and rodents suggest that the anterior piriform cortex may be particularly involved in identification of the molecular characteristics or identity of an odor stimulus (e.g., isoamyl acetate/banana), while the posterior piriform cortex may be more involved in higher order encoding of odor quality or categorical similarity (e.g., fruity).

Gottfried and colleagues (Gottfried, Winston, & Dolan, 2006) used a cross-adaptation paradigm and fMRI to assess difference in encoding of odorant structure and odor quality in human piriform cortex. Cross-adaptation of piriform cortical response was compared between odorants that were either structurally similar or shared odor

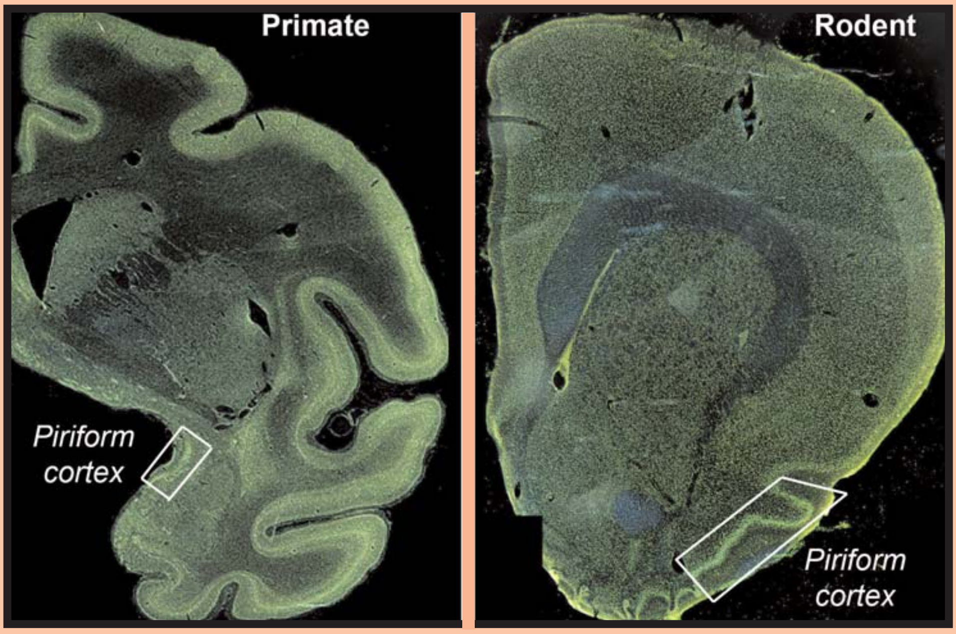


Fig. 2 Images of nissl stained coronal sections through primate and rodent forebrain showing relative size and locations of the piriform cortex. In both mammals, the piriform cortex is a three layered structure. The expansion of the neocortex in primates has moved the piriform cortex to the medial side of the temporal lobe. In both images, medial is to the left.

perceptual quality. The authors found significant cross-adaptation of molecularly similar odorants in the anterior piriform cortex, but relatively little cross-adaptation between structurally different odorants that had different odor qualities. The reverse was true in the posterior piriform cortex. In the posterior piriform cortex, odors that shared similar qualities showed stronger cross-adaptation. The authors suggest that these data support a functional separation of structural identity and perceptual quality along the anterior to posterior axis of the human piriform cortex.

A similar conclusion comes from work in our lab with rats trained to discriminate odorant mixtures from their components (Kadohisa & Wilson, 2006b). Recordings from single-units in the anterior and posterior piriform cortex were then made in the trained rats and compared to odor naïve animals. The results showed that in anterior piriform cortex, odor training induced a narrowing of the "odor receptive field" of individual neurons, with single cells becoming more selective in their responses to the trained odors. In addition, we combined the activity of single-units recorded from the anterior piriform cortex into a virtual ensemble, which is perhaps be more indicative of the type of information downstream sites would receive. In naïve animals, this ensemble responded to each individual odorant distinctively, and, as might be expected, treated the mixture as fairly similar to its components (e.g., responses to isoamyl acetate were similar to a mixture containing isoamyl acetate). However, in trained animals, the ensemble response to the mixture became as distinct from its components as the responses to the individual components. We interpreted these results as similar to those of Gottfried et al., in humans, where the anterior piriform cortex encodes odor about the specific identity of the stimulus. The specificity is enhanced when responding to familiar odors or odor mixtures.

In the posterior piriform, in contrast, odor experience was associated with a broadening of single-unit receptive fields, and ensemble coding of odors and their mixtures became more similar. We interpret these results as consistent with odor quality coding in posterior piriform,

cont. pg 4

What's new in the Olfactory Cortex?
continued

where similarities between familiar odors are encoded. Thus, since both a fruity odorant and a mixture containing that odorant may have fruity qualities, posterior piriform neurons respond to both similarly. Again, this encoding mode is most pronounced with familiar odors.

Interestingly, not only was posterior piriform encoding of mixtures and their components more similar after experience, but also the encoding of the components themselves became more similar. Thus, odorants experienced together within a mixture subsequently evoked more similar responses to each other when presented alone, than the individual odorants did if they had never been experienced together. These cortical changes could contribute to the changes in quality perception of odors that have been paired in a mixture (Stevenson, 2001). For example, when a cherry and smoky odor are experienced as a mixture, the smoky odor comes to evoke a more cherry-like perceptual quality when later presented alone.

Odor familiarity and hedonics

The ability to discriminate between similar odors improves with familiarity. This olfactory perceptual learning appears to be due to changes in several places along the olfactory pathway, including the olfactory bulb and piriform cortex. For example, previous work from a number of labs has suggested that neurons within the piriform cortex respond differently to familiar odors compared to novel odors (Wilson, 2003; Wilson & Stevenson, 2006). Similarly, there is a differential activation of the human piriform cortex by familiar odors compared to novel odors. Experience-induced changes within the piriform cortex thus may contribute to both improved sensory processing and a form of episodic memory encoding that a stimulus has been experienced before. If this differential response to previously experienced odors is involved in the encoding of familiarity, then impairments in familiarity judgment may coincide with a disruption of piriform cortical function. Similarly, several lines of evidence suggest that odor-evoked activity in the piriform cortex may be influenced by the hedonic response to the odor. Given the strong reciprocal interaction between the amygdala and the piriform, this emotional contribution to odor encoding makes sense. Each of these issues was examined over the past year.

Li et al., (Li, Luxenberg, Parrish, & Gottfried, 2006) used a cross-adaptation paradigm combined with fMRI in humans to examine the involvement of the piriform and orbitofrontal cortex in olfactory perceptual learning. While in the MRI machine, subjects were tested with a set of odorants, then adapted to one target odor for 3.5 min, and then tested with either structurally or perceptually similar odorants. As reported in both animals and humans previously, discriminability of the target odorant from either structurally or perceptually similar odorants improved following the 3.5 min exposure. Odor-evoked activity within piriform and orbitofrontal cortex was then compared between structurally or perceptually similar odorants, or unrelated odorants before and after the prolonged exposure. The results suggest that responses in piriform cortex to perceptually similar odorants became more distinct after exposure to one of them. No change in difference between control odorants or odorants related in chemical structure were seen in piriform cortex. However, in orbitofrontal cortex, odorant exposure improved distinctiveness of activity levels for both quality and structurally related odorants. Furthermore, within subject analyses showed that experience-dependent improvement in perceptual discrimination correlated with orbitofrontal cortex activity changes. The selective role of piriform cortex in discrimination of odor quality rather than odor structural identity in this study seems in contrast to this group's other work (Gottfried et al., 2006), nonetheless, these findings, along with other work in humans and animals (for review see: (Wilson & Stevenson, 2006)), show the important role of familiarity-induced cortical plasticity in olfactory perception.

Changes within the piriform may not only be important for perceptual learning, but also judgments of whether an odor has been smelled before or not. Plailly et al., (Plailly, d'Amato, Saoud, & Royet, 2006) used PET imaging to examine activity in olfactory cortical areas while human subjects performed an odor detection task, judged odor familiarity and judged odor pleasantness/unpleasantness. Half of their subjects were diagnosed schizophrenics. It has been previously demonstrated, and confirmed in this study, that schizophrenics have normal odor detection thresholds, but are impaired in judging odor familiarity and pleasantness. On the latter task, schizophrenics are more likely to judge pleasant odors as unpleasant. Plailly et al.'s PET data suggest that, as part of a constellation of cortical changes, the impaired odor familiarity and hedonic judgments in schizophrenics are associated with decreased activity within the left piriform cortex compared to healthy controls performing the same tasks. Thus, these results show a role of piriform cortex in encoding of both prior experience and emotional valence of odors.

In rats, work from Geoff Schoenbaum's lab further emphasizes the role of piriform cortex in building odor perceptions that include emotional/associative content (Calu, Roesch, Stalnaker, & Schoenbaum, 2007). Single-units were recorded in rat posterior piriform cortex during odor discrimination training in a Go, No-Go task. The authors found that responses to odor cues was heavily dependent on their association (rewarded or not), with a significant proportion changing their odor-evoked response during reversal training (odor previously signaling reward now not rewarded). The posterior piriform cortex is rich in intracortical association fibers and also receives a strong input from the basolateral nucleus of the amygdala, which together may allow this highly associative processing of odors. In contrast, the anterior piriform cortex is more strongly influenced by afferents from the olfactory bulb, and displays reduced propensity for associative conditioning

cont. pg 5

What's new in the Olfactory Cortex? continued

related change (Roesch, Stalnaker, & Schoenbaum, 2007).

Multimodal interactions

Not only do cortical representations of odors reflect odor quality and hedonic associations as described above, but piriform cortical activity is also influenced expectations and multimodal inputs. For example, work from several labs has demonstrated that activity within the piriform and orbitofrontal cortex may change as a result of non-olfactory stimulation associated with odors or odorant sampling, and/or changes in arousal or behavioral state. In humans, Gonzalez and colleagues (Gonzalez et al., 2006) imaged (fMRI) olfactory cortex while subjects read words associated with odors, such as "garlic", or non-olfactory related words such as "needle" or "rhyme". They found that reading odor-related words evoked bilateral activation of piriform cortex, but not orbitofrontal cortex compared to the non-odor related words. They argue that these results are consistent with findings in other sensory and motor systems wherein the central encoding of the representation of language semantics is distributed and may include the primary sensory areas related to the meaning of the words.

Odor background

Together, the studies summarized above argue that olfactory cortex is an integrative center, creating synthetic representations of odor mixtures which are strongly influenced by past experience, hedonic associations, expectations and other multimodal inputs. However, the olfactory system also faces a task that involves not synthesis, but rather separation of odors from background. On any given inhalation, odorant molecules of a target (e.g., cup of coffee at the cafe) are mixed together with odorant molecules of many other things (e.g., baked goods on the counter, neighboring customers, etc.), yet the coffee, as an object, is perceived as distinct from that background. With all the molecules from different sources present within the nose, how does the olfactory system make this separation? The piriform cortex appears to contribute by very rapidly adapting to stable background odors (Kadohisa & Wilson, 2006a). The very high degree of odorant specificity of adaptation in the anterior piriform cortex allows responses to subsequent stimuli, present against this background, to be encoded as distinct and essentially the same as if the odor was present alone. The olfactory bulb does not appear to capable of making this same separation and treats the odor and background as a mixture (Kadohisa & Wilson, 2006a), although active sniffing in rodents may facilitate more peripheral separation from odors and background (Verhagen, Wesson, Netoff, White, & Wachowiak, 2007).

Summary

New research into olfactory cortical function is beginning to bridge the gap between receptor transduction/odorant ligand recognition processes and odor perception. What is emerging is a rich, integrative process, heavily dependent on experience and cortical plasticity. Odor perception relies on an experience-dependent process, wherein percepts of odorant stimuli are built from inhaled odorant molecules, emotional reactions and memory into single, multi-dimensional odor objects. The next few years should prove to be even more exciting ■

REFERENCES

Buck, L., & Axel, R. (1991). A novel multigene family may encode odorant receptors: a molecular basis for odor recognition. *Cell*, *65*(1), 175-187.

Calu, D. J., Roesch, M. R., Stalnaker, T. A., & Schoenbaum, G. (2007). Associative Encoding in Posterior Piriform Cortex during Odor Discrimination and Reversal Learning. *Cereb Cortex, 17*(6), 1342-1349.

Gonzalez, J., Barros-Loscertales, A., Pulvermuller, F., Meseguer, V., Sanjuan, A., Belloch, V., et al. (2006). Reading cinnamon activates olfactory brain regions. *Neuroimage, 32*(2), 906-912.

Gottfried, J. A., Winston, J. S., & Dolan, R. J. (2006). Dissociable codes of odor quality and odorant structure in human piriform cortex. *Neuron, 49*(3), 467-479.

Haberly, L. B. (2001). Parallel-distributed processing in olfactory cortex: new insights from morphological and physiological analysis of neuronal circuitry. *Chem Senses, 26*(5), 551-576.

Kadohisa, M., & Wilson, D. A. (2006a). Olfactory cortical adaptation facilitates detection of odors against background. *J Neurophysiol, 95*(3), 1888-1896.

Kadohisa, M., & Wilson, D. A. (2006b). Separate encoding of identity and similarity of complex familiar odors in piriform cortex. *Proc Natl Acad Sci U S A, 103*(41), 15206-15211.

Li, W., Luxenberg, E., Parrish, T., & Gottfried, J. A. (2006). Learning to smell the roses: experience-dependent neural plasticity in human piriform and orbitofrontal cortices. *Neuron, 52*(6), 1097-1108.

Neville, K. R., & Haberly, L. (2004). Olfactory cortex. In G. M. Shepherd (Ed.), *The synaptic organization of the brain* (5th ed., pp. 415-454). New York: Oxford University Press.

Plailly, J., d'Amato, T., Saoud, M., & Royet, J. P. (2006). Left temporo-limbic and orbital dysfunction in schizophrenia during odor familiarity and hedonicity judgments. *Neuroimage, 29*(1), 302-313.

Roesch, M. R., Stalnaker, T. A., & Schoenbaum, G. (2007). Associative encoding in anterior piriform cortex versus orbitofrontal cortex during odor discrimination and reversal learning. *Cereb Cortex, 17*(3), 643-652.

Stevenson, R. J. (2001). Perceptual learning with odors: implications for psychological accounts of odor quality perception. *Psychon Bull Rev, 8*(4), 708-712.

Verhagen, J. V., Wesson, D. W., Netoff, T. I., White, J. A., & Wachowiak, M. (2007). Sniffing controls an adaptive filter of sensory input to the olfactory bulb. *Nat Neurosci, 10*(5), 631-639.

Wilson, D. A. (2003). Rapid, experience-induced enhancement in odorant discrimination by anterior piriform cortex neurons. *J Neurophysiol, 90*(1), 65-72.

Wilson, D. A., & Stevenson, R. J. (2006). *Learning to smell : olfactory perception from neurobiology to behavior.* Baltimore: Johns Hopkins University Press.


Measure smell continuously and in real time with technology and services from E-Nose Pty Ltd.
Contact Graham Bell: (02) 9209 4083
g.bell@atp.com.au Web: www.chemosensory.com

Vol. 9 No.3 June 2007

Rejoinder: The Unfulfilled Promise of Flavor Enhancement

Sari Mustonen and Hely Tuorila

Dept Food Technology
University of Helsinki
Finland FI-00014

sari.mustonen@helsinki.fi

We read with great interest the review *"Dynamics of food flavour perception in the over 60s: New implications for food design and diet for older people"* by Bell and Strauss (Chemosense, April 2007). While the review brings up a wealth of good information and discusses highly relevant implications for food industry, a slight gap appears to exist related to recently published research on chemosensory performance and the implications for food product design. In particular, the EU-funded research project *HealthSense*, mentioned in the review, resulted in several papers that rebut the usefulness of flavor enhancement as a possible pathway to compensate for the impairing sense of smell. Flavor enhancement seems like a simple and straightforward tool, but it has serious limitations, listed below.

First, the success of flavor enhancement is probably strongly dependent on the type of added flavor: adding smoke aroma to cold cuts decreased liking, while added pepper mix had no influence on liking or intakes (Koskinen et al., 2005). Second, even when a well-liked berry aroma was added to a semisolid snack product as a heightened concentration, no support for the beneficial effect of flavor enhancement was found among an elderly population (Koskinen et al., 2003a). Third, given the heterogeneous effect of aging on chemosensory perception, especially the sense of smell (see Fig. 1), it would be a challenge to find the right level of heightened aroma to satisfy the flavor preferences of the entire age segment. The heightened flavor might, at its best, appeal to some individuals with impaired sense of smell, but it would be too strong for those whose sensory capabilities have remained perfect. Fourth, a selective impairment of olfactory functioning may change the perception of some, but not all odor compounds, and thus, there is a risk of imbalanced flavor (Koskinen et al., 2003b). Flavor is a subjective experience!
Kremer et al. (2007a) used two food systems to study the benefit of three different compensatory strategies: flavor enhancement, textural change, and trigeminal stimulation. None of these increased liking for the experimental samples among the elderly. Some subgroups preferred modified samples, but the preference could not be explained by age-related losses in sensory acuity. Also another paper by Kremer et al. (in press) showed that, despite the age-related changes in food perception, liking for food is not reduced in the elderly population. In line with Koskinen et al. (2003, 2005), Kremer et al. (in press) concluded that, since normal deterioration of the sensory systems with age starts gradually, people may continuously adapt to their diminished perception and do not experience decreased liking for food. Thus, while the intensity perception varies between the elderly and the young (Koskinen & Tuorila, 2005; Kremer et al., 2007b), hedonic responses remain largely stable with increasing age. According to Kremer et al. (in press), this is probably due to the sensory and hedonic aspects being processed by different areas in the brain and thus not converging.

The studies by Koskinen et al. and Kremer et al. were conducted with independently

cont. pg 8

Rejoinder: The Unfulfilled Promise of Flavor Enhancement continued

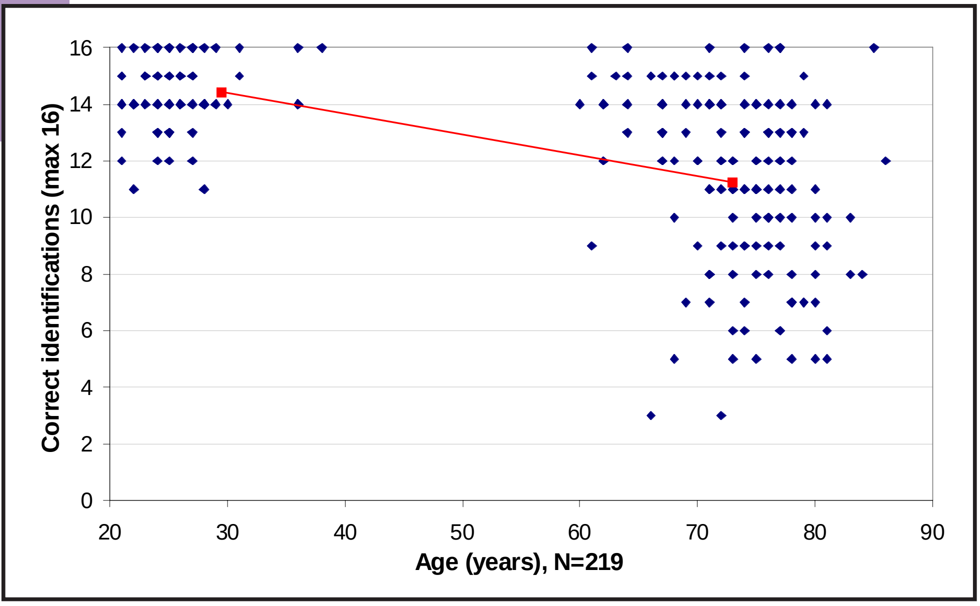


Figure 1. Individual differences in olfactory performance increase via aging. This figure shows a scatter plot of odor performance scores by 219 Finnish people (20-38; 60-85 years old) in Scandinavian Odor Identification Test (SOIT; Nordin et al., 1998). The end points of the trendline show the mean number of identified odors in both age groups, illustrating that on average, the odor identification abilities decrease during aging. (Mustonen et al., in press)

living, subjectively healthy elderly. Essed et al. (2007), in turn, conducted a large long-term study with elderly residents of a nursing home. The single blind randomized 16 weeks parallel study consisted of a control group, a MSG group, a flavor group and a flavor plus MSG group. The groups received corresponding flavor additions to their foods during the study period. After 16 weeks, energy intake or body weight did not increase in any of the groups, and no differences were found between the groups in these measured variables. Enhancing the flavor of cooked meals with flavor and/or MSG did not lead to a higher energy intake or body weight among nursing home residents. The study questions the validity of the findings by Schiffman and colleagues on the success of adding umami compounds and/or flavor to elderly people's food, which the review in *Chemosense* partially leaned on.

Until now, flavor enhancement has regularly been proposed to be a solution to cure the nutritional problems of the elderly people, even though a causal relationship between impaired chemosensory function and decreased food intakes has not been proven.

Studies measuring the chemosensory function of the elderly have found either a very weak or absolutely no association between impaired chemosensory capabilities and liking of intensified food flavor. The findings achieved in the EU project *HealthSense* demonstrate that decreased sensory acuity causes losses in food perception of the elderly, but obviously does not cause reduced liking for food to the extent that it could be the predominant reason for diminished food intakes.

To conclude, recent research does not provide evidence of the value of flavor enhancement. It might be worthwhile to look for other strategies when trying to increase food intakes of the significant and continually growing elderly population. Texture of food might need further consideration (Kälviäinen et al., 2003; Forde & Delahunty, 2004; Roininen et al., 2004). Furthermore, fresh, well prepared, delicious meals, served in an attractive and socially stimulating environment, appeal to any age group (Nijs et al., 2006). Research can help to identify the bottlenecks that hinder aging elderly consumers from fully enjoying their meals ■

cont. pg 9

Rejoinder:
The Unfulfilled Promise of Flavor Enhancement

continued

REFERENCES

Essed NH, van Staveren WA, Kok FJ, de Graaf C. (2007) No effect of 16 weeks flavor enhancement on dietary intake and nutritional status of nursing home elderly. *Appetite*, **48**, 29-36.

Forde CG, Delahunty C. (2004) Understanding the role cross-modal sensory interactions play in food acceptability in younger and older consumers. *Food Qual. Pref.*, **15**, 715-727.

Kälviäinen N, Roininen K, Tuorila H. (2003) The relative importance of texture, taste and aroma on a yogurt-type snack food preference in the young and the elderly. *Food Qual. Pref.*, **14**, 177-186.

Koskinen S, Nenonen A, Tuorila H. (2005) Intakes of cold cuts in the elderly are predicted by olfaction and mood, but not by flavor type or intensity of the products. *Physiol. Behav.*, **85**,314-323.

Koskinen S, Tuorila H. (2005) Performance on an odor detection and identification tests as a predictor of ortho- and retronasal odor intensity ratings in the young and elderly. *Food Qual. Pref.*, **16**, 383-92.

Koskinen S, Kälviäinen N, Tuorila H.(2003a) Flavor enhancement as a tool for increasing pleasantness and intake of a snack product among the elderly. *Appetite*, **41**, 87-96.

Koskinen S, Kälviäinen N, Tuorila H. 2003b Perception of chemosensory stimuli and related responses to flavored yoghurts in the young and elderly. *Food Qual. Pref.*,**14**, 623-635.

Kremer S, Bult JH, Mojet J, Kroeze JHA. (2007a) Compensation for age-associated chemosensory losses and its effect on the pleasantness of a custard dessert and a tomato drink. *Appetite*, **48**, 96-103.

Kremer S, Mojet J, Kroeze JHA. (2007b) Differences in perception of sweet and savoury waffles between elderly and young subjects. *Food Qual. Pref.*,**18**, 106-116.

Kremer S, Bult JH, Mojet J, Kroeze JHA. (2007, in press) Food perception with age and its relationship to pleasantness. *Chem. Senses.*

Mustonen S, Vento S, Tuorila H. (2007 in press) Measurement of olfactory function. *Finnish Medical Journal* (abstract in English).

Nijs K, de Graaf C, Siebelink E, Blauw YH, Vanneste V, Kok FJ, van Staveren WA. (2006) Effect of family-style meals on energy intake and risk of malnutrition in Dutch nursing home residents: A randomized controlled trial. *J. Gerontol. A Biol. Sci. Med. Sci.*, **61**, 935-942.

Nordin S, Brämerson A, Lidén E, Bende M. (1998) The Scandinavian Odor-Identification Test: development, reliability, validity and normative data. *Acta Otolaryngol.*, **118,** 226-234.

Roininen K, Fillion L, Kilcast D, Lähteenmäki L. (2004) Exploring difficult textural properties of fruit and vegetables for the elderly in Finland and the United Kingdom. *Food Qual. Pref.*, **15**, 517-530.

Useful Chemical Senses Book

Tastes and Aromas: The Chemical Senses in Science and Industry, Edited by Graham Bell and Annesley J. Watson. 214 pages. Published by UNSW Press and Blackwell Science, 1999. ISBN: 0-86840 769 0. Hard Cover. Price: US$ 30 / AUD$ 40 (includes tax if applicable, postage and handling). Order from: g.bell@atp.com.au

A limited number of this extremely useful volume are, for a short time only, available at a 50% discount. *Tastes and Aromas* has been hailed as a great teaching aid and resource for the practicing sensory scientist. Written by leaders in their fields as fundamental information, the volume retains its value and is rich in scientific and practical quality. Beautifully packaged in hard cover, it will continue to be a durable reference for many years to come.

Chapters include mini-reviews by (first authors) Stoddart; Bartoshuk; Youngentob; Prescott; Lyon; Weller; Bell; Saito; Lambeth; Noble; Morgan; Best; Barry; Sullivan; Key; Mackay-Sim; Atema; Hibbert; Barnett; and Levy.

Content covers the chemical senses in human culture; fundamentals of smell; taste; pungency; oral touch and pain; applied sensory evaluation; cross-cultural studies; perfumery and flavour chemistry; wine preference; psychophysics; sensory mapping; physiology of odour encoding; anatomy, growth and aging; emerging chemosensory technologies; sensors; marine chemical signals; electronic noses and chemosensory machines.

Avail yourself of a copy while these limited stocks last.

Every sale will support *ChemoSense.*

Order from: g.bell@atp.com.au ■

Vol. 9 No.3 June 2007

Perfume and Islam

Jenni Ibrahim

jenniib@iinet.net.au

In most cultures the idea of paradise is a garden. So it is easy to see why Islam, a religion which started in the deserts and oases of the Arabian Peninsula, frequently uses a luxuriant and fragrant garden as a metaphor for heaven. In Islam's holy book, the Koran, the gardens of heaven are described as having rivers of pure unpolluted water, blossoms and fully laden fruit trees (Kelly, 1986).

Persian gardens were known to be highly fragrant. In fact the rose bush comes from this part of the world. The rose is the symbol of Sufism, the mystical tradition of Islam.

For millennia fragrant plants have been identified among the forests, jungles and gardens of the world for use in making incense and perfume. Muslim scientists have played a significant role in the long history of the science of perfumery.

Today's perfume industry predominantly targets women. So it is rather surprising to find that Islam largely prohibits a Muslim woman's use of perfume and incense outside her home.

On the other hand, Muslim men are encouraged to apply scent, especially before attending the congregational Friday prayers in the mosque, and before (but not after) entering into the state of ritual purification for the Hajj or pilgrimage to Mecca.

Using perfume with an alcohol base may invalidate the ritual ablutions a Muslim makes before praying. The well-known Islamic prohibition on consuming alcohol applies to intoxicating forms of alcohol. So many Muslims prefer to use scent made from essential aromatic oils. Muslims online stores abound in such products.

Guidance on how a Muslim should behave comes from two main authorities:

- The Koran (or Qur'an), which Muslims believe contains the words of Allah (Arabic for God) as given to the prophet Mohammed (570-632 CE[1]) over a number of years; and
- The Hadith, or traditions, which are the sayings and reported conduct of the prophet Mohammed himself, as verified by a chain of witnesses and authorities.

Together, these authorities allow all human actions to be divided into an (asymmetrical) ordinal scale with eight points. There are three degrees of prohibition and four degrees of endorsement (Table 1). Everything else is permissible; this forms the eighth and largest group, midway between the others.

-3	Forbidden (haram)
-2	Undesirable
-1	Not advantageous
0	Permissible
+1	Commendable
+2	Optional
+3	Obligatory
+4	Inevitable obligations

Table 1.

Few activities are prohibited or mandated outright; usually they are limited to certain conditions and contexts. This assessment applies to the acceptable and unacceptable use of perfume and incense by Muslims. The most often-cited Hadith authority is Bukhari[2] (Maulana Muhammad Ali, 1944).

Reaching inner spiritual purity is seen as a key aim of Islam; outward cleanliness is considered to be a necessary preparation (Maulana Muhammad Ali, undated). The use of perfume in Islam seems to be tied to notions of cleanliness and sexual fidelity.

Perfume. Photo credits: Jenni Ibrahim

Generally, the following uses of fragrance are endorsed by Islam:

- Men using perfume in crowds, such as at prayer gatherings; and
- Burning incense to ensure the mosque or prayer space smells sweet.

However, the same source says that women are to refrain from using perfume (or perfuming their hair and bodies with the aromatic smoke from burning incense) in a way which might attract (or distract) a male who is not her husband. This limits women's use of perfume and incense anywhere where she might meet a man who is not of her household.

Perfume and incense have been used for thousands of years to enhance personal

cont. pg 11

[1] CE Christian Era, equivalent to Anno Domini. The Muslim calendar starts in 610 CE, when the prophet Mohammed emigrated from Mecca to Medina. The 354-day lunar years are counted from then and designated AH (in Latin anno Hegirae, meaning the year of the Hijra or emigration).

[2] His full name was Muhammad Ismâ'îl al-Bukhârî

[3] Ibn means 'son of'

Perfume and Islam continued

body odour and to mask unpleasant smells. Muslim scientists in the first millennium helped develop the science of extracting fragrances from plants, and pioneered their use in perfumery, alchemy and medicine. Among them:

- **Jabir** - (full name Abu Musa Jabir ibn[3] Hayyan, born c721 - died c815CE, Iraq) - a prominent Islamic alchemist, pharmacist, philosopher, astronomer, physicist and chemist, called Gerber in the West. He wrote the Book of Perfume Chemistry and Distillation about distillation, evaporation and filtration.
- **Abu Yusuf Ya'qub ibn Ishaq**, known as **Al Kindi** (born 801 Kufa, Iraq - died c866-873 CE) an Arab astrologer, philosopher, alchemist, optician and musical theorist, experimented with different combinations of plant extracts to produce perfumes.
- **Ibn Sina** the polymath known in the West as Avicenna and whose full name was Abu 'Ali al-Husayn ibn 'Abd Allah ibn Sina al-Balkhi (born 980CE Bukhara, in present-day Uzbekistan - died 1037, Hamadan, Iran). Ibn Sina improved on the distillation techniques used at the time, and wrote the Canon of Medicine in which essential oils were frequently used at treatments.

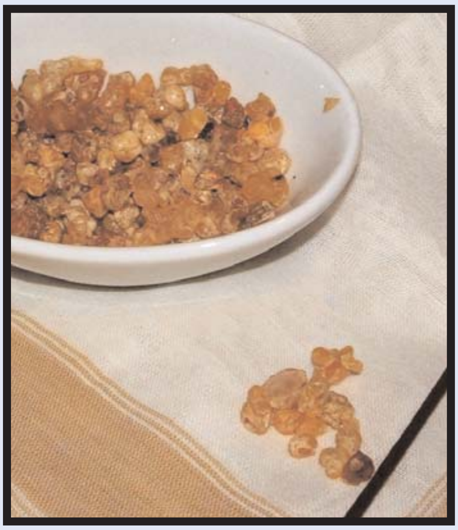
And long before the advent of Islam in the Arabian Peninsula there was a flourishing trade in frankincense and myrrh. There is evidence of this in Hadramut and Dhofar in southern Arabia (modern day Yemen) dating back at least 3 000 years. The "incense route", which pre-dated the silk route by hundreds of years, started there, where the valuable frankincense trees grew (Rosengarten, 1973; Bloom and Blair, 2000).

There's even a record of the Egyptian pharaoh Sahure 4 500 years ago receiving 80 000 measures of myrrh. And of course we all know of the story of three wise men who brought valuable gifts of gold, frankincense and myrrh 2 000 years ago to the new-born King (Rosengarten, 1973).

The word perfume means *par fume* - literally "through smoke". The deliberate use of fragrances is thought to have originated with production of aromatic smoke from burning of resins, bark and wood (Rosengarten, 1973). The resins were produced by making a cut in the bark of a tree. The substance which oozed out was called a gum (hence gum Arabic, although much is not a true gum). Incense was used in burial ceremonies and in the fumigation of homes, although initially only the wealthy could afford to do this.

From its beginnings in what is now Yemen the incense route continued north to Petra in Jordan, and from there to the markets of Syria and Egypt. In the late fifteenth century in Nuremberg, Martin Behaim documented the multiple stages that spices (and perfumery ingredients) passed through on their way to retailers in Europe (Jardine, 1996). No wonder they were so expensive - each dealer took their cut along the way.

The Muslim prophet Mohammed himself was a spice merchant in Syria and Yemen, and for some time was partner in a shop in Mecca which sold myrrh and frankincense.



Frankincense. Photo credits: Jenni Ibrahim

These and other ancient fragrances are still in use today. The following fragrant plant products have Islamic associations.

- **Frankincense** - literally the "Franks' Incense" brought back from the Middle East by the Frankish crusaders, comes from *Boswellia* species grown in Oman, Yemen and the north coast of Somalia. After slashing the tree's bark the exudate (resin) hardens and is collected. It is still used in perfumery, aromatherapy and in the incense used in Christian churches.
- **Myrrh** *Commiphora myrrha and Cistus ladaniferu* comes from a shrub grown in Ethiopia which exudes an aromatic resin and is said to be one of the gifts from the Queen of Sheba to King Solomon. There are records dating back thousands of years of myrrh's existence in Egypt, Palestine, and present day Somalia. Another substance also referred to as myrrh in the Old Testament comes from a *Cistus* sp. (Kelly)
- **Benzoin**, the main ingredient in tincture of benzoin, Friars' Balsam, a common styptic and antiseptic, comes from *Styrax* species. Although there are over 100 Styrax species grown from China to California, the main species of commercial value in perfumery and incense are Siam benzoin (S. *tonkinensis*) and Sumatra benzoin (*S. benzoin* and *S. paralleloneurum*) from South East Asia where it is known in the Malaysian and Indonesian languages as kemenyan or kemayan.(Grieve, 1931). The two forms differ in appearance and dominant constituents. *Sumatra benzoin* contains cinnamic acid while *Siam benzoin* contains benzoic acid and vanillin.

  Like myrrh and frankincense, benzoin resin is also collected after slashing the bark. In South East Asia benzoin smoke is produced in charcoal braziers to purify a

cont. pg 12

Perfume and **Islam** continued

home from bad spirits and is said to repel mosquitoes.

The terms benzoin and frankincense are sometimes used interchangeably In South East Asia for the locally-produced benzoin. When the resins are burned their odours are very similar - to my nose at least.

- **Aloe** *Aquillaria agallocha* known in Arabic as '*Ud*, is a fragrant tree which grows in the jungles of east and west Malaysia and has been used for centuries throughout the Muslim world for making incense. Not to be confused with 'Aloe vera' (the succulent used in complementary medicine) *Aquillaria agallocha* is referred to in ancient texts including the Bible.

The eighth-century Egyptian jurist and poet Muhammad ibn Idris al-Shafi'i wrote (in translation):

> Gold is just dust when still in the ground.
> And 'ud, in its country of origin,
> Is just another kind of firewood.

In Malaysia and Indonesia, this aromatic wood is called *gaharu*, a Malay word derived from the much older Sanskrit term agaru, meaning 'heavy' - a high-quality piece will sink in water. The *Susruta Samhita*, one of the "great three" texts of Ayurvedic medicine, describes how people of the Ganges plain used smoldering *agaru* for worship, as perfume and to fumigate surgical wounds. In those times, *agaru* came largely from the tree Aquilaria agallocha, which was then found in the foothills of Assam, a north eastern state of India.

Chips of *aloewood* (also known as *agarswood* or *agarwood*) are still widely used across the Muslim world - burnt as incense in mosques in Saudi Arabia and in ceremonies to mark the birth of a child, as a women's and a men's perfume, to scent clothes and to keep the Turkish water pipe fresh and sweeten its smoke. It is also used in Western perfumery, apparently being the origin of the "woody, old violin" note to the Mitsouko, a French perfume launched by the house of Guerlain in 1919.

- **Rose** *Rosa* species - said to have originated in northern Iran and spread through the Middle East and Asia Minor to the Eastern Mediterranean. Roses are evident in Jewish (the thirteen petalled rose), Christian (*rosary* means rose garden) and Muslim symbology, healing practices and art.

  Ibn Sina's improvement of the distillation processes developed by Al Kindi and Jabir was aimed at extracting the essence from roses - attar (*'itr* or rose oil). One of Ibn Sina's 100 books was entirely devoted to roses. Double distillation was developed later, in the sixteenth century. Rosewater was used as a tonic and in cosmetics and creams.

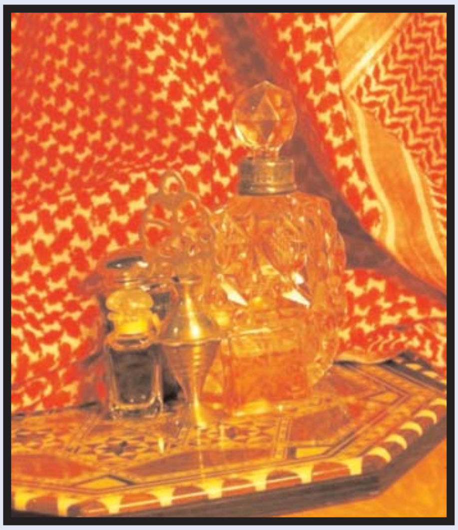
- **Lawsonia** - known as *Camphire*, *Henna* and *Mehndi* and native to India, Egypt and the Middle East. As henna *Lawsonia* is best known as a dye for skin, nails and hair. The bush produces very fragrant white and yellow flowers, not only used to make the henna dye, but also for making incense.

- **Pelargonium** and **geranium** - There is a legend that the prophet Mohammed tossed his freshly washed shirt onto a mallow plant to dry out, but when he lifted it up the plant had turned into the world's first geranium.

The Islamic world has contributed much to our current understanding of the processes of extracting and using odoriferous substances from plants and of the ways that odours affect the mind and the body ■

The author

Jenni Ibrahim was born and raised in Australia and gained a PhD in Psychology from La Trobe University, Melbourne in 1976. She married into a Malay Muslim family and lived and worked for many years in Malaysia before returning to Perth, Western Australia, as a senior public servant. Jenni recently retired to write and pursue community interests, representing the perspectives of health consumers, and to research her family's history, which she regards as "an addiction".



Perfume. Photo credits: Jenni Ibrahim

REFERENCES

Bloom, Jonathan and Blair, Sheila (2000) *Islam: A Thousand Years of Faith and Power*, TV Books LLC, New York.

Grieve, Mrs M (1931) *A Modern Herbal*, Dover Publications, New York, digitised at http://www.botanical.com/botanical/mgmh/mgmh.html

Hansen, Eric (2000) The Hidden History of Scented Wood, *Saudi Aramco World*, **51** (6) December http://www.saudiaramcoworld.com/issue/200006/the.hidden.history.of.scented.wood.htm

Islam QA *The Muslim Woman* (undated) at http://www.islamqa.com/special/index.php?ref=6991&subsite=16&ln=eng

Jardin, Lisa (1996) *Worldly Goods: A New History of the Renaissance*, London, Macmillan

Kelly, Frances (1986) *The Faithful Garden*, Methuen, Sydney.

Keville, Kathi and Green, Mindi (1995) *Aromatherapy: a complete guide to the healing art*, Crossing Press, excerpted at http://www.healthy.net/scr/article.asp?ID=1712

Maulana Muhammad Ali (undated) *The Religion of Islam*, Muslim Welfare Organisation of Malaysia, Kuala Lumpur.

Maulana Muhammad Ali (1944) A *Manual of Hadith*, Lahore.

Mission Islam (undated) Muslim Women's Dress in Accordance with the Qur'an and Sunnah, at http://www.missionislam.com/family/hijab.htm

Moulavi M H Babu Sahib (1974) *Know Islam!* Moulavi M H Babu Sahib, Singapore.

Rosengarten, Frederic Jr. (1973) The Book of Spices, Pyramid, New York.

Shaykh Faraz Rabbani. What is the relation of scent to Islam? *Sunni Path - the Online Islamic Academy* http://qa.sunnipath.com

AACSS at Novotel Barossa Valley

9th Scientific Meeting, Thursday 26th to Saturday 28th July 2007

Novotel Barossa Valley Resort, Rowland Flat, SA

The ninth scientific meeting of the Australasian Association for ChemoSensory Science will be held from the 26th to 28th July 2007. There will be a wine theme but the conference will cover the Society's usual broad range of chemosensory interests. (These dates are designed to dovetail with the 13th Wine Industry Technical Conference to be held in Adelaide starting 29th July).

Draft Program.

Thursday evening. Conference mixer 6-7pm. Plenary lecture 7-8 pm.

Friday. Morning and Afternoon Sessions. Evening: Conference Dinner.

Saturday. Morning session. Afternoon optional winery tour - at additional cost

Poster sessions will be held on Friday.

Conference and Accommodation

Conference Registration Fee is A$350 ($335 for students) - payable to AACSS by 31st May. This includes conference, morning and afternoon teas, Thursday evening mixer and Conference Dinner as well as membership of AACSS.

Accommodation

Delegates wishing to stay at the conference venue may choose to stay 1, 2 or 3 nights and should book accommodation directly with Novotel Barossa Valley. You will need to mention that you are with AACSS in order to access the conference rate. Twin share rooms are available for $181 per night and single share for $168 or $208 (with spa) per night. Rollaway or sofabeds can be arranged with the hotel for an additional $60 per person, per room per night. Room rates include fully-cooked breakfast. Accommodation is limited and any unbooked accommodation will be released in early June.

Details of the venue & contacts for booking accommodation:

http://www.novotelbarossa.com/
Tel: (08) 8524 0000 | Fax: (08) 8524 0100

Conference registration (see attached registration form):

Payable on or before 31st May.

Students:

If finances allow, a limited number of a limited number of post graduate (4th year and over) student subsidies will be offered by AACSS to students, to assist with fees and accommodation. Deadline for application is 31st May. If you are eligible, tick the box on the registration form.

Abstracts.

Abstracts are due on or before 31st May. Please send an electronic version to Stephen.Trowell@csiro.au using the attached template. Speakers will be selected by the Program Committee.

Australasian Association for ChemoSensory Science
9th Scientific Meeting **Registration & Payment**

Full name ______

e-mail address ______

telephone ______

Institution/company ______

Postal Address ______

Special dietary requirements? ______

Would you be interested in a transfer to/from Adelaide ❑ On Thursday evening?
❑ On Sunday morning?

Are you a graduate student? ❑

Would you be interested in a ½ day winery tour/tasting at ~$50? ❑

Payment details:

I enclose a cheque for (tick as appropriate):

$335 (students) ❑ $350 (all others) ❑

made payable to "Australasian Society for Chemosensory Science"

I have paid by direct deposit (tick as appropriate): $335 (students) ❑ $350 (all others) ❑

Reference (e.g. your initial and surname) ______

Receipt no ______

Bank: ANZ BSB: 013-332 Account No: 3502-86686.
Account name: "Australasian Association for Chemosensory Science".

Return to: Stephen Trowell
GPO Box 1700 Canberra ACT 2601

or e-mail form to Stephen.Trowell@csiro.au

Registration fees are not refundable.

Title: ______ Authors: ______

Affiliation: ______

Text (250 words maximum)

Indicate preferred format: ❑ Poster ❑ Platform Proposed session:______

ADVERTISEMENT

TM

E-NOSE

MEASURE SMELLS CONTINUOUSLY AND IN REAL TIME WITH E-NOSE TECHNOLOGY

WHAT DOES E-NOSE PTY LTD DO?

It designs, builds and distributes electronic noses (E-Noses) which are chemical sensor array devices that monitor, identify and measure smells and other airborne chemicals, continuously and in real-time.
E-Noses have many applications, from being air pollution monitors to medical diagnostic and security devices.

REAL-TIME AND CONTINUOUS MEASUREMENT ON SITE

Our devices work continuously on site, for immediate action, thereby removing the slow and expensive method of bagging air samples for later analysis at a remote lab. Other e-noses have, up until now, been laboratory instruments measuring a wide range of chemicals. The Company's strategy is to tailor its robust, industrial-strength E-Noses to meet specific customer needs. This results in smaller, faster, more robust and more affordable devices.

PROVEN SYSTEMS *NOW* OPERATING

Two systems have been developed for the red meat industry and the water (sewage) industry. Several Australian abattoirs and water companies, and a number of research projects are employing our E-Noses. A new version of the latest Mk3 E-Nose has been specified for detection of graffiti vandals.

R&D PAY-OFF: REAL-TIME IDENTIFICATION OF SMELLS

E-Nose Pty Ltd has an on-going R&D effort which recently made a breakthrough in the technology of odour identification in real time. In this patented method, odours from known sources are used to build "templates" against which incoming odours can be judged and identified. This opens the way for highly effective and competitive devices for world markets.

E-Nose Pty Ltd is now actively pursuing markets in human inspection and surveillance. We have been listed in the *NSW Security Capability Directory* available from all Austrade offices worldwide.

PROCESS AND POLLUTION CONTROL

We were recently recognised in *The Chemical Engineer* (Jan 2007) as contributing to global progress in e-nose technology. Our aims are to have E-Noses used in control of air quality in large buildings as well as in controlling outdoor environmental pollution.

Australian States such as NSW now have tough anti-pollution laws which are being applied to both individuals and corporations. E-Noses offer comfort and cost savings to companies at risk of breaching environmental law.

HUMAN AND ANIMAL HEALTH

E-Nose P/L is collaborating with the Australian Sheep CRC to facilitate introduction of devices to detect fly strike, fleece rot and other parasites as "e-tagged" sheep pass through a high-tech race.

Diagnosis of human health from the breath will be non-invasive, safe, relatively cheap and rapid. It will save time and money, and mitigate considerable risk to the patient. We are working with UNSW on early detection of lung cancer.

INTELLECTUAL PROPERTY

E-Nose has a portfolio of patents for platform technologies and know-how. It owns all its IP outright. The company is prepared to work with partners to create new technology and markets.

OUTLOOK

The Company aims to develop markets in the region as well as internationally. Sales in Australia began in December 2004. Plans for exporting are in progress.

THE E-NOSE RESEARCH TEAM

E-Nose Pty Ltd was founded in February 2003 by Dr. Graham Bell and six scientists who have pioneered research in smell and electronic noses. The company is owned by these founders and ATP-Innovations Pty Ltd. The company is based at the Australian Technology Park (ATP), Sydney.

E-Nose Pty Ltd currently employs six staff and several sub-contractors. It is governed by a Board and advised by a Technical Advisory Board.

E-NOSE

145 National Innovation Centre I Australian Technology Park I Eveleigh NSW 1430
T: +61 2 9209 4083 I M: 0416 099 529 I F: +61 9209 4081 I E: g.bell@atp.com.au

Upcoming Events

9-11 July, 2007	**39th Annual AIFST Convention** Adelaide Convention Centre Adelaide South Australia Info: aifst@aifst.asn.au or www.aifst.asn.au
12-17 July 2007	**IBRO** (International Brain Research Organisation) Melbourne, Australia Contact: http://www.ibro2007.org
19-23 July 2007	IBRO Satellite on Avian Brain, Cognition and Behaviour Heron Island, Queensland, Australia Info: http://workshops.med.monash.edu.au/birdbehaviour07
26-28 July 2007	**AACSS: 9th Annual Meeting** Adelaide, South Australia Contact: Stephen.Trowell@csiro.au
28 July - 2 August 2007	**The 13th Australian Wine Industry Technology Conference** Adelaide, South Australia Contact Rae Blair: rae.blair@awitc.com.au
29 July - 4 August 2007	**Summer School on Human Olfaction** Dresden, Germany Info: www.tu.dresden.de/medkhno/riechen schmecken/summerschool2007.htm
12-16 August 2007	**7th Pangborn Sensory Science Symposium** Hyatt Regency, Minneapolis, USA Info: www.pangborn2007.com
15-22 September 2007	**The European Symposium on Insect Taste and Olfaction (ESITO X)** Roscoff, France Info: www.esito-symp.org
6-8 May 2008	**Enviro 08** Melbourne Info: rvquitz@bigpond.com
21-25 July 2008	**International Symposium on Olfaction and Taste (ISOT)** San Francisco, USA Now calling for proposals for satellite meetings Contact Tom Finger: tom.finger@uchsc.edu
8-10 October 2008	**The 3rd IWA Specialist Conference on Odours and VOC** Barcelona, Spain Contact: r.steutz@unsw.edu.au■

ChemoSense (ISSN 1442-9098)
Web: http://www.chemosensory.com
Published by **E-Nose Pty Ltd**
P.O. Box 488 Gladesville, NSW Australia 2111
Ph. (+61 2) 9209 4083 ; Fax (+61 2) 9209 4081

Production Team
Editor: Graham Bell, g.bell@atp.com.au
Advertising: Brian Crowley, b.crowley@atp.com.au
Design and Layout: Lawton Design Pty Ltd

Coming up in ChemoSense

Retronasal Smelling

Odour and Pain

*Visit our Site: www.chemosensory.com