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Confusing tastes with flavours

Charles Spence[1], Malika Auvray[2], & Barry Smith[3]

1. Crossmodal Research Laboratory, Department of Experimental Psychology, Oxford University, Oxford, UK
2. Institut Jean Nicod, CNRS UMR 8129, Ecole Normale Supérieure, Paris, France
3. Centre for the Study of the Senses, Institute of Philosophy, University of London, UK

ABSTRACT

People's use of the terms 'taste' and 'flavour' is often confusing, both in everyday use and in the academic literature. Failure to distinguish these 'basic' terms is likely to slow the development of our understanding of the chemical senses, currently a rapidly growing area of study in perception science. Our aim here is to defend the idea that, ultimately, it doesn't make sense to treat experiences of the putative basic tastes, such as 'sweetness' and 'sourness' in our everyday experience as *tastes*. Rather, we suggest, the evidence supports the view that they should be treated as flavours, just like 'fruity' or 'meaty'. Here we highlight the pervasive nature of the confusion between tastes and flavours, and outline a number of reasons for its occurrence, linked to the topics of attention and oral referral. We then provide psychological, physiological, and philosophical reasons to support the stance that tastes should be classified as a sub-component of flavours and show how doing so helps to dissolve certain debates.

Keywords: Flavour, taste, senses, perceptual system, sensory modality

1. Introduction

The uses of the terms 'taste' and 'flavour' are far from clear in either our everyday language or in scientific journals. To many, these terms are interchangeable (or at least they are used in that way); to others they are definitely not. But even among those who distinguish the two terms, their use of them is seldom consistent. Many researchers who recognize a distinction seem to use the term 'taste' when what they appear to mean is 'flavour'. We will use as our definition of flavour the following from the International Standards Organization (ISO 5492, 1992, 2008) where flavour is defined as a: *'Complex combination of the olfactory, gustatory and trigeminal sensations perceived during tasting. The flavour may be influenced by tactile, thermal, painful and/or kinaesthetic effects.'* (see Delwiche, 2004, p. 137; see also Green, 2004; Lundström et al., 2011; Spence, 2012b; Tournier et al., 2007). Taste is defined as those sensations that result from the direct stimulation of the gustatory receptors localized on tongue and occurring elsewhere in the oral cavity.

Although these definitions are broadly accepted, several core questions remain open: Can tastes be elicited by the stimulation of some receptor surface other than those found on the tongue and in the rest of the oral cavity (Nilsson, 1977; Trivedi, 2012)? Does flavour perception involve the stimulation of receptors other than those classically thought to be involved in taste, smell, and trigeminal sensation (Murphy et al., 1977; Spence et al., 2010)? Below, we show how the incautious use of the terms 'taste' and 'flavour' can lead to erroneous and confusing claims, which, in turn, may well slow progress when researchers attempt to provide a correct epistemology of flavour perception. Here, it should be noted that research on flavour is no longer the obscure topic (at least for psychologists, philosophers, and cognitive neuroscientists) that it once was. The increased interest in this field of investigation stems both from the broad consequences involved for the food and beverage industries (e.g., Simons & Noble, 2003), and from a growing belief amongst many cognitive neuroscientists that a better understanding of the multisensory processes at stake in the perception of the flavours of foods and beverages might well shed light on theories of multisensory integration more generally (see also Murray & Wallace, 2011; Spence, 2012a; Stevenson, 2009). The rapid growth of interdisciplinary research on the topic of flavour that has been seen in recent years[1] makes it all the more timely to try to get our terms straight (cf. McBurney, 1986, for an earlier attempt to take the confusion out of the fusion of the chemical senses).

Below, we review the evidence on flavour, taste, smell, somatosensory, and trigeminal sensations. We start by outlining some of the confusions that symptomatically occur at the linguistic level, before going on to discuss the perceptual and cognitive factors underlying these confusions. Finally, we end-up by proposing what we hope to be a satisfactory resolution to the confusing use of the terms ‘taste’ and ‘flavour’, namely we claim that when we are talking about our perceptual experience, there is no taste that isn’t a flavour.

2. Linguistic issues and explanations

This section aims to resolve some of the semantic issues in this area. After discussing the complexity of the use of the terms ‘taste’ and ‘flavour’, we provide basic characterisations of the terms used in the field of flavour research.

2.1. The complexity of the terms taste and flavour

Starting with the term ‘taste’ and to what it refers to in a food context, there are several possibilities: 1) Taste (or tastes) as qualities of the foods or liquids we consume; 2) Taste as the sense we use to discover these qualities; 3) Taste (or tastes) as the characteristic experiences generated by that sense when we eat or drink. Note here that people often run these different uses of the term together, and the consequences of doing so are, we argue, far from trivial. Indeed, some have argued that the failure to resolve a number of important scientific debates, such as the nature-nurture debate, boils down, at least in part, to the way in which different groups of scientists have, over the years, understood and interpreted a few key terms (Angier, 2009; Lehrman, 1970; see also Reed & Knaapila, 2010). As Stein et al. (2010, p. 1713) put it recently:

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[1] As, for example, evidenced by the launch of several new journals in this area, including a journal entitled *Flavour*, along with special issues and supplements appearing in many of the leading science journals, involving *Nature* (in 2012; see http://www.nature.com/nature/journal/v486/n7403_supp/index.html#out) and *Current Biology* (forthcoming).

> Whatever phenomenon we choose to study, first and foremost, we must define it. To do so we must deal with the issue of semantics because different definitions lead to different kinds of research questions. These, in turn, determine how we construct conceptual frameworks that help us to understand those phenomena.

As an illustration of this point, consider the term 'sense modality' as it is ordinarily used to speak about the five senses, and as it is used in the psychology and neuroscience literature to talk about physiological mechanisms. It doesn't follow from the fact that common sense and sensory science use the same words that they necessarily mean the same thing when using them. It certainly doesn't follow from the fact that science distinguishes more than five senses that common sense is mistaken (a point that has been cogently made by Nudds, 2011): that will depend on how the common sense and scientific understandings of the notion of sense relate to one another.

The last few years has seen a revival of interest in the question of how exactly we should distinguish between sensory modalities, and this question stands at the core of several theoretical research areas (see Macpherson, 2011, for a recent volume gathering both contemporary and classic articles on the topic). It is therefore all the more critical in the growing field of research on flavour perception, where definitions often vary across the different disciplines, to answer the question of what exactly distinguishes taste from flavour since this has broader implications for the debate concerning how we should distinguish between sense modalities. It is not just a matter of what distinctions we can make between different perceptual experiences, but rather, a question of which distinctions matter in terms of advancing our knowledge and understanding of the phenomena in question (McBurney, 1986).

Not taking into account the question of definitions runs a risk of serious confusion. As an example, take the following quote from the introduction to philosopher, Carolyn Korsmeyer's (2005, pp. 3-5) edited volume *The taste-culture reader: Experiencing food and drink.* There she states that:

> Except where otherwise specified, the word “taste” in this book serves as a shorthand for the experience of flavour in all its dimensions, including those supplied by the other senses.

So far, so good. But then, shortly thereafter, she goes on to say that:

> Not all flavours can be classified according to the four “basic” types, and some of the most sought-after tastes are spices…

Presumably the four ‘basic flavour types’ that Korsmeyer (2005) is referring to here are actually the four basic tastes: bitter, salt, sweet, and sour (see below for a discussion of additional basic tastes such as umami and metallic). It is easy to see, then, how a reader might quickly become confused.

Similar problems also arise when it comes to our understanding and our use of the term ‘flavour’. In its everyday use, as well when following the ISO definition, it is simply meant to pick out the combination of taste, smell, and trigeminal irritation (should it occur). However, other influential researchers in the field use the term in order to talk about a separate psychological construct (e.g., see Prescott, 1999; see also Abdi, 2002; Petit et al., 2007; Stillman, 2002). For instance, according to John Prescott (1999, p. 350), flavour is a *functionally* distinct sense, although it is *cognitively* constructed from the integration of two sensory systems that are physiologically distinct: olfaction and gustation.

Here it is perhaps also important to bear in mind that others working in the food industry often refer to the odour/aroma of orange, say, as a flavour; they do so on the understanding that the majority, some say as much as 80%, of what we think of as flavour comes from the nose (e.g., Martin, 2004; Murphy et al., 1977; Rosenblum, 2010; Shankar et al., 2010).

Given these difficulties in disentangling what belongs to taste and what belongs to flavour, it is easy to see how a naive reader can become confused. Correspondingly, in the academic field, both food critics (e.g., Davidson, 1988, p. 13) and food scientists (e.g., McBurney, 1986, p. 123) have been known to express their frustration at their inability to define the relevant terms meaningfully when it comes to talking about the chemical senses and flavour.[2]

> We should resist the categorizing imperative. The senses did not evolve to satisfy our desire for tidiness. (McBurney, 1986, p. 123)

> If tastes are married to aromas, as they are to produce flavours, the whole problem of the description becomes even more difficult. And here I stop. (Davidson, 1988, p. 13)

The problem of providing a characterisation of taste and flavour goes far beyond merely idle terminology: whether one considers sweetness, for example, to be a taste or a flavour attribute, hinges fundamentally on what one thinks a taste or a flavour actually is. If human flavour perception is thought of as cutting across receptor types and defined as what provides basic information about the nutritional qualities of the foods and beverages we eat and drink (Auvray & Spence, 2008) then sweetness should certainly be considered a flavour. On the other hand, if one considers that the senses should be characterized by a strict correspondence to receptor types, the term 'sweetness' should only ever be correctly used to describe a taste; that is, a gustatory quality. This way of capturing the difference between sensory systems and human perception is in line with Matthen's means of distinguishing between sensory modalities and perceptual modalities (see Matthen forthcoming). Put in his terms, a basic taste such as 'sweetness' is a taste as detected by a sensory modality but it is a flavour as detected by a perceptual modality.

In addition, we argue that people are simply not able to isolate in experience the unique consequence of the stimulation of their gustatory receptors. And given that we deploy terms

[2] At a conference of leading food scientists held at the Ingestive Behavior Research Centre in Purdue, Indiana in 2011, no consensus could be reached amongst the many international delegates present with respect to the question of how exactly to define flavour – or rather which senses contribute to our flavour experiences.

for tastes, such as ‘sweetness’, on the basis of our experience, we cannot be talking about tastes proper in this sense, by our (folk) use of the term ‘sweetness’. Furthermore, given that the terms ‘taste’ and ‘flavour’ are often interchangeable in their everyday usage (see Rozin, 1982), our aim in this article is to argue that it does not make sense to treat taste attributes, such as, for example, sweetness, as belonging to a distinct category from flavour attributes, such as, for example, fruitiness or meatiness, which we recognise in our experience of eating and drinking.

2.2. Basic characterisations: Tastes, odours, trigeminal sensations, and flavours

With respect to scientific terminology, the basic tastes that we can detect are widely agreed to consist of bitter, sour, sweet, salty, and umami (e.g., Bartoshuk, 1978; Lawless, 2001; Schiffman, 2000; see Kawamura & Kare, 1987, on umami). The one other basic taste that has, on occasion, been added to this list is metallic (e.g., as in the taste of blood, and as an undesirable aftereffect of taking certain pharmaceutical drugs; see Lawless et al., 2005; Lindemann, 1986; Schiffman, 2000; though see Stevens et al., 2006).[3] However, it is important to bear in mind that there is still some debate here as to whether or not something’s tasting metallic should count as a taste, physiologically-speaking, since it sometimes appears to be modulated by the stimulation of the olfactory receptors in the nasal mucosa; i.e., the experience can differ as a function of whether a participant pinches his/her nose or not (e.g., see Hettinger et al., 1990), and this is not usually thought to be the case for tastants. Hence, one might think, this qualifies it as a flavour rather than a taste (see Lawless et al., 2004; though see below for further discussion of this point).

It actually turns out to be very difficult to find a pure tastant (that is, one that can only be detected by gustatory receptors, and whose perception is not influenced by the stimulation of the olfactory receptors). As Mojet et al. (2005, p. 9) put it: *“We suggest that most tastants can be smelled and that this smell contributes to taste intensity ratings.”* If we take such evidence seriously, and there seems to be no reason why we should not, then the fact that a

[3] Here we will not cover the topic of electrical tastes, that is, taste experiences elicited by the electrical stimulation of the tongue (see Bujas, 1971; Bujas et al., 1974; Keeley, 2002). Notice that electrical stimulation of the tongue can also give rise to the experience of metallic tastes (Cardello, 1981; Lawless et al., 2005).

nasal contribution is involved in the experience of certain metallic-tasting compounds would not in-and-of-itself provide a strong argument against metallic being a basic taste after all. Rather, we can turn this argument on its head, and use it to argue that – contrary to popular scientific belief – most tastants actually give rise to flavour experiences (albeit flavours with only a very weak olfactory contribution).

Odour perception is particularly interesting given its dual status. The olfactory receptors located in the olfactory epithelium can be stimulated either via the nose when sniffing (this is known as orthonasal olfaction), or via the mouth, during eating and drinking, as volatile chemicals rise up through the nasopharynx (this is known as retronasal olfaction).[4] Thus, as Rozin (1982) noted some years back, olfaction appears to constitute a 'dual modality'. First, it provides information about objects in the environment: dangers such as predators and fire, food sources (Stevenson, 2009), and potentially appropriate mates (e.g., Rikowski & Grammer, 1999; Wedekind et al., 1995). Second, the (retronasal) olfactory system also provides information regarding that which an organism is soon to ingest, and which is currently being masticated (i.e., chewed) in the oral cavity (note here that some food odours are only released following mastication, as in the case of cashew nuts; see Crocker, 1950). In people's everyday usage of the term, then, 'to smell' seems to mean detecting a substance whose origin (or source) is localized outside of the body (i.e., ordinary uses would appear to refer selectively to orthonasal olfaction or 'sniffing').

The trigeminal system provides information (conveyed by the fifth cranial nerve; Abdi, 2002; Lundström et al., 2011) concerning chemical irritation and nociception. In parallel with their anatomical separation from the taste nerves in the oral cavity, the trigeminal receptors in the nose (not to mention those found in the mouth, eyes, and, in fact, over the whole of the rest of the body surface; Lawless, 2001) are distinct and separate from the olfactory receptors (Lawless, 1989, p. 57). The influence of trigeminal inputs on flavour perception has, for many years, been underestimated; so much so that some researchers have described it as 'the forgotten flavour sense' (see Lawless, 1989). That said, it is now widely acknowledged that the trigeminal system often contributes to flavour perception (e.g., see

[4] Avery Gilbert (2008, p. 100) has suggested that we may be the only creatures to have two senses of smell.

Abdi, 2002; Green, 1996, 2004; Viana, 2011). Activation of the trigeminal system occurs, for example, when we eat hot chillies or mustard. It is what gives rise to a feeling of heat in the mouth and, on occasion, a pinching, painful sensation at the bridge of the nose (Lawless et al., 1985). The trigeminal system is also responsible for the pungency of certain foods (see Govindarajan, 1979; Green, 1996, 2004), while also mediating the cool sensation we experience when eating peppermint (Crocker, 1950; Nagata et al., 2005).

Capsaicin and piperine are amongst the purest of trigeminal stimulants: Capsaicin gives rise to chemical heat (a warm or burning type of irritation) with little or no apparent taste, smell, or additional flavour elements present (Lawless, 1984). By contrast, many spices trigger a variety of irritative flavour experiences (Lawless, 2001, p. 627). It turns out that numerous ingredients are capable of activating the trigeminal system: *The Handbook of Flavor Ingredients* lists about two dozen common spices and more than 40 flavour compounds that have irritant and/or astringent properties (see also Viana, 2011). Carbon dioxide is another of the ‘pure’ trigeminal stimulants, one that gives rise to an odourless sensation in the nose (Lundström et al., 2011; Wajid & Halpern, 2012). It is also what gives rise to the experience of carbonation (i.e., of fizziness) when drinking sparkling water or champagne (see Chandrashekar et al., 2009; Dessirier et al., 2000).[5]

<u>Oral-somatosensory</u> cues also provide an important contribution to our experience of food and drink. The somatosensory system provides information about the texture and consistency of a food. The stimulation of the somatosensory receptors on the tongue appears to be crucial when it comes to complex food experiences such as the perception of creaminess/fattiness (Bult et al., 2007; though see also Chale-Rush et al., 2007; Mattes, 2009; Sundqvist et al., 2006 Wajid & Halpern, 2012). Our perception of the chewiness of a food results from the activation of the mechanoreceptors in the jaw (e.g., Delwiche, 2004; Lundström et al., 2011). Of course, it is the *active* mastication (not to mention the formation of the rounded food mass known as the bolus that occurs during swallowing) rather than merely the *passive* stimulation of the oral-somatosensory receptors that is key to delivering

[5] Chandrashekar et al. (2009) actually title their paper, *The taste of carbonation*, creating yet another source of confusion when it comes to attempts to try and define, not to mention distinguish between, the sensory modalities involved in flavour perception.

such experiences (see also Shepherd, 2012, Chapter 17). This latter observation highlights the importance of proprioceptive/kinaesthetic inputs to our experience of foods. It is necessary for, but not a constitutive part of, flavour.

Thermal temperature cues constitute another important influence on our taste and flavour perception. As Crocker (1950, p. 7) put it a number of years ago: *"Hot beverages and soups depend upon temperature as an important part of their flavour.*" Temperature and texture cues modulate, or else should be thought of as a part of, the multisensory perception of flavour. So, for example, when liquids (such as coffee) are cooled, their perceived bitterness is often accentuated. Similarly, chilling a wine enhances our perception of both its acidity and bitterness. Perceived sweetness, meanwhile, typically declines as the temperature at which a food or beverage is served falls. Thus, temperature is one of the attributes of a food or beverage that can influence not only our perception of complex flavours, but also our perception of what are commonly considered as the basic tastes. In recent years, technological developments have allowed researchers to demonstrate that the effects of temperature and texture change on flavour perception cannot simply be attributed to any physical change in the release of volatile compounds from the surface of the food or beverage (e.g., see Bult et al., 2007).

Thermal tastes refer to the 'illusory' tastes that many people experience when a tasteless thermal probe is placed on their tongue. These tastes are illusory in the sense that the entire experience derives from the temperature cue, whereas in the cases described above, changes in the temperature of a foodstuff merely modulated the experience of a tastant that was already perceptible. It has been reported that roughly 1/3rd to ½ of the population experience such a 'thermal-taste' illusion (see Cruz & Green, 2000; Green & George, 2004). Barry Green and his colleagues found that by raising or lowering the temperature at various points on people's tongues, they were able to elicit sensations of sweet, sour, salty and bitter. Intriguingly, those individuals who experience the thermal-taste illusion also tend to experience other 'tastes', i.e., flavours, as being more intense as well (Bajec & Pickering, 2008). As yet, little is known, about how thermal stimulation activates taste receptors. It may be akin to the electrical stimulation of the taste buds.

Flavour perception is the next issue for discussion. Where does it fit in? First, notice that when people describe the *flavour* of a foodstuff, they *often* use descriptors such as fruity, meaty, spicy, musty, stale, creamy, etc. Are flavour descriptors used to cover everything else that we want to say about foods and beverages over-and-above the so-called basic tastes, and their respective combinations (Rozin, 1982)? It is first crucial to note that it is rare to have such experiences in the absence of any contribution whatsoever from oral-somatosensation (Green, 2002), not to mention the proprioception/kinesthesis that comes with crunching, chewing, and oral-mastication (Shepherd, 2012, Chapter 17). In this sense, flavor would normally involve the integration of more-or-less simultaneous inputs from gustation, retronasal olfaction, oral-somatosensation, and proprioception/kinesthesis (Lundström et al., 2011). While opinions vary, trigeminal sensations are readily incorporated into flavour perception as we see from the everyday use of food descriptors such as ‘spicy’, ‘pungent’, ‘hot’, and ‘fizzy’.

However, we have argued earlier that it seems reasonable to include ‘sweet’ among the flavour descriptors even though it is considered by some to be a descriptor for tastes proper. Perhaps the ordinary (and confusing) use of the word ‘taste’ has application here, but notice that when people talk about the ‘taste of a banana’ they are not really talking about a basic taste, nor even about a combination of basic tastes. Rather they are talking about the banana’s flavour as experienced by means of the *act* of tasting (Halpern, 1983; Piggott, 1990). Note here that blocking the nose removes the fruit character of banana from experience (Finck, 1886; Shepherd, 2012, pp. 28-30; see also Smith, 2012).[6] As is the case with many other experiences in flavour, we do not experience taste alone: it is accompanied by odours, somatosensations, and/or trigeminal sensations. In other words, flavour experiences are always defined in a multisensory space. Although the contribution of one sensory modality can be missing, there is always more than a single sensory modality (or dimension of experience) involved.

[6] If this is done while eating, and there is still sweetness present in the mouth, then the likelihood is that the experience of flavour may persist (see Spence, 2012). Blocking the nose before eating/tasting commences, however, will prevent the establishment of any fruit character whatsoever.

2.3. Confusions associated with the terms ‘taste’, ‘tasting’, ‘odour’, and ‘flavour’

The scientific characterisation of the terms taste, tasting, odour, and flavour given above seem to be reasonably clear, and so one might be led to believe that confusions only occur in everyday language:

> In informal conversation, the sensory outcomes of eating or drinking are usually labelled ‘taste’. Scientifically, however, taste is strictly the sensation experienced by means of the taste buds, and comprises but a part of what is more correctly labelled ‘flavour’. (Stillman, 2002, p. 1491)

However, there are many confusions associated with these terms both in everyday language and in the setting of the laboratory/journal. Below, we review some of the typical confusions, in order to subsequently discuss their possible underlying causes.

In a study by Paul Rozin (1982), the author highlighted the extent to which taste and flavour are associated linguistically. He gave questionnaires to native English speakers. They had to judge whether ‘taste’ or ‘flavour’ was the most appropriate term to use in a series of 16 sentences given with a blank space to replace the relevant term. When items involved the four basic tastes (note that umami was not used in this study), taste was judged the most appropriate term, for twelve others involving olfactory components (e.g., banana), the two terms (taste and flavour) were used seemingly interchangeably.

In everyday language, people do not appear to make any principled distinction between the sweetness of a substance (according to the above quote, a taste) and its fruitiness (according to the above quote, a flavour), at least when consuming a sweet-tasting fruit. Both sweetness and fruitiness, we would like to argue, are evaluated in similar ways by the ‘act of tasting’ (see Auvray & Spence, 2008; Gibson, 1966; Halpern, 1983; McBurney, 1986; Smith 2007) and count as flavours – albeit distinct ones. Most people have no idea of the physiological origins of the sensations they have when tasting. *A fortiori*, they have no idea that sweetness actually happens to be different from fruitiness in that the former results principally — though not exclusively, as has now been shown — from the stimulation of gustatory receptors, located on the tongue, among many other places[7]; while fruitiness is an attribute that requires the stimulation of both the nose (olfactory receptors) and mouth (gustatory receptors). They are both experienced as a result of acts of tasting and can thus be treated as belonging to the same category: that of flavours, which people often call ‘tastes’.

People’s failure to distinguish between what we think of here as two flavour attributes can certainly cause confusion in laboratory settings, if what is being investigated is taste proper. For instance, one cannot always be sure that what participants are reporting on (or are asked to rate) in psychophysical studies of flavour perception is only the sweetness of a fruity beverage, treated as purely the upshot of gustatory stimulation. When it has been claimed that the odours of a flavour influences what participants report about taste (Stevenson & Boakes, 2004)[8] this would constitute a confusion, according to us, between mere tastes which they don’t experience and the odour enhanced flavour of sweetness, which they do.

Notice that what others would count exclusively as a taste term is often used for other things. Westerners, for example, are more than happy to describe odours as sweet, when smelling vanilla, caramel, or strawberry, say (Spence, 2008; Stevenson, 2012a; Stevenson & Boakes, 2004; see also Blank & Mattes, 1990). Here it is perhaps worth looking in rather more detail at what happens, for example, when people who smell ripe strawberries describe them as smelling sweet. In such situations, it appears that people are applying the term ‘sweet’, a term that they normally apply to what they are tasting, to something they are merely smelling. In addition, it may seem as though the transfer of a word for a taste onto a smell is due to a direct association between the taste and the smell. However, it is much more likely that the association is driven by the closeness of the aroma of ripe strawberries,

[7] Note that taste receptors are also found in the nose, the stomach, the intestines, and in the pancreas where they influence appetite and help to regulate the release of insulin. They are also found in the airways and even in sperm (Trivedi, 2012).

[8] It should be mentioned that the phenomenon of ‘halo dumping’ makes this all the more difficult (Abdi, 2002; Clark & Lawless, 1994; Kappes et al., 2006): *“Halo dumping occurs when subjects are provided with only one intensity scale (sweetness) to rate a mixture of two sensations (sugar and strawberry). Forced to use one scale for two sensations, the subjects “dump” the second sensation onto the only available scale. This dumping effect disappears as soon as subjects are provided with a scale for each sensation.”* (Abdi, 2002, p. 448).

sensed orthonasally, to the odour of ripe strawberries processed retronasally, and the fact that the latter is inseparably paired in our experience with the tastant sweet. It's that pairing that provides us with our experience of the flavour of strawberry. So the association is not between a taste and an orthonasal smell but between a flavour (a taste-smell interaction) and a orthonasal smell, mediated by the retronasal component of ripe strawberry flavour and the way that olfactory component is inextricably bound up with sweetness in our experience.

The transfer of the attribute sweet from what we taste to what we smell is easier to understand when we remember that much of what we taste is due to smell. It's just that the retronasal olfactory component of tasting something sweet, like ripe strawberries, goes missing in our experience. The attribute 'sweet' does not itself describe an aroma; rather, it is associated with aromas, like vanilla, that are normally paired with sweetness (at least for Westerners) in certain flavour compounds that we experience. There are several things to note here. First, we don't notice that we are applying a flavour attribute we taste to something we smell; at the outset, sweetness just seems to be an attribute of particular odours. Second, when it is pointed out to us that sweet is something we taste, not something that we smell, we most likely think that we are associating the sweet taste of the strawberry directly with how it smells (orthonasally). Though, in fact, the association of sweetness with what we smell goes via the former's inseparability from retronasally-detected strawberry odour and its closeness to what we recognisably smell as the aroma of strawberries.

The connection that people make between tastes and flavours is also illustrated in another way. When asked, many people will tell you that taste is the sense that gives rise to the perception of flavour (Nudds, 2004). People typically report that they have lost their sense of taste when they are suffering under the influence of a heavy cold, or otherwise lost their ability to smell. All they have actually lost (temporarily in the case of a cold) is their sense of smell. More generally, very often we think we're experiencing tastes when, in fact, we are using more than just the sense of taste in order to do so. This is another way in which taste and flavour are confused.

According to a popular way of seeing things, whenever a person rates the *sweetness* of a food or beverage, what they are *trying* to do is to refer to its *taste* — although according to the argument outlined here they are normally actually referring to its flavour. By contrast, whenever a participant refers to the fruitiness of a drink, the spiciness or pungency of a food (Viana, 2011), or the mustiness of a wine, they must either be referring to its *flavour*, or perhaps to its *aroma* (detected by orthonasal olfaction, as with sniffing).[9] One reason for the dual possibility in the latter case is that the vast majority of what we think of as the components of flavour actually result from the retronasal stimulation of the olfactory receptors in the nose and very (or relatively) little from the stimulation of the gustatory receptors on the tongue (e.g., Crocker, 1950; Martin, 2004; Murphy et al., 1977; Shepherd, 2012). Since most flavour descriptors can also be used as odour descriptors (see Figure 1), if a person merely sniffs a wine, say, it is clear that their descriptions can only be of the odour (i.e., of the volatile compounds arising from the wine and detected via orthonasal olfaction), rather than of the flavour (since they haven't tasted anything yet). But note here that what that person might be responding to is actually their expectancy of the wine's likely flavour given a particular orthonasal odour profile (see Stevenson, 2009) as in the case of a 'sweet-smelling' wine. By contrast, if someone actually tastes a wine and then says "it's fruity", one might be tempted to think that what they are referring to is the flavour, drawing both on the contribution from aromas and tastes.

[9] Remember here also that many of those working in the flavour industry often use the term flavour to describe orthonasal olfaction/aroma (see Shankar et al., 2010). We have also seen that people regularly transfer a term that they use for a taste, like 'sweet', to odours. This is either an association of a smell with what can normally be tasted. Alternatively, however, it is because 'sweet' is a flavour term, and so equally applicable to a flavour or an aroma (the argument forwarded here).

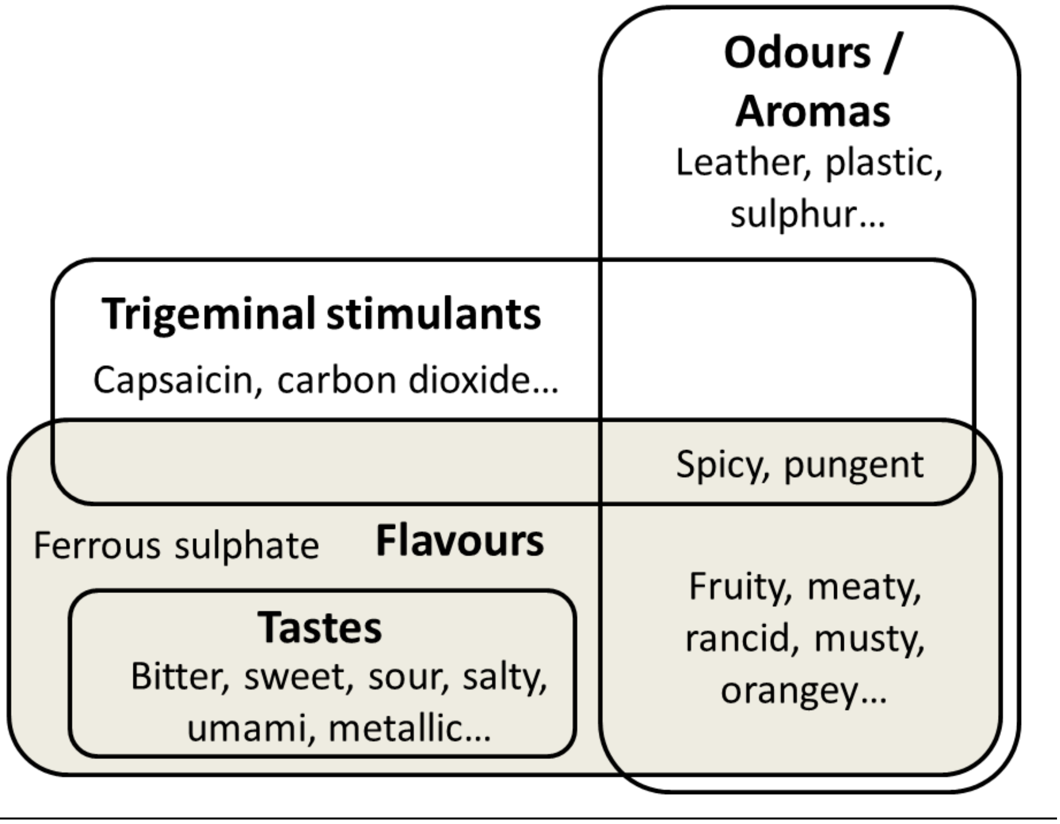

Figure 1. Taste, flavour, trigeminal, and odours descriptors. Note that the only flavour that cannot also be smelled orthonasally is, apparently, ferrous sulphate (see Lawless et al., 2004).

3. Physiological and psychological reasons for the confusion

Apart from linguistic reasons, it is important to note that there are also other reasons that might help to explain why people confuse taste and flavour:

> To understand flavour completely, we must consider not only its chemistry and physics but also the physiology and psychology of its perception and our reactions to it (Crocker, 1950, p. 7)

After emphasizing the importance of smell/taste confusions both for clinical cases and for psychophysical research, and the frequent confusions between these latter two and trigeminal sensations, we will highlight the crucial role that *oral referral* and *attention* both play in terms of driving the confusion between the different components of flavour.

3.1. Confusing tastes, flavours, and trigeminal sensations

As has already been noted, the loss of smell is often identified by those affected as a loss of taste (Bull, 1965). For instance, blocking the nose (as when one has a heavy cold) dramatically reduces what one believes that one can taste. In fact, however, we can all still taste salt, sweet, sour, bitter, umami, and presumably also metallic. This confusion has been taken to illustrate the fact that people simply do not recognize the crucial contribution that retronasal olfaction makes to what they think they are merely tasting. However, the fact that food appears to 'lose its taste' when one's nose is blocked can (and frequently has) been taken to highlight the fact that the sense of smell contributes to the perception of flavour in food and drink (e.g., Rozin, 1982). Confusions do not only occur between tastes and flavours though, but also between tastes, flavours, and trigeminal sensations. Take, for example, the following:

> the sensory reaction to pepper compounds is not really a thermal sensation, even though we use the term "heat." It is more accurately classified as a chemically-induced irritation that is different from both the sense of taste and the sense of touch. To physiologists, taste is defined as sensations derived from the taste buds on the tongue and soft palate which mediate our experiences of sweet, sour, salty, and bitter. Pepper heat is a chemical sensation from stimulation of the nerve endings of the trigeminal nerve, which is distinct from the nerves that make contact with taste buds and are involved in taste sensations. Although the trigeminal nerve is also responsible for touch, heat, cold, and pain sensations in the mouth, the pepper sensations cannot be classified as touch, either, since they involve no physical deformation of touch receptors (Lawless, 1989, p. 57).

For the next example, let us return to the case of so-called *metallic tastes*. These can be elicited either chemically, when the taste buds on the tongue come into contact with solutions containing metal salts, or by direct stimulation by the metals themselves (Laughlin et al., 2011; Piqueras-Fiszman et al., 2012). Furthermore, it has also been reported that applying an electric current to the tongue can give rise to metallic tastes as well (just try sticking a 9-volt battery on your tongue). Here it can be seen how terms for tastes may actually refer to trigeminally, chemically, or even electrically-induced sensations. However, it turns out that what people mostly refer to as a metallic 'taste' is often actually a metallic flavour (according to the traditional definition that flavours are only experienced when a perceiver's gustatory and olfactory receptors are stimulated at more or less the same time), since nasal occlusion tends to reduce the intensity of the percept for at least certain solutions such as, for example, in the case of ferrous sulphate ($FeSO_4$). In other words, what people refer to as a metallic taste sometimes involves a component of olfactory referral to the mouth (Murphy & Cain, 1980; Murphy et al., 1977).

However, the picture is even more complicated than this since the metallic taste elicited by copper metal, bimetallic stimuli (e.g., zinc-copper, lead-silver) or small batteries is apparently unaffected by nasal occlusion (see Lawless et al., 2005). The example of so-called metallic *tastes*, then, nicely illustrates how a person's everyday experience does not allow them to discriminate between tastes and flavours, and as a result they are all called experiences of tastes; whereas some experiences of metallic are really experiences of metallic tastes, others are experiences of metallic flavours (according to the traditional view of flavours). According to our way of resolving the confusions between tastes and flavours this problem would disappear, since what surfaces in experience is a metallic flavour even though different possibilities involving different compounds (stimulating one or more different kind of receptor) account for the way such experiences arise.

One of the only ways in which to distinguish between tastes and flavours might be to block a participant's nose in order to determine what remains in experience (see also Burdach et al., 1984; Nagata et al., 2005). Such a procedure would likely help an individual who wants to distinguish between the various other components contributing to his/her experience in an act of tasting. It would not, however, be guaranteed to isolate tastes since, with the nose blocked, one may be experiencing a taste, a trigeminal, or thermal (or possibly even an electrical) sensation (see Wajid & Halpern, 2012). Note here that the test of a tastant as something that doesn't change when the nose is blocked or unblocked would show that 'sweetness', 'sourness', etc. were not necessarily tastants. As was already mentioned, Mojet et al. (2005) have shown that there is often a change in our perception of intensity of our experience of sweet, salty, sour and bitter substances when olfaction is involved. Nagata et al. (2005, p. 193) have captured the very same problem that is often faced by participants when presented with stimuli at close to threshold. To them, in the case of absolute detection, i.e., when there is a lack of qualitative information, it becomes very difficult to know which sense modality is responsible for the detection of the stimulus or object, especially when qualitative information is lacking, as is it often is at the absolute detection threshold. The fact that tastants are not experienced alone has been nicely expressed by the eminent food scientist, Harry Lawless, in a quote that we fully endorse:

> Almost every chemical placed in the mouth has multiple sensory effects. The notion of a monogustatory tastant is illusory. (Lawless et al., 2005, p. 193)

These examples highlight that the experience of flavour is an intrinsically multisensory experience. Tastes are seldom if ever *experienced* on their own and their experience is modified by the presence of odours and trigeminal sensations.

3.2 Oral referral

As Bartoshuk and Duffy (2005, p. 27) put it:

> 'Taste' is often used as a synonym for 'flavour'. This usage of 'taste' probably arose because the blend of true taste and retronasal olfaction is perceptually localized to the mouth via touch.

It is still a point of discussion as to quite how important (if at all) oral-somatosensation really is to the phenomenon of oral referral. Certain of those researchers currently working in the area believe that one also needs the presence of a tastant in the mouth for oral referral to take place (see Lim & Johnson, 2011, 2012). For example, Lim and Johnson (2012) have recently demonstrated that oral referral to the mouth is significantly stronger when the tastant is congruent with the olfactant. This perception of something as appearing to come from the mouth has been called the location illusion. This is where sensations occurring, or originating, in the nose are ‘referred to’ or experienced as if they were being transduced by the receptors in the mouth. An example that should help to illuminate one of the principal reasons for this frequent confusion between the various components of flavour was documented some years ago by Murphy et al. (1977).

Murphy et al. (1977) demonstrated that when a tasteless aqueous olfactory stimulus was placed into a participant’s mouth, he/she would usually label the resulting experience as a taste, rather than as a retronasal odour. The experience is also localized to the oral cavity, even though the sensory percept is itself principally mediated via the activation of the olfactory system. This example would certainly appear to suggest that the presence of a tastant isn’t needed for oral referral to occur. However, before coming to any firm conclusion on this score it is worth seeing Stevenson’s (2012) discussion on attention below (see also Murphy & Cain 1980; Rozin, 1982).

When speaking of what may be an illusion, it is important to pause for a moment in order to consider the cross-modal phenomenon of *sweetness enhancement*. This refers to the perceived increase of taste intensities when particular odours are added to sucrose solutions (e.g., see Stevenson & Boakes, 2004). For example, when a vanilla odorant (that does not give rise to any taste sensation) is added to a sucrose solution, the resulting mixture is rated as tasting sweeter than the pure sucrose solution when presented by itself in solution (see Stevenson et al., 1998). By contrast, adding a strawberry odour suppresses the sourness of solutions containing citric acid (see Stevenson et al., 1999), thus showing that odour-induced tastes can be functionally equivalent to sweetness. Note here also that sweetness isn’t the only taste/flavour attribute that can be enhanced by means of the delivery of an associated olfactory stimulus. There is now also good evidence in support of the existence of saltiness, bitterness, and sourness enhancement by means of olfactory stimulation (e.g., see Lawrence et al., 2009; Seo et al., 2013; Stevenson et al., 1995; Yeomans et al., 2006).

However, the discussion that follows will focus on the case of sweetness enhancement as that has been studied most extensively to date.

The next question that one can ask here is whether or not the phenomenon of sweetness enhancement is cognitively penetrable; i.e. can the effect be cancelled as soon as we believe or know that it is (orthonasal) smell that is influencing our perception of sweetness? Or is it a robust, belief-independent effect in experience — like, for instance, the Muller-Lyer illusion? Can the sweetness enhancement effect be modified as a function of the particular tasting strategy that is adopted by participants during their exposure to odour-taste mixtures (for instance, by an analytic versus synthetic approach to the perception of flavor, see Bingham et al., 1990; Prescott et al., 2004)? If this is the case, then there should be an effect of prior training on such a phenomenon. However, Stevenson (2001) reported that training individuals to identify the separate components of an odour-taste mixture actually had no effect on the sweetness enhancement effects of suprathreshold odorants on sweetness ratings, or on their ability to identify the component parts of the odour-taste mixture. Indeed, it was findings such as these that led Stevenson and Tomiczeck (2007) to suggest that the failure to affect odor-taste by attentional manipulations requires a biological and not to a psychological explanation:

> … it is not that participants normally do not attend to flavors but rather that their capacity to do so is limited by biological constraints. These biological constraints are apparent when participants are expressly asked to discriminate the components of flavors (odors and tastes) or of taste mixtures alone or of odor mixtures alone. In all of these cases, participants — even with substantial training — are typically unable to do so. (Stevenson & Tomiczeck, 2007, p. 302)

Of course, the fact that olfactory-gustatory interactions such as the sweetness enhancement effect can occur when either one or both of the component stimuli are presented at a level that is individually sub-threshold level (see Dalton et al., 2000; Labbe et al., 2007; Shepherd, 2012, p. 122) is going to make it that much harder for an individual to unequivocally determine the correct physical source for a given flavour experience.

3.3. The question of attention

Finally, the question of attention and expertise proves crucial to understanding what exactly underlies most people's inability to discriminate the different components of flavour. Stevenson (2012a, b), for instance, has put forward an attentional account for why people do not recognise the olfactory component in flavour, and hence label the perceptual experience of flavour, taste. Here, though, one needs to be careful, since Stevenson's research is based primarily on the use of *orthonasally*-presented odours, whereas what we are really interested in when it comes to the role of attention in the deconstruction of flavour is *retronasal* olfaction. Titchener (1909, p. 135) anticipated the link between attention and flavour when a little over a century ago he said:

> Think, for instance, of the flavour of a ripe peach. The ethereal odor may be ruled out by holding the nose. The taste components – sweet, bitter, sour – may be identified by special direction of the attention upon them. The touch components – the softness and stringiness of the pulp, the pucker feel of the sour – may be singled out in the same way. Nevertheless, all these factors blend together so intimately that it is hard to give up one's belief in a peculiar and unanalyzable peach flavour. Indeed, some psychologists assert that this resultant flavour exists.

Although, as we have just seen, there is evidence to suggest that people do not find it all that easy to direct their attention to the separable components of flavour even when directed to do so (Ashkenazi & Marks, 2004; Marks, 2002). Perhaps the fact that people do not recognize the olfactory component in flavour is because with retronasal olfaction, unlike in the case of orthonasal olfaction, they do not recognize that they can have voluntary control, as they do with sniffing (see Stevenson, 2009). The swallowing response pumps odours from the oral cavity via the nasopharynx, up into the olfactory epithelium. This can subsequently generate a flavour experience. Intriguingly, Ashkenazi and Marks reported that while participants could endogenously direct their attention to better detect a weak tastant (sucrose) when it was presented in isolation, they were unable to direct their attention to enhance the detection of vanillin (delivered in solution as a retronasal odorant), nor were they able to direct their attention to sucrose or vanillin when they were presented together (i.e., when presented as a traditional flavour stimulus).

The question of attention is closely linked to the question of expertise: If the confusion between smell and taste merely reflects a problem associated with the appropriate allocation of attention, then panellists trained to focus their attention on each component should be better able to report on only one of them. In other words, while the naïve participant might not make any meaningful distinction between taste and smell, perhaps the trained panellist can just report on the sweetness of a solution, or, having tasted it, report selectively on its retronasal odour (and not accidentally report on, or be influenced by, its flavour; see Bingham et al., 1990). But are they really able to do so?

According to Stevenson (2009, p. 155), there is indeed an expertise effect. In his book, *The psychology of flavour*, Stephenson suggests that in the case of retronasal odours, the identification of a particular element when other odours, tastes, and/or textures are present is much harder. That said, experts may be somewhat better at this than novices, at least for those odours that they happen to be familiar with. However, as we have just seen, being directed to attend to the olfactory element in a flavour does not appear to help naïve participants detect that element (Ashkenazi & Marks, 2004).

So, while the view that experts are better at distinguishing the retronasal component of a flavour from other components may be prevalent amongst some sensory scientists, it is important to note that people hardly ever report solely on the gustatory stimulation while at the same time successfully ignoring any contribution from olfaction. So it is not so clear that people, even experts, can selectively report on sweetness, say, and entirely ignore the contribution of olfactory cues (see Stevenson, 2001). For instance, in one descriptive analysis of the characteristics of a wide range of odours, 65% of assessors gave “sweetness” as an appropriate descriptor for the odour of vanillin, while 33% described the odour of hexanoic acid as being sour (Dravnieks, 1985). 110 of 140 assessors reported strawberry odour as sweet and only 60 that it smelled of strawberries and 99 that is was fruitlike.

In addition, a number of studies have underlined the fact that while expertise can certainly help at the conceptual level, it does not necessarily help at the perceptual level (Stevenson, 2009). In other words, it can help an individual to categorize certain (familiar) flavour components more easily but this is not necessarily accompanied by enhanced perceptual capacities. This has been nicely illustrated in the case of wine expertise: While the perceptual abilities are similar for experts and regular wine drinkers, conceptual abilities are enhanced in experts and it has been argued that this allows them both to organise and use their perceptual knowledge more efficiently (e.g., Ballester et al., 2008; Berg et al., 1955; Hughson & Boakes, 2001; Parr et al., 2002; Solomon, 1997; see also Stevenson, 2009).

3.4. The question of separability

At this point, we can ask whether the various components of flavour are really separable? Brillat-Savarin (1835, p. 41) was *'tempted to believe that smell & taste are in fact but a single sense, whose laboratory is in the mouth & whose chimney is the nose'*. Indeed, if experts and non-experts both have difficulties in distinguishing between taste and (retronasal) smell, the question arises of their very separability in experience. Thus, one additional reason for not wanting to make too sharp a distinction between taste and flavour comes from the fact that there isn't a simple one-to-one correspondence between taste perception and taste receptors; nor even between smell perception and the stimulation of olfactory receptors in the nasal epithelium, given the possibility of pure trigeminal stimulants being experienced as if they were odours. Instead, it turns out that individual chemicals can activate multiple sensory systems, while multiple classes of sensory receptors can give rise to specific experiences (e.g., tastes/smells). So, for example, Nagata et al. (2005) have demonstrated that stimuli such as 1-menthol (the principal flavour in mint), actually stimulate several sensory systems simultaneously. In particular, 1-menthol leads to the stimulation of tactile (including thermal, in this case, cold), olfactory, gustatory (in this case, bitter), and nociceptive (i.e., pain), receptors (and hence sensations).

What is more, certain bitter-tasting compounds, including astringent compounds such as aluminium potassium sulphate (otherwise known as alum; Breslin et al., 1993), activate somatosensory neurons (e.g., see Finger et al., 2003; Liu & Simon, 1998). The polyphenols in wine skins and pips produce the tactile experience of astringency. These tannins, which one finds in strong tea, red wines, nuts, and some fruits, give rise to the experience of the ‘drying or puckering’ of the mouth by coagulating the proteins on the tongue, thus making the saliva less slippery. Some polyphenols are also thermal stimuli (Cruz & Green, 2000), and were thought of, in the past, as gustatory qualities (see Bartoshuk, 1978). Similarly, many olfactory stimuli give rise to irritation in the nose (Cometto-Muñiz & Cain, 1995), thus appearing to be trigeminal sensations. In fact, most olfactants will also stimulate the trigeminal system when presented at a suitably high concentration (Lundström et al., 2011; Wajid & Halpern, 2012). Some chemesthetic compounds also possess aroma and/or taste qualities (Green, 2004). Moreover, some taste compounds (such as salts and acids) elicit oral chemesthetic responses that give rise to oral irritation or pain (Dessirier et al., 2001). Thus, it can be seen once again, that the origins of an individual’s perceptual experience may be quite unknown, or hidden, to them. In fact, the idea that people do not know how their senses combine to give rise to flavour experiences crops up repeatedly in the literature (e.g., Lundström et al., 2011; Sundqvist et al., 2006). People nevertheless tend to classify their experiences as smells, tastes, or mouth-feels. But how do they arrive at these classifications when the experiences do not carry information about their origins? On what basis do people classify an experience as a taste why does it seem so compelling to do so, and what does it mean to do so? Whatever the answer is here, a further question is how *ought* we to classify such experiences in order to gain insight, theoretically into what is going on.

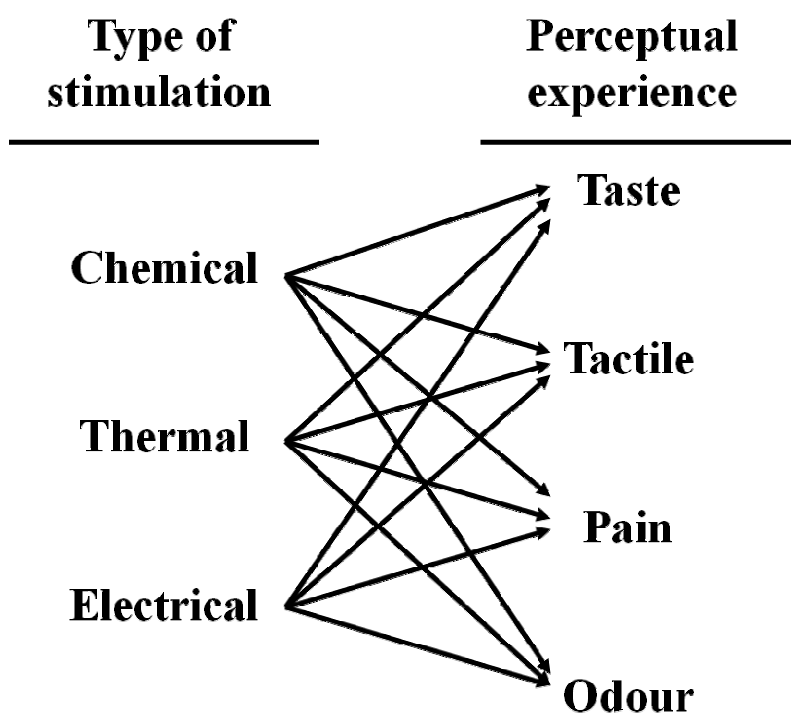

Figure 2: Schematic illustration showing the many-to-many correspondence between sensory inputs and perceptual experiences (see also Iannilli et al., 2008; Nagata et al., 2005).

One might wonder whether there are flavours that are not also orthonasal odours. The only example that we have come across involves solutions of ferrous sulphate that Lawless et al. (2004) argue have little or no odour of their own outside of the mouth. As Lawless et al. (2005, p. 193) put it, *"they are not effective orthonasal stimuli at the concentrations which evoke a strong retronasal smell"*. The idea here, then, is that odour is released in the mouth following some kind of catalytic reaction.

4. Taste and flavour: Unravelling the confusion

As we hope this review has made clear, many of the seeming taste sensations that we experience can be induced in a variety of different ways: e.g., by thermally stimulating the tongue (Bajec & Pickering, 2008; Cruz & Green, 2000), by electrically stimulating the tongue (Bujas, 1971; Bujas et al., 1974; Cardello, 1981; Lawless et al., 2005), by the delivery of retronasal odours together with tasteless oral-somatosensory stimulation

(Murphy et al., 1977), by the transduction of tastants in the mouth, and/or by some combination of the above (see Figure 2). All these routes to 'tastes' count as perfectly normal for many tasters. Should all of these experiences be called experiences of tastes, and should they be distinguished from flavours? They are not all taste (gustatory) sensations but they all get classified by people as tastes in perception.

> Sensory pathways are known to overlap widely in the periphery, with so-called "gustatory nerves" responding to taste, tactile and thermal stimulation, all of which occur simultaneously during ingestion. (Delwiche, 2004, p. 142)

Of course, our perceptual experience of a taste doesn't necessarily have to illuminate the origins of the percept: It may be subliminal, as in certain cases of sweetness enhancement (Dalton et al., 2000; Stevenson & Boakes, 2004; see also Sunqvist et al., 2006). Even if the sensation, or percept, of a sweet taste is accompanied by, for instance, heat, it doesn't necessarily prevent us from having the feeling that we are tasting sweetness. Thus, if we want to restrict pure taste to what results solely from the firing of gustatory receptors on the tongue (not to mention in the rest of the oral cavity), then we cannot unequivocally relegate the perceived quality of sweetness to taste.

Having an experience of tasting sweetness does not necessarily indicate that the taste receptors that code for sweetness are firing. It is better, then, to treat sweetness as a component of flavour, an ingredient in the perception of complex flavours or mixtures, however it may arise. If we can have experiences of sweetness when olfaction is knocked out, and all other sensory effects, such as thermal sensations, are neutralised, this would be a case of pure taste, but it happens only under highly controlled laboratory conditions, or in cases of clinical pathology. Thus, we would argue that there is no bar to calling sweetness a flavour, and hence there are good reasons to reject the commonly-held view in the food sciences that tastes and flavours can, and should, be distinguished in perceptual experience. Given the difficulties of experiencing a pure taste (under most conditions), we should not treat attributes, such as sweetness, as belonging exclusively to a category of taste attributes distinct from flavour descriptors, such as, for example, fruitiness, meatiness, or as in the above quote, 'oranginess' (at least when talking about our everyday experience).[10]

Does it really matter that 'pure' tastants are seldom experienced in isolation, and that even when they are experienced in clinical or laboratory conditions they are not recognized as such? It may well be reasonably common knowledge that acetic acid is a tastant that at suitably high concentrations can be smelled. However, the work of Mojet et al. (2005) suggests that basic tastants (such as sodium chloride, sucrose, caffeine, citric acid) when dissolved in a variety of substrates are rated as more intense (at least by younger participants) when their nose is open than when it is blocked with a nose clip. What is more, the presence of many of these tastants in a solution can also be detected at above-chance levels merely by orthonasal olfaction (sniffing). As Mojet et al. (2005, p. 20) put it:

> In conclusion, it can be said that, contrary to what is commonly assumed, all so-called 'pure tastants' used here – and in many experiments in the same or even less pure grades by others – are also olfactory stimuli.

It is worth dwelling here on the fact that responding to pure tastants in solution is a rather strange experience for most people. So, for example, in one recent experiment, the participants were unable to consciously name the tastants used as sweet, sour, bitter, and salty (Simner et al., 2010, p. 566). Instead, when descriptors were provided by the participants, they tended to be flavours and not tastes (e.g., orangey, lemony, metallic, and fishy, respectively).

Typically, people tend not to separate the unisensory elements that give rise to multisensory flavour percepts. The sweet taste of vanilla cream or almond paste leaves us assuming that the sweetness is in – or is part of – the vanilla or the almond. Undoubtedly, this is most likely a learned association (see Spence et al., 2010; Stevenson & Boakes, 2004; see also

[10] It should be noted that a radical implication of this claim would be to assume that, at least in the case of conscious perception, there is no such thing as a pure taste. Assuming such a position, however, does not require one to deny that correctly establishing the class of sensory receptors responsible for transducing specific stimuli isn't a worthwhile endeavour in its own right (Wajid & Halpern, 2012).

Shepherd, 2012, p. 122, 138), hence, the culturally conditioned sweetness enhancement effect (see Spence, 2008) of some odours like vanilla for Westerners but not necessarily for the native Japanese. In our everyday discourse, we do not separate out the taste of sweetness from the flavour we describe as fruity or having a vanilla 'taste' or from attributes such as stale or fatty, which, who knows, may have more to do with texture, touch and/or gustation (Mattes, 2009; Mela, 1988; though see also Sundqvist et al., 2006).

A lot has been said about the nature of tastes, physiologically-speaking, and the nature of the experiences that we take to be tastes. But where does that leave flavours and flavour perception? Our suggestion is that what we experience by acts of tasting are flavours. These are often labelled as 'tastes' in everyday language, because people assume that tastes are what we experience through acts of tasting. There are far more flavour terms than proper taste terms and the category that people think of as tastes tend to extend to incorporate all the terms that are properly flavour terms. So the confusion of taste and flavour terms is somewhat understandable. However, it is to go further still to think that the experiences of the 'tastes' or flavours we enjoy in an act of tasting are generated by the single physiological sense of taste. Acts of tasting, unless specially contrived, or as the result of some clinical condition or other, *always* involve far more senses than merely gustation, as we have repeatedly seen. Thus, the phenomenology involved in eating and drinking is not that of separate sensations but a complex compound experience. Perceiving a sweet flavour is far easier, and more common, than perceiving the proper taste of sweetness (again as we have seen). Consequently, we would argue that sweetness should count among the flavour terms just as much as the other flavour attributes, such as fruity, and meaty, their being just as readily experienced (see Figure 1).

However, we are left with the following conundrum of flavour perception and of multisensory perception more generally. Is the single unified experience of a flavour – as we are told – the joint result of sensory information from taste, touch, and smell? In addition, as we are told that this case illustrates that many of the experiences we think of as unimodal are, in fact, the product of multisensory integration; then how unimodal are the components we point to? Are the experiences of taste, touch, and smell that contribute to our experience of flavour themselves the result of inputs from more than one sensory modality? If so, we face a foundational problem. What are the building blocks that feature in multisensory perception and of what are they composed? If they are sensory modalities that require no input and no crossmodal influence from other modalities they may be very remote from conscious perceptual experience and so not the sorts of things that can be thought of as the senses we rely on in perceptual experience. On the other hand, our ordinary way of thinking about the senses has been shown to be at best confused and at worst inadequate when it comes to characterizing experiences such as those that result from acts of tasting. Answering these questions is a task still to-be-completed and it is also crucial to many current research programs. Nevertheless, the right way to think about flavours and flavour perception will most likely benefit from avoiding unnecessary confusions between tastes and flavours.

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