Vol 14, No.4 October 2012

Chemo sense

EDITORIAL

Enter the Blogosphere

By Graham Bell
g.bell@e-nose.info

Less than a decade and a half ago, no-one but a few Stanford geeks had heard of Google. Now it is known to almost every computer user in the world. Google and its many versions (such as Google Earth, Google Maps and Google Scholar) serve many purposes, but Google's primary use remains the direction of a computer user to crucial sources of information. It is possibly the most important humanitarian innovation since the internet itself. Google is a channel through which the light of knowledge is accessed by countless millions of people. Happy 14th birthday, Google Inc., born 4th September 1998.

As that 'birth" was happening, we were devising the first issue of *ChemoSense*. We have since published 56 quarterly issues and over 500,000 words about the important field of chemosensory research. In 2003 we changed from printed hardcopy to electronic-only communication. The cost saving was significant, and allowed *ChemoSense* to survive and serve an even greater readership.

As the power of the internet grows, we now face questions of whether it is possible or even necessary to continue in the brave new world of free, open-access

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Sensory Insights: Recent research advances

John Prescott
TasteMatters Research & Consulting prescott18@gmail.com

Reprinted from: http://prescotttastematters.blogspot.com.au/
& www.taste-matters.org

CHOOSING TO LIKE OR LIKING TO CHOOSE?

How do you know what foods you like? Simple. It's that inner voice, that warm feeling, that ..... subjective positive 'something' whenever certain foods are thought about or mentioned or available. Tapping into this subjective state is, at first sight, relatively straightforward. If I want to know which food you like or which of several you prefer, I can ask you. Sensory and consumer scientists do this all the time. You can be asked to provide a rating of liking for a food, or be asked to rank foods in order of preference, or simply choose one food out of several to consume. Each of these approaches accesses some aspect of what

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INSIDE:

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information. We have entered the age of the blog, and the "blogosphere". There is no barrier to entry for a blogger. Anyone with internet access can post any kind of material, good or bad, with very little obstruction (in most countries) from governments and internet service providers. Sound and vision can be freely "posted" on vehicles such as *YouTube*, to live or die by people's interest in the material. It's a case of "publish and be damned". Damnation happens: "information" and "free speech" communicated on these media have had dire consequences, most recently in deadly riots within many Islamic communities.

It becomes important for users of web-based information channels to be selective: to take notice of good information and reject and ignore the false and ill-intentioned. For those who wish to use the blogosphere to communicate to the well-intentioned recipient of information, it is essential to post material of good quality and voracity. The reader is the consumer, editor, reviewer and censor of the blog. The reader is also developing "blog fatigue".

For communicative scholars and academics, the internet channels offer an opportunity to reach untold numbers of readers and in places undiscovered by journal publishers. In this issue we bring you reproductions (with permission) of three recent blogs by the esteemed chemosensory scientist, John Prescott. In them, he directs your attention to important issues in chemosensory science. This is high quality blogging: the issues are important to people in the field and to society, and the thinking behind them is deeply considered and offered in the best faith.

So where does this leave a communication vehicle such as *ChemoSense*? Except for the selective role of editorial input, regular timing, a familiar format, an ISSN number, the broad scope of high quality authors and the large recipient list of important people, there is not much reason not to bow out and leave the task of communicating developments in chemosensory science and commentary on it, to bloggers. For the time being, however, readers will have access to electronic media including ChemoSense and high quality scientific blogs. Time and evolution will resolve the matter. In another 14 years things may be unrecognisable.

AACSS: For those interested in attending a scientific meeting on the chemical senses in Australia, there will be no meeting of AACSS in 2012, but one will be held in 2013 at Hamilton Island, The Great Barrier Reef, 20-22 June 2013 ■

Sensory Insights: Recent research advances
continued

you are feeling towards the food at that moment. They reflect the subjectivity of your preferences.

Deriving subjective measures is sometimes seen as a problem, mainly because we often equate objectivity with reliability and hence see subjective responses as somehow inferior and unreliable. This in turn has led to searches for objective measures of subjective states, the most recent of which is brain imaging, typically via fMRI techniques. While it is perfectly possible to show brain correlates of positive and negative emotions associated with foods, there is the rather important question of what is used to validate the brain response. That's right .... a subjective report.

Turning to technologies such as MRI is understandable because it is a natural assumption that technology solves problems. Yet, to help us understand likes and dislikes there are some far more basic questions that need to be addressed. Why, for example, when a person provides a high rating of liking for a food in a sensory test does this often fail to predict what they will purchase at a later date? At one level, the answer is obvious. Eating a small piece of confectionary in a test situation – even if it is judged as very delicious (a 10!) – differs from real life eating in that the context is artificial, the amount is unrealistic, the influence of brand is often absent, and you are removed from all those factors that are influential in making choices.

Studies in the psychology of decision-making have shown repeatedly that situational factors including one's mood at the time, and a variety of environmental influences (including, for example, the weather), are incorporated into decisions. These influences are not only often unrelated to underlying preferences, but they also operate largely outside of our conscious awareness. In other words, your selection of *Biffo Brand Baked Beans* may be as much about the fact that it is cold outside as it is about your likes and dislikes. This is not good news for a food industry wanting to predict consumer behavior from the basis of sensory tests. It doesn't mean that the sensory tests are useless, merely that they serve only to make sure the sensory properties are within acceptable parameters.

Unfortunately, there's more bad news. It is widely assumed that attitudes, beliefs and emotions, including preferences, precede behaviours: I wear my seat belt because I value road safety; I smile because I am happy; I choose food A over food B because I prefer food A. But none of these things are necessarily true, at least not all of the time. Let's take emotions. More than a century ago, the pioneering psychologist William James wrote about expression as being central to the experience of emotions, and raised the possibility that we might experience subjective emotions as a *consequence* of monitoring our physiological and behavioural responses to situations. According to James, it wasn't at all clear that the fear we experience when being chased by a bear (those were dangerous times!) is not due to

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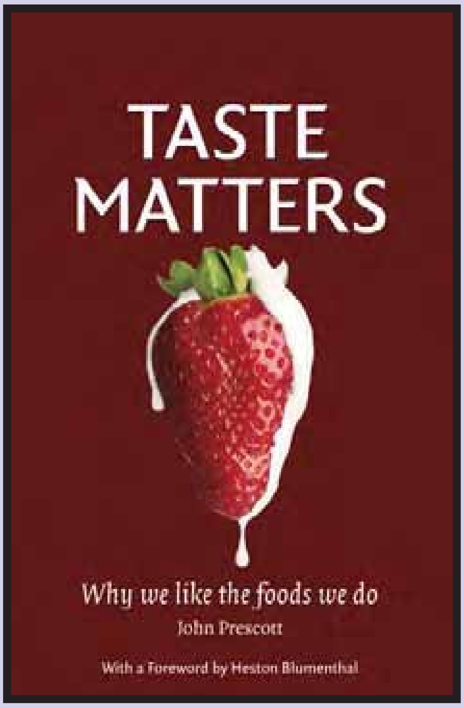

the fact that we feel our heart racing, and our palms sweating, rather than *vice versa*. A somewhat similar view was proposed decades later by another psychologist, Stanley Schacter, who showed that whether a drug makes you anxious or happy can depend entirely on the context in which its effects are experienced.

Most recently, a variant of this idea – the facial feedback hypothesis – was proposed to explain how facial expressions might not only reflect emotions, but also produce them. This hypothesis was tested in an ingenious experiment in which facial muscles were manipulated by having the participants hold a pen between their teeth, parallel to the mouth, forcing the facial muscles into a smile. Compared to a control group who simply held the pen in their hand, these participants rated a set of cartoons as funnier. In effect, forcing a smile produced the same type of mood state usually thought to produce smiles.

What does all this social psychology have to do with food likes and dislikes? A recent study has confirmed a number of findings from the past decade that the decisions and choices that we make play an active role in producing the preferences that we assume lead to those choices in the first place. Alos-Ferrer and colleagues [1] asked groups of university students to rate their liking for holiday destinations. The experimenters then selected four of these: two were moderately, but equally liked; one was liked less than these; and another was liked more. Each of the moderately liked destinations was then paired with one of the others, and the students were then presented with these pairs and asked to pick one from each pair. This produced a situation where one of the equally liked destinations was paired with a less liked destination (and therefore likely to be picked) and the other was paired with a more liked destination (and therefore unlikely to be picked). In other words, the students were forced into choosing one alternative and rejecting one alternative, when both were previously rated equally liked. When the students were once again asked to rate the destinations, the researchers found that the chosen destination was now preferred over the one that wasn't chosen.

One explanation for this effect – now shown in several studies using different types of stimuli – is that increases in liking are based on observations and interpretation of our own past behavior. For example, we might infer from that fact that we have already chosen an alternative that that alternative was previously valued, and this in turn creates a biased view of the alternative's current value. An account of choices was also provided by Festinger's cognitive dissonance theory, first proposed in the 1950s. Festinger suggested that a choice between equally valued alternatives creates an unpleasant psychological tension (or dissonance) that is relieved when we decide that one alternative is actually superior to the other.

Both of these views rely on recall of past choices. However, in another recent report in which choices determined preferences for odours [2], the participants were asked to recall their choices. It was found that preference changes *did not* rely on an explicit recall of which odour was chosen and which one wasn't. This suggests strongly that the change is preference was not simply a way of justifying the choices that had been previously made. Another explanation not requiring an explicit memory of choices comes from studies showing that neutral stimuli used as cues become more valued when they signal either the availability of choice [3] or are associated with an evaluation [4]. Thus, choice seems to be intrinsically rewarding and so that anything associated with choice becomes preferred.

This being the case, should we be relying on choices or subjective measures of food preferences? From the point of view of assessment of consumer likes and dislikes, it is clear

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that the process of forcing a choice induces a preference. We might expect then that sometimes choices and preferences are highly correlated and sometimes not, depending on how such tests are conducted. But is this any different from what we all experience in a supermarket? Probably not, but recall that choices can be decided by aspects of the context that may be unrelated to the product chosen. Thus, those situational factors that momentarily influence the choices that you make now become highly influential in shaping your longer-term preferences. This does not mean that either choices or measures of preferences are meaningless, just that they are more complex than we generally assume.

1. Alos-Ferrer, C., Granic, D-G., Shi, F. & Wagner, A.K. (2012). Choices and preferences: Evidence from implicit choices and response times. *Journal of Experimental Social Psychology*, in press.
2. Coppin, G., Delplanque, S., Cayeux, I., Porcherot, C. & Sander, D. (2010). I'm No Longer Torn After Choice : How Explicit Choices Implicitly Shape Preferences of Odors. *Psychological Science*, **21: 489-493.**
3. Gast, A. & Rothermund, K. (2011). I Like It Because I Said That I Like It: Evaluative Conditioning Effects Can Be Based on Stimulus-Response Learning. *Journal of Experimental Psychology: Animal Behavior Processes* **37: 466-476.**
4. Leotti, L. A. & Delgado, M.R. (2011). The Inherent Reward of Choice. *Psychological Science*, **22: 1310-1318.**

FEELING TASTES

When we learn about the senses, it is usually as if we are studying a set of five or six separate devices, each responsible for a distinct function: sight, hearing, touch, smell, taste, and perhaps balance. But sensing – and in particular, perception - is not really about what the sensors (eyes, eardrum, tastebuds, and so on) do, anymore than computing is mostly about the keyboard or mouse. Perception is a function of what our brains do with the signals arriving from our peripheral sensory receptors.

There has recently been a distinct shift in emphasis in both behavioural and neuroscience research to examining the ways in which information from different sensory system interacts to provide information about the world. In particular, there has been increasing interest in how odours and tastes combine to generate perception of food flavours [1]. The idea of sensory integration in the perception of flavour is not new. Writing in the early 19th century, the gastronomic pioneer, *Brillat-Savarin was "tempted to believe that smell and taste are in fact but a single sense, whose laboratory is the mouth and whose chimney is the nose"* [2].

An emphasis on the importance of senses working together has been termed an "ecological approach" to perception, an approach especially associated with the psychologist J.J. Gibson. Gibson [3] argued that the primary purpose of perception is to seek out objects in our environment that are biologically important. As such, the physiological origin of sensory information is less relevant than that the information can be used in object identification. Effectively, then, the key to successful perception is that sensory information is interpreted as qualities that belong to the object itself. Viewed this way, flavour is a functionally distinct sense that is "constructed" from the integration of distinct sensory systems (smell, taste) in order to identify and respond to objects that are important to our survival, namely foods.

Even what we think of as distinct senses may in fact be multisensory. Many of the "odours" that we encounter everyday in fact stimulate both our sense of smell and the touch, pain and temperature receptors in the nose that belong to the trigeminal nerves. So, the coolness of menthol is a tactile sensation, rather that a smell. The role of both olfactory and trigeminal receptors in producing smells is well-known. The role of the sense of touch in our perception of taste is less well understood, but may be vital in our taste experiences.

Under most circumstances, taste and tactile sensations in the mouth are so well integrated that we cannot begin to disentangle them. After all, foods and drinks simultaneously produce both tastes and tactile sensations. However there is growing evidence that our tastes experiences may themselves be multisensory. From a physiological point of view, this is not too surprising since taste buds contain fibres that respond to touch and temperature. This explains why, for example, a moving tactile stimulus, e.g. a cotton bud moved along the

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side of the tongue, has been shown to "capture" a taste placed on the tongue, with the location of the taste following the movement of the cotton bud.

Recently, sweet and sour/salty tastes have been shown to be elicited by, respectively, heated and cooled probes placed on areas of the tongue that contain taste buds. This research, by Barry Green and colleagues at the John. B. Pierce Laboratory at Yale University in the USA, has now been followed by another study from this laboratory showing the importance of temperature in taste perception. Green & Nachtigal [4] observed a difficulty in perceiving sweet tastes – for example, while licking a lollipop – when the tongue remained outside of the mouth. Once the tongue was retracted into the mouth, however, the sweetness was obvious. These researchers examined that possibility that the higher internal mouth temperature was responsible for this effect. Prior research had shown that temperature could influence sweetness, an effect that is evident when we compare the sweetness of ice-cream straight from the freezer with the same, but now much sweeter, ice-cream that has been allowed to melt at room temperature.

By comparing the rate of adaption to sweetness – the way in which the sweetness declines with continued exposure to the taste – at different temperatures, Green & Nachtigal were able to show that warming the tongue outside of the mouth by dipping it into a solution with the same temperature as inside the mouth (37^{O}C) produced the same effect on sweetness as withdrawing the tongue into the mouth.

An intriguing question though is why the same effects did not occur when the study was carried out using the bitter taste of quinine. Why there are particular interactions between sweetness and temperature and not other tastes and temperature is unknown, but is again consistent with earlier studies that have been unable to consistently show that tastes at different temperatures vary in intensity.

Another theoretical contribution by J.J. Gibson was to make the distinction between the active gathering of information via the senses (sniffing, listening) versus a more passive process (smelling, hearing). Implied in this distinction is a process by which we attend to the sensory information, but also involves movement, and tactile feedback from that movement. For example, if I want to gather more information about something that occurs in my peripheral vision, I'll turn towards it.

Active perception seems to be a hallmark of eating. We sniff the aromas coming off the food, we sip and reflect on the flavour of the wine, and manipulate the food in our mouth to maximise the tastes and flavours. Surprisingly, however, there has been very little research on what effects such active perception has on our perceptions of foods and beverages. In the case of eating, though, one effect of active perception is to stimulate our sense of touch, once again producing a multisensory experience. One well-known example of this is the sensation of astringency. Eating a green banana, or walnuts, or drinking black tea, cranberry juice or red wine all produce sensation of drying or roughness on the tongue and palate ..... but only if we move the tongue so that the two surfaces connect with one another.

Green and Nachtigal, in another study of how tastes and touch sensations interact, compared the effects of passive to active tasting of sweet, salty, sour and *umami* (mono-sodium glutamate, or MSG taste) tastes. In the former condition, tastes were applied with a swab to different parts of tongue, but tongue remained immobile. In the active condition, the participants were asked to touch the tongue to the roof of the mouth and also swallow. Hence, this condition more closely resembled normal eating.

This study did indeed find that active tasting had a strong impact on taste intensity ...... but only for the taste of MSG. MSG taste intensity was much higher during active tasting but that of the other tastes was largely unaffected. Of all the tastes, *umami* tastes have seemed to have a "mouthfilling" quality. Moreover, as these researchers point out, active food manipulation including chewing is needed to break down the food's physical structure, releasing the glutamate and other amino acids responsible for umami tastes. This process may also be behind the fact that in this study, MSG intensity in either condition was highest at the rear of the tongue. No such 'tongue geography' effects were seen however for the other tastes.

The more taste perception is studied,

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the less it appears to be a simple interaction of soluble molecules with receptors in taste buds. This study further reinforces an emerging view that, in the mouth, what we touch is what we taste, and vice versa.

1. Prescott, J., Psychological processes in flavour perception, in *Flavour Perception*, A.J. Taylor and D. Roberts, Editors. 2004, Blackwell Publishing: London. p. 256-277.

2. Brillat-Savarin, J.-A., *The Physiology of Taste*. 1994 ed. (1825), London: Penguin Books.

3. Gibson, J.J., *The Senses Considered as Perceptual Systems.* 1966, Boston: Houghton Mifflin Company.

4. Green, B.G. and D. Nachtigal, Somatosensory factors in taste perception: Effects of active tasting and solution temperature. *Physiol. Behav.*, 2012. *in press*.

DRIVING A BETTER TOMATO

Even simple foods and beverages are composed of sometimes dozens, but often hundreds, of different chemical compounds. For the most part, these are volatiles, that is, compounds that in the first instance contribute to the aroma of the food. Together with the non-volatile taste compounds – the sugars, acids, salts, amino acids and so on – the aroma compounds make up the characteristic flavour of the food. We know that not all aroma volatiles contribute equally to flavour: some may have no impact, others are crucial to defining the flavour of the food. A subset of these important volatiles may also be the key compounds that determine whether or not you like that flavour.

Take the tomato .... or the strawberry. These are two fruits about which most of us will have strong opinions in regards to flavour quality. We all tend to have an idealized tomato or strawberry flavour memory, somewhere from our past, with occasional reinforcements from holidays in countries where the great flavour of these fruits seemed to have been somehow preserved. But the everyday fruit? It is easy to be impressed by the technical skills that must have been employed to eliminate flavour from our supermarket tomatoes and strawberries.

When let down by the flavour of regular produce, some consumers turn to organic versions in the belief that this approach produces better flavours. Even if this is true (and there is little evidence as yet), then access to sufficient quantities at local supermarkets is likely to be a problem for some time. Breeding programs are a potentially more fruitful approach to producing better flavour. After all, certain varieties of fruit are already selectively bred to have better resistance to disease, better handling qualities, and in some cases, flavour. Hence, Heirloom tomatoes are seen (in the USA at least) as a variety that typically has better flavour appeal.

So far, so good. But in producing a better tomato, what would the breeders breed for? Or, if we wanted to genetically modify a tomato to produce better flavour, which genes would we target? The answer comes down to knowing which volatiles are the most crucial ones that best deliver the most acceptable flavour. To date, an assumption has been made for tomatoes and other fruits and vegetables that those volatiles present in the greatest amount and which are perceived most easily (that is, have the lowest detection thresholds), are the most important contributors to flavour and therefore to consumer acceptability.

The relationship between aspects of flavour and preferences is a key question throughout the food industry. Companies often wish to know which characteristics of their products (or indeed their rival's products) is 'driving' preferences. This is, what qualities are most responsible for variations, up or down, in liking, and conversely what characteristics are irrelevant. A traditional way of doing this has been to have consumers rate liking for products, while specially trained panels rate the intensity of sensory descriptors. The outcome could potentially be simple - your product has too much acid and not enough sugar – but seldom is. Terms such as *grassy, lemony, medicinal*, or *cherry* might be used quite consistently by the trained panel, and also may link well to consumer preferences. However, quite a large extra step is required before a company could then alter their product to maximize the good attributes and minimize the bad ones. A major issue is that terms used by trained panels may reflect the perception of one compound in the food or a combination of many. When we turn to horticultural products, it becomes even more complex due both to variations across seasons and sample, and also the fact that the grower requires either a breeding program or

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gene technologies to implement changes.

Now, a broad multidisciplinary group at University of Florida (USA), including prominent sensory/consumer scientists Linda Bartoshuk and Howard Moskowitz, has addressed the question of what drives tomato preferences by powerfully combining genetic, sensory and chemical profiling of a wide range of tomato cultivars [1]. Their results are surprising on a number of fronts, not least from what they *did not* find. The levels of compounds thought to be important for tomato flavour, or their thresholds, had little consistent impact on whether or not a tomato was liked or disliked in the sensory testing. Part of the study included tomatoes from transgenic plants in which a gene that regulated the levels of so-called C6 volatiles (such as the grassy-smelling compound *cis-3-hexenal*) was "switched off". While these tomatoes were certainly different to the tomatoes with normal high levels of C6 volatiles, their flavour was liked equally.

So what *does* contribute most to tomato preferences? The study found this to be a complex question, not only because of potentially dozens of volatile compounds involved but also because the levels of the compounds differed by up to 3000-fold across the tomato samples tested. In addition, some varieties did not perform as expected in the blind sensory tests - supermarket tomatoes were sometimes preferred to Heirloom varieties.

We already know that a strong tomato flavour and sweetness are important influences on tomato liking. The researchers were able to pin down a group of 12 compounds that had a large impact on tomato flavour. Intriguingly, sweetness was also determined by multiple volatile compounds, some of which overlapped with those important to flavour. In particular, three compounds – *geranial* (with a rose-like aroma), and 2-methylbutanal and 3-methyl-1-butanol, both malty-smelling (and contributors to the flavour of a diverse range of other foods/beverages, including dairy products, coffee, and wines) – determined the perception of sweetness, independent of actual sugars in the tomatoes

There has been considerable recent research interest regarding the ability of such retronasal (orally-presented) odours to enhance tastes [2]. Some studies have, for example, indicated that a tastant such as salt can be reduced without loss of acceptability in those foods in which salty-smelling odours are enhanced. What the data from the Univ. Florida study show is that the consumer's perception of, and liking for, sweetness in tomatoes is not simply a matter of the glucose or fructose levels in the fruit. Rather, sweetness is more than a taste; it is a flavour, a combination of sweet tastes from the carbohydrates and sweet smells from the volatile compounds.

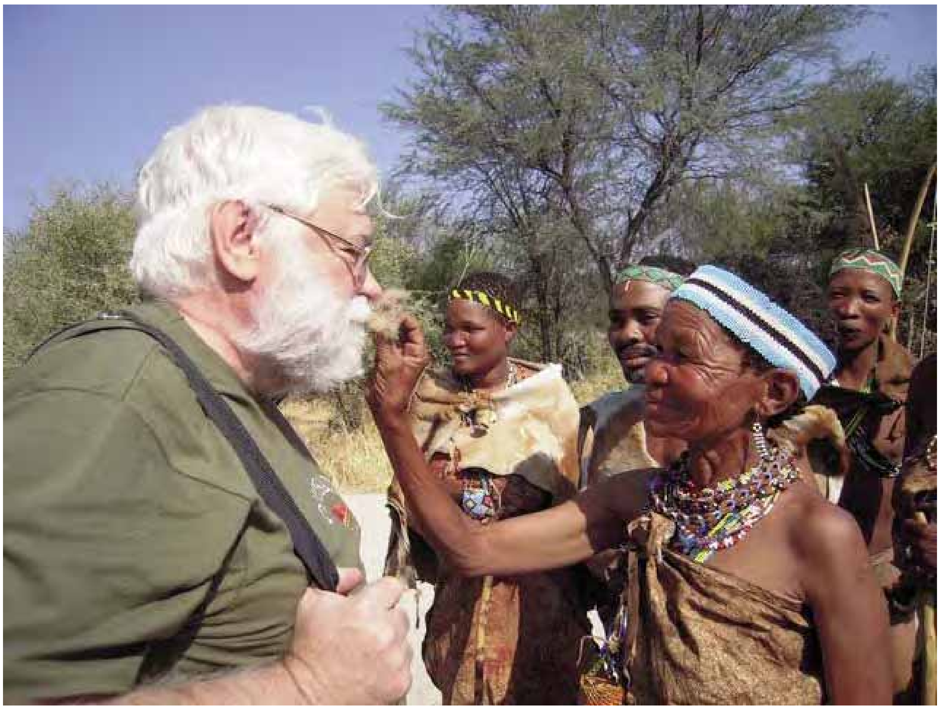
The crucial lesson from this study is that the powerful combination of sensory/psychophysical, chemical and genetic tools can provide more reliable clues to the sources of consumer preferences. Without these different kinds of data, a finding that non-preferred tomato varieties had low sweetness levels might have led to a conclusion that a higher sugar content was required. In a context of promoting fruit and vegetables as a healthier and tastier alternative to fast foods, a breeding strategy to 'correct' the apparent defect might be counter-productive. Instead, demonstrating that volatiles can be important determinants of sweetness and acceptability could justify breeding varieties perhaps with lower sugar levels but enhanced sweet-smelling volatiles.

1. Tieman, D., et al., *The Chemical Interactions Underlying Tomato Flavor Preferences.* Current Biology, 2012, 22(11), 1035 –1039
2. Prescott, J., Psychological processes in flavour perception, in *Flavour Perception*, A.J. Taylor and D. Roberts, Editors. 2004, Blackwell Publishing: London. p. 256-277■

NEWS

Olfactory Greeting : “This is the Smell of our Country”

By Graham Bell: g.bell@e-nose.info



Graham Bell performing a San sniffing greeting.

On a recent trip to Botswana in Southern Africa, I had the pleasure of meeting a small family of San people who live in the Kalahari Desert. At the beginning of the ritual greeting, the oldest member of the group approached each visitor with a small piece of fur which she dipped into a tiny leather bag, rubbing it on something unseen in the bag. The fur was then held to the visitor’s nose. She said in her amazing click-tonal language words translated as “Welcome. This is the smell of our country”.

I have travelled relatively widely and met people from many cultures but this is the first formalised olfactory greeting I have ever received.

There was something deeply relaxing and sincere in this procedure. The odour of the fur was musky and beautiful. The ritual completed, the group was introduced by the translator and we passed a couple of hours together in the bush, being shown “bushman” hunting skills, the making and shooting of arrows and poison for arrow tips, making quivers, the use of particular thorns as needles, digging for scorpions and handling the mean little beasts, fire making, and playing games that involved both athletic prowess and mental agility.

Displacement of desert people in Namibia and Botswana in recent years has drawn concerned comments from international humanitarian agencies (2006, UN Committee on the elimination of racial discrimination). The people we met were spending time in a benevolent environment, among the wide-eyed tourists of which I was one. It was a great privilege to meet these famous hunters and nomads whose culture is many tens of thousands of years old, as witnessed by the paintings left by their ancestors all over now-inhabited parts of Southern Africa. With “our” group’s home country some 600 km away, I wondered how much longer there will be a sweet musky smell to associate with it, as the diesel fumes and dust from mining machinery fills the air and drives out all before it.

I hope this item of news will engender support for legal and political measures being taken to protect the San and other Southern African desert people, and support their need for land and hunting rights as well as economic opportunities they may rightfully derive from the invasion of their fragrant country by mineral developers and tourists.

For more information on the San people of Botswana: http://en.wikipedia.org/wiki/Bushmen ■

Upcoming Events

13-17 October 2012	**Neuroscience 2012** New Orleans USA www.sfn.org
3-7 February 2013	**Australian Neuroscience Society** Melbourne, Victoria, Australia www.ans.org/ans-annual-conference/
7-21 April 2013	**AChemS** Huntington Beach, California, USA www.achems.org
2-5 July 2013	**ISOEN 2013: International Symposium on Olfaction and Electronic Nose** EXCO, Daegu, Korea www.isoen2013.kr
11-15 August 2013	**10th Pangborn Sensory Science Symposium** Rio de Janeiro, Brazil Abstract Deadline: 15 February 2013 www.pangborn2013.com
8-11 September 2013	**21st International Clean Air and Environment Conference** Sydney, Australia www.casanz.org.au

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P.O. Box 488 Gladesville, NSW Australia 2111
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