Vol. 4 No.2 March 2002

Chemo sense

EDITORIAL

On the Scent of a Better World

By Graham Bell

Director
Centre for ChemoSensory Research, UNSW
g.bell@unsw.edu.au

World events in 2001 have left many shocked and dismayed, yet we have much to look forward to. The Australasian Association for ChemoSensory Science (AACSS) has resolved to offer the world's chemical senses community the opportunity to meet in Australia in December 2002 at unique, beautiful and inspiring Heron Island, on the Great Barrier Reef.

What might we expect ChemoSensory Science to produce in the foreseeable future? Here, ChemoSense provides at least two answers from leading scientists: Our first review shows how *chemesthesis* works at a molecular level to give the oral and nasal sensations of hot and cold. This knowledge provides new insights into flavour perception as well as into basic mechanisms of pain. Then we examine how cognition is affected by environmental odour and whether the practice of aromatherapy has any validity.

This issue marks five years of operation of the Centre for ChemoSensory Research. Its forward vision is to stimulate ChemoSensory Science to create a safer, healthier and more prosperous world ■

Chemesthesis : Hot and Cold Mechanisms

Hessamedin Alimohammadi and Wayne L. Silver

Department of Biology
Wake Forest University
Winston-Salem NC USA

It has been 90 years since G. H. Parker first described a chemical sense distinct from the senses of gustation and olfaction, and responsible for the detection of chemical irritants. What Parker originally called the *common chemical sense* has since been redefined and renamed (Keele, 1962; Green et al., 1990), and is now referred to as *chemesthesis*, the sensory system responsible for detecting and initiating responses to chemical irritants.

We now know that the chemically sensitive free nerve endings originally described by Parker do not constitute an independent chemical sense, as he thought. Instead, these nerve-endings are a subset of pain- and temperature-sensitive fibres belonging to the general somatic sensory system, and are found throughout the skin and mucosal membranes. Advances in the field during the past 5 years are now bringing us closer to understanding the molecular mechanisms underlying chemesthetic sensibility.

Trigeminal nerve mediated chemesthesis

In humans, chemesthetic sensibility is perhaps best exemplified by the chemosensitive branches of the trigeminal (Vth cranial) nerve innervating areas of the eyes, nose and mouth (see Figure 1 page 2). We stimulate our chemesthetic sense through these fibres any time we eat peppers, chew spearmint or cinnamon gum, come into contact with tobacco smoke, or drink carbonated beverages (see Box).

Although free nerve endings from other cranial and spinal nerves also respond to chemical stimuli, most of the research on chemesthesis, especially as it relates to taste and smell, has involved trigeminal chemoreception in mammals. The fibres of the trigeminal nerve that respond to chemical stimuli are referred to as *polymodal nociceptors*, responding to painful levels of thermal,

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Chemesthesis : Hot and Cold Mechanisms continued

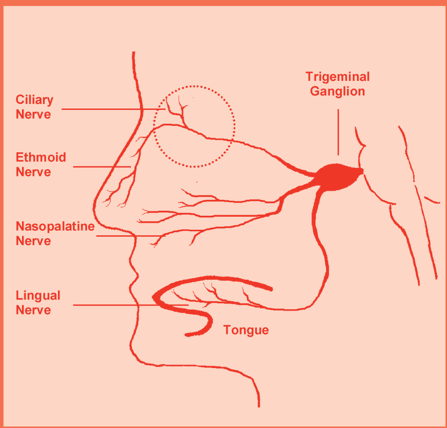

Figure 1. Branches of the chemically sensitive trigeminal nerve innervate the cornea and areas of the nose and mouth.

mechanical, and/or chemical stimuli. Interestingly, there appears to be a considerable amount of overlap between chemical sensitivity and the thermal modality. In contrast, a lesser amount of overlap appears to exist between chemical sensitivity and the tactile modality.

Chemical stimulation of trigeminal fibres in the cornea and the nasal and oral cavities leads to a variety of sensations, and are usually described using physically tangible words such as numbness, tingle, fizz, itch, prickle, bite, sting, or pain. Certain chemicals such as capsaicin, the active ingredient of hot peppers, and menthol cause sensations best described using thermal descriptors such as warm, hot, cool, chill, or cold.

Transduction mechanisms

Trigeminal nerve fibres are found within or below epithelial layers, making them less accessible to incoming stimuli than olfactory or gustatory receptors. In between epithelial cells, some of these fibres extend virtually to the surface of the epithelium, stopping only a few micrometers from the surface, below the line of tight junctions. Therefore, in order to stimulate trigeminal nerve endings, chemical stimuli must first travel through either the lipid phase of epithelial cell membranes, or through the aqueous phase of epithelial tight junctions. Hydrophobic irritants primarily use the lipid phase, and lipid solubility is an important factor for the efficacy of hydrophobic irritants in the eyes, nose, and mouth.

Of course, trigeminal irritants are not limited to hydrophobic compounds. A broad range of compounds with diverse chemical structures and properties has been shown to stimulate trigeminal nerve fibres. This observation necessitates the existence of a diverse set of

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Book early to avoid disappointment.

The Australasian Association for ChemoSensory Science (AACSS) meeting at Heron Island,

Queensland from 7-11 December, 2002.

All members of the Australasian and International Chemical Senses communities are cordially invited to participate. Booking is now open and important information is given below.

Who should attend?

Researchers and applied scientists in the chemical senses from research institutions and academia, as well as industrial delegates are welcome. A contingent of Australian and international representatives of the food, wine, beverage, perfume, pharmaceutical, flavour, air & water quality industries are expected to attend. The AACSS meeting is open to the international chemosensory community (AACSS, AChemS, ECRO, JASTS, Pangborn, Chemometrics) as well as accompanying families/guests, who may stay at the Island at AACSS accommodation rates. Admission to the meeting will be at the discretion of the AACSS Organisers.

PROGRAM

Symposia:
Each will be hosted by an AACSS member who will assist the speakers and co-ordinate the initial content in concert with the Program Chair. People wishing to take part in any of the following are encouraged to correspond directly with the AACSS host. Organisers retain the right to change Program contents without notice. Please help make the Program a success by volunteering to participate in a Symposium.

- Targeting, Development, Regeneration (hosts Anne Cunningham and Brian Key)
- Taste, Olfactory & Trigeminal Psychophysics (host John Prescott)
- Marine and Invertebrate Systems (Host to be announced)
- Large Mammal Chemical Ecology and Olfaction (Host to be announced)
- Cerebral Processes (Host John Patterson & Caroline Owen)
- Chemosensory Memory and Cognition (Host Bob Boakes)
- Clinical Issues - smell and taste loss (Host Graham Bell, Alan Mackay-Sim)
- Industrial Issues: more competitive wine, food and beverages (Host Jenny Weller)
- Machines and Models - Chemosensory Devices & Sniffers (Host Brynn Hibbert)

Call for Volunteer Papers:
Submissions of abstracts for symposium, oral and poster papers must be sent to the Programme Chair, John Prescott, John.Prescott@stonebow.otago.ac.nz by the **Abstract Deadline: 30 September, 2002.**

Why Heron Island? AACSS has something unique to offer its members and international chemosensory people by hosting a meeting on Heron Island. This rare geographical jewel in the Coral Sea is two hours by boat from Gladstone, Queensland, or 30 mins by helicopter. Heron Island offers you one of the most exciting conference venues imaginable. Built on a tiny coral atoll, surrounded by rich coral and marine life, it consists of a solitary luxury, low-built resort, and a marine research station. It is, without any argument, one of the most beautiful, exciting, yet relaxing places on Earth. Just do a web-search and see how many people around the world have raved about it. Over 60% of people on Heron Island, at any time, are from abroad.

A confirmed booking at the Heron Island P&O Resort is essential to attending the meeting.

HERON ISLAND RESORT BOOKINGS
A confirmed resort booking (Heron Island Resort and transfers to and from the island) is essential for registration at the Meeting, as this is the only accommodation available. Rates quoted here are at a special 20% discount exclusive to AACSS Meeting participants and their parties. Stays may be extended at these rates before and/or after the Meeting, depending on room availability. *The Resort provides three meals inclusive in the room rates.*

Please make your hotel and island transfer bookings as early as possible. Room numbers are limited and will available on a first-come first-served basis. AACSS accepts no responsibility for attendees' hotel, transfers or travel bookings or any matters arising therefrom. Attendees must see to their own accommodation and travel arrangements. All bookings must be finalised by the **Hotel Deadline: 23rd August 2002.** The Organisers have reserved 50 rooms which will be held until this date. Thereafter, unreserved rooms will be returned for sale to the general public and cancellation fees will apply.

All your accommodation on Heron Island and launch/helicopter transfers must be made directly by you through Wendy Burchmore of Tourism Queensland Groups and Conferences (see contact details below). Once you have a confirmed booking the AACSS Organisers will contact you regarding conference presentations and registration.

Wendy.Burchmore@tq.com.au
Phone +61 7 3535 5837
Fax: +61 7 3535 5045

Rates per person per night, twin share x 4 nights (AUD$*). Includes full board:

Class	Rate	Sole Use	Extra adult	Child (3-14y)
Turtle Rooms	157.50	232.50	112.50	67.50
Reef Suites	202.50	277.50	112.50	67.50
Heron Suites	247.50	322.50	112.50	67.50
Point Suites	330.00	405.00	n/a	n/a

Transfer to and from Island:

	Adult		Child	
Ex Gladstone	One way	Return	One way	Return
Launch	61.50	123.30	30.75	61.50
Helicopter	274.00	466.00	137.00	233.00

Meeting Registration Fees:
Non-student $120 Student $60
Payable on arrival at the Island.
* 1AUD$ is approximately equal to 50 cents US.

Sponsors
The Meeting is sponsored by:

- Goodman Fielder
- *ChemoSense* and the Centre for ChemoSensory Research of the University of New South Wales.
- AACSS , which will support students to attend by making available the "Free of Charge" accommodation incentives offered by Heron Island Resort .

Other sponsors are invited to contact the Organiser.

Student Assistance: Please act now
Assisting students to attend this meeting is a priority of the Organisers. It is important that students express interest as early as possible (by end of May 2002). The amount offered will be determined by available resources. General guidance is as follows: Students must be prepared to find their own transport to and from Gladstone and pay the conference student registration fee (AUD$60). The transfer to the island by launch and on-island costs (food and accomodation) will be partly or fully met by the assistance package. Assisted students must be willing to share accommodation with other students of the same gender. A number of lowest-cost rooms will be held until 31 May 2002 to help students attend. Thereafter, while assistance may be offered, the lowest cost accommodation cannot be assured. It is unlikely that assistance will be offered after 23rd August 2002. Student assistance should be requested NOW by e-mailing: The Organiser AACSS Heron Meeting: g.bell@unsw.edu.au

Photo: Courtesy of Heron Island, P & O Resorts

IMPORTANT DATES:
Heron Island Resort Bookings OPEN on 1st April 2002
Student Assistance Expressions of Interest: 31 May 2002
Booking Finalisation Deadline: 23rd August 2002
Abstract Deadline: 30 September, 2002
Meeting: 7-11 December, 2002

IMPORTANT CONTACTS:
Heron Island Accommodation:
Wendy.Burchmore@tq.com.au
Send Abstracts to Program Chair:
John.Prescott@stonebow.otago.ac.nz
Other inquiries including Student Assistance:
The Organiser: g.bell@unsw.edu.au
Web: www.chemosensory.com

FIRST STEP: Contact Wendy Burchmore and make your Heron Island Accommodation Booking. This is the essential first step.
SECOND STEP: A Program Organiser will contact you thereafter.

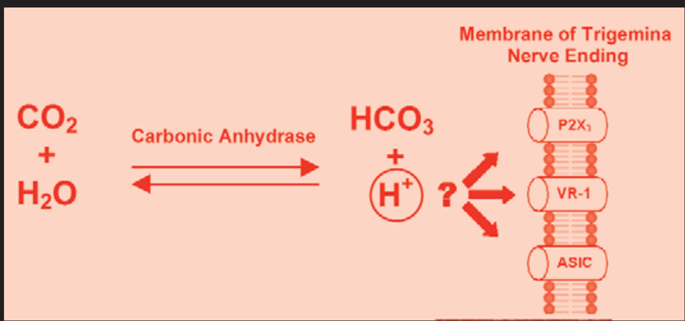
SEE YOU IN PARADISE!

Chemesthesis : Hot and Cold Mechanisms continued

THAT UNMISTAKABLE TINGLE...

The 'tingle', 'fizz' and 'sting' that we associate with carbonated drinks are classic examples of sensations arising from the chemesthetic sense. Most adults consider these sensations pleasurable, despite the fact that they are irritating and sometimes painful. Anyone who has ever had the experience of a 'flat' soda knows that without the chemesthetic component, a soda is really nothing more than just sweetened, colored water.

So just how does carbonation cause stimulation of the trigeminal nerve? Recent experiments suggest a key role for intraepithelial acidification. Both in the oral and nasal cavities, carbon dioxide has been shown to activate trigeminal nerve endings via a carbonic anhydrase mediated pathway.



In the epithelial tissues of the oral and nasal cavities, the ubiquitously present enzyme carbonic anhydrase converts CO2 to carbonic acid, transiently acidifying epithelial tissues. Liberated protons are then free to interact with acid-sensitive membrane bound receptor proteins on intraepithelial trigeminal fibers. Experimental results suggest that the vanilloid receptor (VR1) is at least partially responsible for the nasal trigeminal response to CO2 gas. It is likely that acid-sensing ion channels (ASIC) and perhaps ionotropic purinoceptors (P2X) also contribute to CO2 sensitivity.

receptive mechanisms, of which only a handful are currently known. Classically, the term *chemoreceptor* has been used in reference to the chemoreceptive fibres of the trigeminal nerve, and the actual mechanisms of interaction between these fibres and environmental chemical stimuli are at best only partially understood.

So how exactly does a chemical irritant activate free nerve endings? A potentially irritating chemical compound that has penetrated outer epithelial layers can act either *directly* or *indirectly* on the membranes of trigeminal nerve endings. Depolarization of these nerve endings is the initial step to the sensation of irritation and pain, and any mechanism used by a chemical irritant that can lead to the appropriate level of depolarization will lead to the production of action potentials in the nerve. It does not matter if the transduction is through a *direct* interaction with a specific membrane bound receptor, or if it is through an *indirect* secondary mechanism.

Currently, the best understood example of *direct* chemical activation of trigeminal nerve endings is arguably that of the capsaicin receptor. Transduction of capsaicin, the active ingredient in chili peppers, is mediated via a capsaicin-gated channel that is found in the small- to medium-size sensory neurons of the trigeminal ganglion. This channel has recently been cloned and sequenced (Caterina et al., 1997). Capsaicin contains a vanilloid moiety, and therefore this receptor is known as the vanilloid receptor, VR1. The activation of VR1 by capsaicin leads to a depolarization in the nerve ending that is subsequently sustained by voltage-sensitive calcium channels in the ending and transmitted centrally. The VR1 is an excellent example of a polymodal receptor, being

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Chemesthesis : Hot and Cold Mechanisms continued

sensitive to not only capsaicin, but also noxious heat and low pH (Tominaga et al., 1998). The receptor's sensitivity to low pH and heat fit nicely with its role as a monitor of the physiological conditions of peripheral tissue.

Why does this receptor respond to capsaicin? The answer is not known, and thus the search is on for the body's endogenous 'capsaicin' molecule. This search has focused mainly on lipophilic compounds, due to the hydrophobic properties of capsaicin (Piomelli, 2001). Capsaicin seems to interact with a cytosolic component of the VR1 receptor, and not with the extracellular domain as was previously assumed (Hwang et al., 2000), suggesting that the endogenous capsaicin molecule should be sought inside the cell. The vanilloid receptor itself is a polytopic protein containing six transmembrane domains. This protein forms a non-selective cation channel in the membrane that is structurally related to members of the transient receptor potential (TRP) family of excitatory ion channels (Caterina et al., 1997).

The VR1 is not the only example of a polymodal receptor. Very recently, a close molecular cousin of the VR1, the cool-menthol receptor (CMR1) has been identified that is activated by both menthol and cool temperatures (McKemy et al., 2002). The CMR1 is yet another illustration of how a plant product like menthol can act on the chemesthetic sense to create a thermal sensation. Similar to the action of capsaicin and the burning 'hot' sensation associated with it, chemical stimulation of CMR1 by menthol and related compounds leads to a cooling sensation. The CMR1 is also a member of the TRP family of excitatory ion channels, and interestingly, a significant proportion of CMR1 expressing neurons also express VR1, giving those cells a distinct temperature response range (McKemy et al., 2002).

In addition to the VR1 and CMR1, several other receptors have been identified in trigeminal nerves. Not all trigeminal sensitivity to low pH in the peripheral tissues is accounted for by the pH sensitive VR1, and the acid-sensing ion channel (ASIC) appears to also contribute to the pH sensitivity of peripheral tissues (Lingueglia et al., 1997). Specific subtypes of several receptors for endogenous compounds such as ATP, histamine, 5HT, and acetylcholine also appear to be expressed in trigeminal neurons.

In the case of receptors for acetylcholine, trigeminal nerve endings appear to express more than one specific subtype of the neuronal nicotinic acetylcholine receptor (NnAChR) (Alimohammadi & Silver, 2000). These receptors also mediate our chemesthetic sensitivity to nicotine, a potent trigeminal stimulus causing sensations of tingling and burning. What larger role specific NnAChRs play in the pain pathway, and the specific functional contributions each different receptor subtype makes remains to be determined.

The fact that many irritant compounds are also lipophilic suggests another possibility for direct activation of trigeminal nerve endings, although not through a receptor-mediated pathway as in the examples previously described. Lipid solvents may depolarize nerve endings by causing physical damage to the lipid bilayer of the trigeminal nerve endings, creating the opportunity for ion flux through the damaged membrane (Bryant & Silver, 2000). Alternatively, exposure of a nerve ending to a lipid solvent may lead to the formation of discrete ion channels in the membrane, leading to ion flow through the disrupted lipid phase. In either case, ion flow can lead to a depolarization which may be transmitted centrally,

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Chemesthesis : Hot and Cold Mechanisms continued

resulting in the sensation of irritation.

For some irritating stimuli, a direct interaction with a receptor is not required. Instead, these compounds activate trigeminal nerve endings *indirectly*. Upon penetration of epithelial layers, these potential irritants must be peripherally metabolized in order to produce an active irritant. The best example of indirect activation is perhaps that of CO2. This relatively inert compound readily activates trigeminal nerve endings upon penetration of epithelial layers. In an aqueous environment, CO2 slowly dissociates, producing protons and bicarbonate ions. This dissociation is catalyzed by the action of carbonic anhydrase, an enzyme present in the epithelium of the nose and mouth, and also in the endothelium of the cornea (see box). Data suggest that carbonic anhydrase activity is essential for the trigeminal nerve response to CO2 in carbonated beverages (Komai & Bryant, 1993), and in the nasal perception of CO2 gas (Alimohammadi & Silver, 2001). In the case of nasal sensitivity to CO2 gas, data implicate the VR1, although it is probably not the sole acid-sensitive receptive mechanism at work. Blocking the VR1 using capsazepine does not lead to a complete block of the response to CO2 gas, suggesting that other acid-sensitive receptors such as the acid-sensing ion channels (ASIC) and perhaps the ionotropic purinergic receptors (P2X) also contribute to CO2 sensitivity (Alimohammadi & Silver, 2002).

Currently, carbonic anhydrase mediated sensitivity to CO2 is probably the best understood example of indirect trigeminal nerve activation. The extent to which indirect activation via peripheral metabolism is involved in chemesthesis remains to be clarified, but more than likely, indirect activation is the mechanism by which many known irritants derive their chemesthetic properties. Pungent aldehydes, ketones, and esters, such as benzaldehyde, cyclohexanone, and ethyl acetate may be working through peripheral metabolism and the enzymatic liberation of protons, alcohols, and other irritants.

Trigeminal protection: withdraw and dilute

So why have animals evolved this chemosensory system, and why is it necessary? Unlike the olfactory and gustatory systems, the major role of trigeminal chemesthesis is to signal potentially or actually *harmful* skin and mucosal conditions, and to trigger adaptive behavioral and physiological responses. For chemesthetic trigeminal stimulation, the chemical source may be either internal or external. Internally, endogenous compounds released during tissue damage and chemicals associated with tissue conditions such as inflammation can lead to activation of trigeminal nerve endings.

Externally, the chemesthetic sense does not function as a long-range detector as does the olfactory system. In fact, most trigeminal stimuli activate the trigeminal nerve at levels that are several log units more concentrated than the concentration required for activation of olfactory receptors. Essentially, trigeminal chemesthesis does not prevent *initial* exposure to harmful chemicals, but once that initial exposure occurs, the chemesthetic sense functions to reduce further contact. In this aspect, the trigeminal chemesthetic system in mammals operates more like the gustatory system, i.e., it is a short-range detector of chemical stimuli.

Chemicals that excite trigeminal chemoreceptors can potentially produce chemogenic pain and trigger protective reflex movements of rejection or withdrawal (Keverne et al., 1986). These reflexes are amongst some of the strongest reflexes of the body and probably evolved in animals as a way to minimize exposure to noxious substances and to perhaps hinder or discourage the consumption of potentially toxic food. The aversive movements associated with chemesthetic activation primarily serve to remove us from further contact with the offending stimulus, and include restriction of the nares, and blinking of the eyelids.

In addition to aversive and rejection movements, trigeminal activation elicits a variety of adaptive physiological responses, including local changes in vascular physiology (Holzer, 1988; Szolcsanyi, 1996). Some of these tissue defensive responses include decreased respiratory rate, apnea, increased mucociliary activity, vasodilation, and plasma leakage. Responses such as increased salivation, increased nasal secretion, increased lacrimation, and sweating tend to dilute the offending chemical irritant and to help remove it from sensitive tissues.

Sensory effector action

While activation of some of the physiological responses mentioned above may be due to trigeminal activation of autonomic fibres, other responses appear to be mediated by the sensory effector action of the trigeminal nerve, through the process of axon reflex (Finger et al., 1990) (see Figure 2). One subset of capsaicin-sensitive trigeminal fibres secrete the vasoactive neuropeptides Substance P (SP) and calcitonin gene related peptide (CGRP) upon stimulation. Stimulation of these peptidergic fibres results in the generation of a signal that is sent towards the trigeminal ganglion and the central nervous system. In the process of axon reflex, this signal can also result in retrograde excitation of other branches of the axon, resulting in neuropeptide release from all branches of the affected axon, leading to local vasodilation and plasma leakage. The tissue defensive actions of this class of neurons have led them to be called *noceffectors* (Kruger, 1988).

Specifically, in the mouth, capsaicin-sensitive sensory effectors have been shown to mediate extravasation (Bryant & Moore, 1995), vasodilation (Izumi & Karita, 1994), and increased salivary flow (Takahashi et al., 1995). Interestingly, evidence from several experiments suggest that oral trigeminal stimulation may peripherally modify the function of the gustatory system (Wang et al., 1995; Osada et al., 1997; Esakov & Serova, 1988).

Similarly, local release of neuropeptides upon nasal trigeminal stimulation has been shown to modify olfactory system function. Trigeminal stimulation decreases responses from olfactory receptor neurons (Bouvet et al., 1987). This action is probably due to the local release of substance P from peptidergic nerve endings, since substance P has been shown to directly inhibit olfactory receptors (Bouvet et al., 1988). Trigeminal stimulation also affects olfactory bulb function. Substance P- and CGRP- containing trigeminal nerve fibres are known to innervate the olfactory bulb, extending as far as the glomerular layer (Finger & Bottger, 1993). Some of these same fibres are collateral branches of nerve fibres found within the nasal mucosa (Schaefer et al., 2002). This suggests that modulation of the olfactory bulb by trigeminal stimulation may be axon reflex mediated, bypassing involvement of a relay through the trigeminal sensory nuclei found in the brain stem.

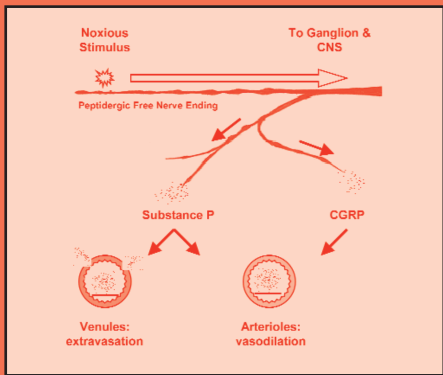

Figure 2. The process of axon-reflex. Upon noxious stimulation, peptidergic fibers send a signal towards the central nervous system, which also travels to the other branches of the same axon through retrograde excitation. This excitation may cause the release of neuropeptides such as Substance P and CGRP, initiating tissue defensive actions such as extravasation and vasodilation.

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Effect of Odours of Essential Oils on Mental Performance

Christine Broughan
Coventry University, U.K.
c.broughan@coventry.ac.uk

Aromatherapy, the use of aroma, mainly from essential oils inhaled or rubbed onto the skin, is said to produce changes in mood, alertness and general health. Various forms of aromatherapy are now practiced widely in Europe, North America and elsewhere. Are such therapeutic claims for inhaled aromas valid?

A series of carefully designed experiments have been carried out recently at Coventry University (Broughan 2001) to find out whether the presence of essential oils can act as sedatives or alternatively improve performance on tasks measuring mental ability.

Most aromatherapists claim that only 'pure' essential oils should be used in aromatherapy and they suggest that synthetic odours will not produce the same results. This has led to what has become known as the "direct versus indirect" debate. Direct and indirect effects refer to the way in which an odour may affect the individual. A hard-wired or direct response will be mediated by physiological changes such as arousal, whereas a soft-wired or indirect response will be mediated by psychological and cognitive factors such as expectations, learning, personality and beliefs.

It is assumed that a direct effect will occur so long as the appropriate chemical is present, and that direct effects are not subject to major individual differences (i.e. the effect will be observed in most people). By contrast, indirect effects will be mediated by various psychological factors and it is likely that individual differences will be notable. The experiments reported here aimed to shed some light on the significance of direct and indirect effects of odours on cognitive performance.

Effect of Perceptually Matched Lavender Oils on Choice Reaction Time

The first experiment sought to test whether lavender oil would significantly reduce reaction time in 48 adults on a choice reaction time task, and to compare lavender essential oil with a *perceptually* matched synthetic oil. During the task, individuals were required to respond to a sequence of numbers presented to them on a computer monitor by pressing the appropriate number on the keyboard. For example, the numbers 2, 4 and 6 might be shown on the screen. After a few seconds the number 4 'lights up' and the participant should respond by pressing number 4 on the keyboard.

It was suggested that lavender essential oil affects choice reaction time through a direct pharmacological mechanism. Lavender essential oil is purported to act as a sedative (Price, 1993) and therefore one would assume that its presence may reduce performance on a choice reaction time task.

It was found that the essential oil significantly decreased performance on the choice reaction time task whereas the synthetic oil did not, when compared to a control condition of no-odour. Did the special nature of the 'essential oil' produce this result, as aromatherapists might claim, or was it due to the chemical differences between the two oils?

Effect of Chemically Matched Lavender Oils

To answer this, a second experiment was carried out, in which the lavender essential oil was compared with a *chemically* matched synthetic oil on the same choice reaction task.

The results showed that both odours significantly reduced reaction time when compared to the control condition with no-odour present. This suggests that, under these conditions, direct physiological effects are responsible for the observed differences in reaction time rather than indirect cognitively mediated effects. It appears to be the chemical constituents of the oil that are responsible for the observed changes in performance and not the perception of the odour.

These results led to the question whether, whilst a direct theory of olfactory influence on cognitive performance had been supported, could it be that indirect effects are also present? To address this issue, a further series of experiments were designed to test whether indirect effects of olfactory stimuli were apparent.

It has been suggested that the primary function of odours is to provide clues to our environment. Therefore it is the 'meanings' associated with the odours that are important and not the chemical constituents of the odours per se. As such, it is the context in which an odour is perceived that is important. Researchers such as Van Toller (1976) have suggested that cognitive appraisal of odours operate at a simple level, in that incoming olfactory stimuli is judged on a simple dichotomy of 'pleasant' or 'unpleasant'. The individual would simply reject those odours judged as unpleasant whereas those assessed as pleasant could be open to much further cognitive appraisal.

Odour delivery during performance of cognitive-motor task

Odour-Liking and Mental Performance

A third experiment was designed to test the hypothesis that the perceived hedonic quality of

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The Smart Foods Centre

The Smart Foods Centre (SFC), an Australian Research Council Key Centre, was founded in 1999 on the concept of developing a healthier food supply through alliance between the higher education sector, government, food industry, University of Wollongong and the community. Its primary role is to support Australia's food industry in an area of national, social and economic importance, viz. the development of healthier value added foods.

The Centre

The SFC is able to play a vital role for food industry through education and research. This is particularly relevant with the changing food regulation and policy climate. Food industry has a need to pose nutritional questions and have them addressed through credible research and development targeting specific population groups. The Smart Foods Centre with its strengths encapsulated by the personnel who work within the programs and their research interests is well positioned to help address these issues. Of particular interest to industry is Smart Foods Centre ability to conceptualise nutritional issues from the population back through to the agricultural level - table to farm. Coupled with broad ranging experience in research in obesity, cardiovascular disease and diabetes (metabolic research), the SFC has great ability to conduct distinctive research. The building of a human calorimeter -the only one in the region, is currently enhancing this expertise. With the established proficiency in human nutrition and dietetic research the Smart Foods Centre has unique capacity in research areas of critical health concern to the Australian population and the "western" world.

Research Areas

Broadly the research areas fall under the following key areas:

- Human performance: *Extending nutrient effects on human physiology well beyond the classical cardiovascular risk factors of blood pressure, cholesterol, triglycerides and lipoproteins to discovery and applied research in heart function, cardiac metabolism, arrhythmia risk, skeletal muscle function, physical activity and fatigue.*
- Human Calorimetry: *Evaluation of human energy balance at rest and in exercise both in healthy and morbid populations. Emphasis will be placed on the opportunities for foods and nutrients to improve the quality of life.*
- Diet and Metabolic Syndrome: *The relationship between dietary factors and elements of the metabolic syndrome at mechanistic and clinical intervention levels.*
- Biomarkers of Oxidation and Antioxidant Function: *Detection and measurement of biomarkers of oxidation and potential identification of antioxidant components in foods that could manage oxidative stress as it relates to human performance and metabolism.*
- Consumer Choices: *Developing a framework for conducting systematic and critical consumer research linked to the development and marketing of new food products and the evolution of the food regulatory system. Focussed research identifying consumer needs, attitudes and beliefs in relation to food and acceptability and adaptability of specific research outcomes into mixed diets*
- Human Trial Methodology: *Further development of dietary intervention trials as a means of establishing evidence for health benefits of nutrients and/or foods. This includes advances in diet methodology, food databases, consideration for exercise/activity and assessment of cardiovascular and other clinical outcomes.*

The Education Program

The Nutrition Management program supports the mission of raising nutritional awareness and developing a healthier food supply. By providing short intensive courses it enables working individuals to undertake pertinent continuing education as part of their career development. The courses seek to expose key nutritional areas of concern and draw upon the key experts in the area both internal to the Smart Foods Centre and externally to other Universities, professional bodies and non-profit organizations. The nutrition management program targets industry personnel responsible for the integration of nutrition into the food supply. Students can choose to undertake short courses as individual units, enroll in Graduate Certificate or Masters program, or undertake a research PhD program or follow up the basic Masters program with a Masters of Business Management.

Areas to be covered this year in the short courses include Food Regulation and Policy, Contemporary Issues in Food and Nutrition, and Food Innovation incorporating issues and opportunities with new technologies including biotechnology. Nutrition Research skill development is also being offered in a condensed course incorporating eight (8) half day sessions and internet materials.

For further information on the Smart Foods Centre please contact Anne McMahon, Education Co-ordinator at the Smart Foods Centre on email anne_mcmahon@uow.edu.au or phone (02) 4221 4829 ■

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Chemesthesis : Hot and Cold Mechanisms continued

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Effect of Odours of Essential Oils on Mental Performance contin.

an odour would largely influence the effect that odour had on an individual's performance during a cognitive task. During this experiment participants had to undertake the same choice reaction time task as before and, in addition, were asked to rate the odour presented to them on a visual analogue scale ranging from 1=very unpleasant to 7=very pleasant.

The results again showed that lavender essential oil has a sedative effect on participant's performance during a cognitive task. The sedative effect increased with the hedonic appreciation of the odour. It was concluded that cognitive mediation appears to occur during odour perception. The hypothesis that lavender essential oil would significantly reduce performance on a cognitive task if considered to be hedonically pleasing was unequivocally supported. This cognitive evaluation apparently takes place even when no recognition of the odour during the task is acknowledged.

The third experiment seemed to unfold more questions that it answered. It was unclear at this stage whether cognitively mediated effects stopped at the simplest level of hedonic evaluation or whether hedonic evaluation represented other cognitive factors such as cultural influences, expectations and beliefs. Alternatively, it may be hypothesised that these other cognitive factors were additional to the role of perceived hedonic quality.

Cultural Variables

Experiment Four tested whether cultural differences would affect individuals' responses to particular odours and whether these differences would be realised in terms of cognitive performance.

Historically, olfactory researchers have suggested that culture plays a significant role in the interpretation of, and subsequent reaction to, certain odours (Classen, 1995). In Experiment Four two nationalities were compared, British and Australian adults. Two odours were examined, a native Australian oil (eucalyptus) and the popular British oil, lavender. It was hypothesised that Australians would be more influenced by the presence of eucalyptus oil and British participants more strongly influenced by the lavender. It was felt that stronger associations would be present with the 'culturally congruent' odour and that these associations would lead the participant to have stronger prior expectations and beliefs regarding the likely effect of the particular oil.

In this experiment participants were required to complete two cognitive tasks. The first of these was a simple vigilance task where the participant had to track a cursor on a computer monitor and respond by pressing the enter key when the cursor 'skipped' a space. The second, more complex cognitive task involved grammatical reasoning in which the participant had to respond either 'true' or 'false' to a number of pairs of statements such as "B is followed by A [BA]".

Results

Overall, the results showed that the presence of lavender decreased performance and eucalyptus oil increased performance on a cognitive task. However, no between group differences (cultural) were identified.

A number of possible interpretations of these findings exist. Firstly, the two groups were culturally too similar: nationality may not be an adequate operational definition of culture due to the 'homogenisation' of these two 'Western' societies. Secondly, while neither group have well defined cultural roots, they share much of their culture in common (Anglo-Celtic). Thirdly, it was questioned whether differences in odour perception due to nationality and culture are still as strongly apparent in society today as historical literature suggests they have been in the past.

A second hypothesis was tested in Experiment Four that examined whether the effect of the odours observed was dependent upon the type of cognitive task performed.

Results showed that significant differences between the odour conditions were only found during 'low order' vigilance cognitive tasks and not during a 'high order' cognitive task such as grammatical reasoning. This fascinating finding may provide an explanation as to why previous studies have produced seemingly conflicting results: the effects of odours on cognitive performance may be heavily task dependent. Further experimental investigations are required to understand the cognitive processes underlying the evaluation of olfactory stimuli and how these impinge on certain cognitive tasks.

It was considered appropriate to extend the previous investigations into individual differences to test whether other factors such as expectations and beliefs would influence the affects that essential oils had on cognitive performance.

Experiment Five tested whether an individual's expectation about the effects of lavender essential oil would vary the observed influence that the odour had on cognitive performance.

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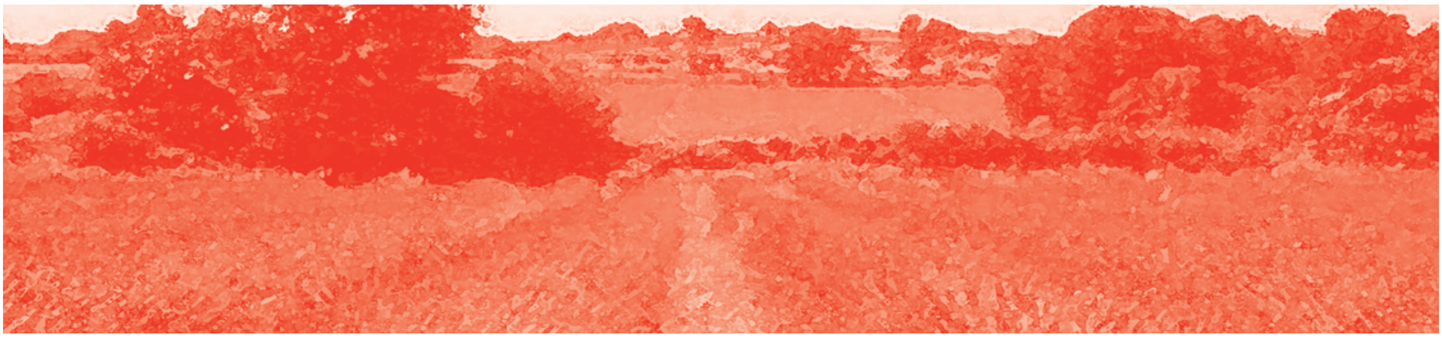
Effect of Odours of Essential

Again the choice reaction time task was employed. No significant differences between high and low expectancy groups were observed. However, it was considered that this might be due *to methodological and experimental reasons.* The experiment used lavender oil. It was felt that the effects of the odour may have been masked by using an odour that is purported to reduce performance in a cognitive task due to the nature of the experimental setting and the participant's desire to perform well.

Having reconsidered the nature of the experiment it was decided to re-test the theory by modifying Experiment Five. In Experiment Six, peppermint essential oil was used instead of lavender and a further factor of 'reinforcement' was added to the experimental design.

The results suggested that people use their experience with, and knowledge of, aromatherapy techniques as a source for developing expectations about



A lavender plantation Photo: Lawton Design pty ltd

their future effects. It was further hypothesised that these indirect expectations are positively reinforced during each successive trial.

Potential Future Directions

The results of the experiments reported here suggest that both direct and indirect mechanisms exist by which odours exert an influence on cognitive performance. However Kuhn (1962) suggests that a mature science is one governed by a single paradigm which co-ordinates and directs the problem solving activity of the researchers who work within it. In olfaction, no one single paradigm has existed by which to guide scientific endeavour. Germane to this subject is the question of how greatly our perceptions of phenomena are influenced by the prevailing paradigm. Direct and indirect effects have built a dichotomy within the scientific arena of olfaction - something that may now be resolved.

Throughout this study, evidence emerged which suggested that a simple dichotomous view of direct and indirect effects may not be the most useful analogy by which to explain the findings from this and previous research. Direct and indirect effects appear to be intertwined, each one feeding from the other, not mutually exclusive as has been previously proposed. Therefore, a theory that reflects this relationship should be considered as the basis for an explanation of the way in which olfactory stimuli affects cognitive performance. The results provide a formal testable scientific model for the role of learning in the effects of essential oils on selected aspects of cognitive performance.

It has been found that, under conditions wherein individuals have a need to change their performance or behaviour and/or they have an expectation that change will occur as a result of an odour being present, alterations in cognitive performance may result from a combination of psychological and physiological factors. It is proposed that change will occur due to three general mediating factors: (1) a desire or need for change, (2) an appraisal of environmental cues, and (3) the *physiological* effect of the olfactory stimuli. In the context of providing support for a three-factor model that includes these dimensions, the following relevant questions need to be addressed: (1) What environmental or situational factors influence the magnitude of the response? (2) Given these environmental factors, what is the role of indirect effects in aromatherapy? (3) How do psychological factors such as hedonic evaluation, anxiety, belief, hope, desire for change and expectancy relate to these environmental factors and contribute to indirect effects of essential oils? And (4) how could one optimally measure and assess the relative contribution of these factors in producing effects on cognitive performance.

Learning theory acknowledges that the time course of the programme plus the anticipation of change based on past experience or belief probably combine in some complex and highly individualised subtle way to produce the pattern of results observed. Many previous experiments that suggest

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direct support for theories of learning rely heavily on context and suggestion, a pattern that was repeatedly shown throughout this study. Further, the direct physiological mechanisms evidenced within these experiments will serve to reinforce these learning patterns.

The further study of such cognitive factors has the potential for increasing understanding of how learning influences odour perception. Firstly, the results of the experiments described within this study suggest that both direct and indirect mechanisms may well coexist, or have concomitant dimensions. For example, indirect effects may occur during the first visit to an aromatherapist due to factors such as a professional attitude of the therapist, confidence in the treatment method and paying for the treatment. These may become associated with the active pharmacological agents of the essential oil as well as the resulting change in behaviour or performance. It is plausible that indirect responses to olfactory stimuli are more likely to be controlled by these cognitive factors than by the immediate and direct association, because of the important roles that meaning, hedonic attribution, imagery and information have in mediating beliefs, desires and expectations

Indeed, consideration of the nature of suggestions inherent in olfactory perception strongly indicates that cognitive factors operate to influence and even determine the nature and magnitude of the change in cognitive performance. The way in which perfumes are marketed gives anecdotal support to this theory.

Although expectations and hedonic evaluation may be salient factors that influence the magnitude of the response to an essential oil, they do not appear to operate alone. Indirect effects are commonly observed in circumstances wherein it is likely that participants not only expect therapeutic effects but also strongly want these effects to occur. It is likely that the magnitude of the influence of 'desire' will be far greater in naturalistic settings rather than experimental settings. In other words, the greater the desire for change, the greater the likelihood of an observed change in cognitive performance.

Concluding remarks

It was found that the odour of essential oils affects cognitive performance, and that evidence suggests that this is due to both direct (physiological/chemical common across individuals) and indirect effects (psychological variables of the individual person). The magnitude and relationship of these mechanisms was examined under a conceptual framework of learning. Much of the research now being carried out under the rubric of olfactory influences on emotion and cognitive processes could be considered under a learning theory framework. The acquisition of odour hedonics is a matter of learning by associations and therefore is not inherent within the odour but forms part of an ecological situation. Whilst individuals' experiences, culture, beliefs and expectations will serve to influence individuals' perception of an odour, many of these experiences will be shared and serve to influence a general agreement as to the location of a certain odour on the hedonic scale. Extreme differences can normally be traced back to extreme circumstances, for example, in food allergies. It follows that if one can control the environment in which odours are experienced then one can influence, through leaning associations, the responses to that particular odour - a theory that marketing companies have been using for years.

The possibilities for future research appear endless, but it was felt that an experiment, which extends the learning theory mechanism incorporating desire and expectations as independent variables, would be most useful at this stage. The validity of the theory should be considered, not only as a way to view information as it unfolds, explaining phenomena on the basis of retrospective knowledge but also its ability to predict the likely response and extent of that response to particular odours (Annett, 1996).

Despite a general opinion that olfactory stimuli are less important than other sensory stimuli, the results of this study suggest that olfaction is of paramount importance to humans. This apparent discrepancy between what is perceived and what is evidenced suggests that olfactory stimuli may operate at a largely sub-conscious level. This would suggest that olfactory stimuli, within a learning framework, would make an ideal therapeutic agent, as used in aromatherapy ■

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Upcoming Events

11-12 April	Short Courses: "Food Policy: How does it Happen?" and " Genies at Work: Specific Applications of Innovative Food Technologies" Smart Foods Centre, University of Wollongong Contact: smart_foods@uow.edu.au http://www.uow.edu.au/research/centres/
18-19 April 2002	2nd Sanitarium International Nutrition Symposium Park Hyatt Hotel, Melbourne Contact: Rachel Parsons (02) 4348 7777 symposium@sanitarium.com.au www.sanitarium.com.au/health-professionals
24-28 April, 2002	AChemS: Association for Chemoreception Sciences Hyatt Hotel, Sarasota, Florida, USA Contact: www.achems.org
30-31 May 2002	Short Courses: "Food and the Law: What is Allowed?" and "Genie in a Bottle: Food Innovations from Manufacturer to the Consumer Door" Smart Foods Centre, University of Wollongong Contact: smart_foods@uow.edu.au http://www.uow.edu.au/research/centres/
24-28 June 2002	Weurman Flavour Research Symposium Dijon, France Contact: www.dijon.inra.fr/aromes/weurman
21-24 July 2002	Combined 35th Annual AIFST Convention and FOODPRO'2002 Sydney Convention and Exhibition Centre Darling Harbour, Sydney, Australia Contact: aifst@aifst.asn.au and www.aifst.asn.au
21-23 July 2002	Symposium on Trigeminal Sensitivity (ECRO Satelite) University of Erlangen, Nuremberg, Germany Contact: Thomas Hummel: thummel@rcs.urz.tu-dresden.de
23 July 2002	Olfaction in Drosophila (ECRO Satelite) University of Erlangen, Nuremberg, Germany Contact: Thomas Hummel: thummel@rcs.urz.tu-dresden.de
23-27 July 2002	ECRO XV Congress University of Erlangen, Nuremberg, Germany Contact: http://www.tu-dresden.de/medkhno/ECRO preliminary.htm
27-28 July 2002	Symposium on Genetic Variations in Taste Sensitivity (ECRO Satelite) University of Erlangen, Nuremberg, Germany Contact: john.prescott@stonebow.otago.ac.nz
31 July - 2 August 2002	The 6th Sensometrics Meeting Dept. Statistics, Univ. Dortmund, Germany Contact: www.stastik.uni-dortmund.de/sensometrics/
17-20 November 2002	The 8th Pacific Rim Biotechnology Conference Sheraton Hotel, Auckland, New Zealand Contact: info@biotenz.org.nz
3-5 December 2002	Third Asia Pacific Symposium on Neural Regeneration Sheraton, Perth, Western Australia Contact: Sarah Dunlop, Ph. +618 9380 1403 sarah@cyllene.uwa.edu.au http://neuro.zoology.uwa.edu.au/symposium.html
7-11 December 2002	Chemical Senses Meeting at the Great Barrier Reef AACSS Fifth Annual Meeting and International Symposium Heron Island, Queensland, Australia Contacts: Wendy.Burchmore@tq.com.au g.bell@unsw.edu.au ■

NEWS

Olfactory Honour *and* *Cash* to Kensaku Mori

One of the world's few significant cash prizes, specifically honouring olfactory science, is the C$25,000 award presented by Simon Fraser University, Vancouver. The 2001 winner of the Frank Allison Linville's R.H. Wright Award, is Kensaku Mori of Tokyo University.

Kensaku Mori is well known to Australian scientists for his work, for having visited Australia during the years of the development of his career, and for hosting visits by them to his laboratories in Japan. Work recognised for the Award included his electrical recordings from the rabbit and mouse olfactory bulb, which were characterised by the molecular features of the odorant.

This is the first time since its inception in 1985 that the Award has been made to a Japanese scientist. Professor Mori joins a formidable line of previous recipients: R. Reed, A. Farbman, D. Lancet, B. Ache, L. Buck, J. Kauer, J. Boeckh, F. Margolis, T. Getchell, J. Hildebrand, V. Dethier, G. Ohloff, J. Adler, G. Shepherd and K-E. Kaissling ■

Craving the Craveable

Sensory and physical attributes of a food make it "craveable," not emotions or benefits conveyed by the product, according to a study by McCormick & Co., and Moskowitz Jacobs Inc., USA.

For example, in the chip category, descriptors such as sharp cheddar, spicy jalapeno, sweet and sour smoky BBQ improves craveability. The study also found that women *prefer to evaluate* chocolate candy, cheesecake, french fries, tortilla chips, and cinnamon rolls for craveability, while men prefer steak, hamburger, ribs, pizza, coffee, and peanut butter.

The ongoing study is designed to identify the elements of food experienced by consumers that result in making a product craveable. Twenty categories of products will be explored, including beverages and other food categories.

Source: http://www.ift.org/extra/newsletter/ ■

Congratulations

To South East Water Ltd, Moorabbin, Victoria, on the establishment of human expert sensory panels for proactive monitoring of water quality.

Staff of S E Water Ltd were intensively trained by the Centre for ChemoSensory Research, UNSW.

The panel is made up of staff members. It is believed to be the first of its kind for the Australian water industry. It is initially intended to monitor human perception of water quality, with the objectives of evaluating the influence of asset maintenance practices, storage conditions and environmental factors on the aesthetic quality of drinking water ■

NEWS

CCR: Fragrant at Five

Decoding a dead chef's secret spice mixture, and specifying the sensors for a "bionic" nose: these were two of around 100 projects completed by Centre for ChemoSensory Research (CCR) since it began five years ago this February.

The stand-alone research Centre of the University of New South Wales began with two well-known chemosensory scientists, Graham Bell and Don Barnett, and a goal to establish a leading research group, in the chemical senses in Australia.

The Centre took up premises at the new and exciting Australian Technology Park at Eveleigh in Sydney and retained lab space and an office at the Kensington campus of UNSW. The Centre soon went on to be 100% self-supporting. All Centre costs are now covered by outside income, including grants and contracts.

In five years the Centre has grown to employ 10 people regularly (part and full-time), as well as an expert taste panel, and many consumer panels in Australia and abroad. The Centre provides work for various technicians, suppliers and expert associates. Much of the Centre's income is bought by companies headquartered outside Australia and represents export earnings for Australia. The Centre's contribution to Australian exports was acknowledged by an Austrade award in 1999.

Special Opportunities for Students

The Centre is proud of its role in spreading interest in smell and taste, particularly in industry. It has also played a part in teaching and training: supervising many PhD, Masters and Honours research students.

The link to industry provides students with valuable training on "real world" problems. Several students have gained unique field experience in Australia and in Asia, and have been subsidised by the Centre to present their research results, here and overseas.

Growing Research Portfolio

New products and services have been developed recently: intensive sensory courses for industry, sales of publications (a book and the bulletin ChemoSense) and product endorsements. Research contracts have varied from a couple of hour's duration to three years. The cash value of these has varied from $200 to $600,000.

The subject matter of Centre research has included a number of studies of consumers' taste preferences for Australian food products in Japan, Korea, Indonesia, Singapore, the UK, Italy and Mexico.

Expertise in artificial noses (e-noses) has been employed at the Centre since its inception. Early work at the Centre was facilitated by a project on e-noses for the Food and Packaging CRC. This has resulted in a patent and a spin-off company.

Application of analytical chemistry in combination with human and animal behaviour has produced some particularly valuable results for industrial clients in areas of food, beverage, packaging and the environment.

Protocols and ethics for innovative medical research sponsored by the

Graham Bell, Brian Crowley, Hae-Jin Song and Miriam Smith assist in the construction of a new flow-dilution olfactometer. Photo: TAFE, ATP Sydney

Centre, have recently been approved and are scheduled to begin in 2002.

Research Relevant to the Community

Although most of the work of the Centre has been confidential, it has supported new public domain research in areas considered important for the community and the future. These have included development of clinical assessment methods for people with smell loss, a study of children's and parents' choices for school lunches, studies of the human perception of dietary fats, and of cognitive processes in odour judgement.

The Centre has supported the establishment of the Australasian Association for ChemoSensory Sciences which seeks to bring together scientists, industrialists and scholars from the wider Indo-Pacific region. The Centre will support their scientific meeting at Heron Island in December 2002.

The Centre is going into 2002 with great enthusiasm, a nearly full order book and new plans and ambitions for realising its vision.

For more information see http://www.chemosensory.com■

Coming up in ChemoSense

Human Pheromone Receptor
Japan's Taste for Urchins
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E-MAIL from Beijing

By Marilyn Styles:
"Your Australian Person in China"

Marilyn Styles in Beijing.

What is a Sensory person like me doing in a place like this, you ask? Well, I am here for a year of education, some sensory work for the Centre for ChemoSensory Research, and to have an adventurous year teaching English and learning about China.

With China's current open door policy, the recent APEC World Congress meeting in Shanghai, entry into the W.T.O., success in the World Cup Soccer and of course the naming of Beijing as the host city for the 2008 Olympic Games, China has now a palpable urgency to get it's citizens to master the English Language.

All those who wish to be successful on the business stage, domestic and international, must master the English language. To practise a profession, to graduate from university, to enter university, to graduate from middle school, English is a *must*, in China.

But beside this new commercial imperative, is the ancient Chinese obsession with food. "Ni chi wan le ma?"..."Have you eaten yet?" is a common greeting: the equivalent of "Hi, how are you?" The uses of this greeting in China dates back to a time when the provision of food was the most important and often most difficult task of each day.

Its continued use reflects the modern Chinese's preoccupation with food and eating."Do you like Chinese food?" is one of the first questions asked of me and all other foreign visitors.

Life here is a moving feast, but not all that moves is food. Life moves along mostly on bicycles and there is never a dull moment. The ordinary worker's food, which I am eating regularly as a school teacher, is very bland and uninteresting to the newcomer: it all seems to merge into "grey stuff, brown stuff, greens and rice." Yes, I do miss Vegemite and Diet Coke and Tim Tams. I dare say you could get all of those if you tried, but at a price, which my Chinese friends refuse to allow me to pay. The solitary $2.50 bottle of Diet Coke still beckons from that shop window where the riot nearly took place when I went in to buy it. Immediately my intentions became known, my hosts jumped into an argument with the shop keeper. Soon everyones' relatives and half the neighbourhood were out on the street all having a say. I drank water, again.

On the way home from an outing to the Great Wall, my kind host declared he knew a place where we could buy some apples. The small car (with six people in it) belching diesel, bumped and turned along country lanes for a very long hour. Eventually the farm was located, a deal was struck for the apples, at a giveaway price, and the picking began. Another exhausting hour later, and loaded with an abundant harvest of small but delicious apples, we retraced our route and eventually arrived back at the teachers' accommodation.

Christmas came and went almost unnoticed. No holiday, of course, but some curiosity from my hosts especially about the giving and receiving of presents. A small party after work, which I gave, was welcomed and enjoyed. China has still to realise the commercial value of the Santa phenomenon. But for now, the bloke in the red suit must wait for China to learn English ■

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Australian Technology Park, Sydney, Australia 1430.
Ph. (+61 2) 9209 4086; Fax (+61 2) 9209 4081
Web: http://www.chemosensory.com

Production Team
Editor: Graham Bell, Ph (+61 2) 9209 4083 g.bell@unsw.edu.au
Advertising & Subscriptions:
Brian Crowley, Ph (+61 2) 9209 4082, b.crowley@unsw.edu.au
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