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The Chemical Senses

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[–] Abstract and Keywords

Long-standing neglect of the chemical senses in the philosophy of perception is due, mostly, to their being regarded as 'lower' senses. Smell, taste, and chemically irritated touch are thought to produce mere bodily sensations. However, empirically informed theories of perception can show how these senses lead to perception of objective properties, and why they cannot be treated as special cases of perception modelled on vision. The senses of taste, touch, and smell also combine to create unified perceptions of flavour. The nature of these multimodal experiences and the character of our awareness of them puts pressure on the traditional idea that each episode of perception goes one or other of the five senses. Thus, the chemical senses, far from being peripheral to the concerns of the philosophy of perception, may hold important clues to the multisensory nature of perception in general.

Keywords: Taste, smell, flavour, multisensory, trigeminal, olfaction, odour

1 Introduction

The long-standing neglect of the chemical senses in the philosophy of perception is due, no doubt, to their being regarded as 'lower' senses, suggesting something simple and uninteresting in comparison with the reputedly 'higher' intellectual senses of vision and audition.[1] This flawed view of the senses has obscured the relevance of the chemical senses and their objects in the philosophy of perception, but we are now beginning to understand their significance in the light of empirical results in neuroscience and psychology about the chemical senses, and the way these results have contributed to the radical overhaul of the traditional conception of the senses.

The distinction between higher and lower senses was largely based on whether the associated stimuli were proximal or distal. Aquinas and Kant both thought that the lower, or bodily, senses could only provide us with information about ourselves; they produce mere bodily sensations, rather than enabling us to perceive the world around us. By contrast with the lower senses (touch, taste, and smell), vision and audition put us 'in touch', so to speak, with distal objects, revealing their perceiver-independent properties and so potentially supplying us with objective knowledge of the environment. This hierarchy of the senses, with its view of the lower senses as giving rise to mere bodily sensations, persists in contemporary discussions of perception (Lycan, 2000; Smith, 2002). Yet despite that persistence, I shall offer reasons for thinking chemosensory perception puts us in touch with objective features of our environment just as much as the other senses do.

2 The Scope of the Chemical Senses

Like all other creatures, humans have receptors that respond to chemicals in their environment, though as humans we have just three chemical senses: taste, smell, and a certain kind of touch. Taste and smell are clearly chemical senses, involving contact between chemical stimuli and chemosensory receptors in the nose and in the mouth. Touch too is chemical when it involves *chemesthesis*, a process due to chemical irritation of the free nerve endings in soft tissue giving rise to characteristic sensations of tingling, stinging, burning, and cooling. Of course, not everything classified as touch involves chemesthesis (de Vignemont and Massin, this volume, III.3). Though as we shall see, flavour experience is due to a complex interaction of the chemical and other somatosensory senses.

It is sometimes claimed that the chemical senses in humans include signalling between people by means of pheromones. The term 'pheromone' was defined by Karlson and Luscher in 1959 to cover 'substances which are secreted to the outside by an individual and received by a second individual of the same species, in which they release a specific reaction'.[2] The definition makes reference to the type of information transmitted and the specific set of responses elicited. The analogy is with hormones, which carry signals between organs of the body. In vertebrates, processing is typically carried out by a dedicated set of receptors in the vomeronasal organ leading to a fixed behavioural reaction.

Do humans signal by means of pheromones? There is little empirical evidence that they do. They certainly secrete chemicals that influence their own and other animals' behaviour but these stimuli are processed by the olfactory system. Humans do have vestigial ducts of a vomeronasal organ in the nose, but the receptors there do not project to the olfactory bulb or any other brain region, so no known mechanism exists for our responding to pheromones, or for them shaping our behaviour. A single research group produced the evidence of pheromone detection in humans but their findings have been widely challenged and other explanations have been offered of the data. So perhaps the most charitable conclusion is that:

> Proponents of a human vomeronasal organ and of human pheromones … have stimulated much debate and raised interesting issues, but [they] do not at present have convincing evidence for the existence of pheromones in humans, functional vomeronasal organs, or an accessory olfactory system in the brain.
>
> (Johnston, 2000: 120)

Humans are, nevertheless, capable of chemical signalling by means of odours and olfaction operating below our threshold of conscious awareness (Pause, 2012; Chen, 2006). Such chemical signals can have strong behavioural effects on mate selection and sexual behaviour, but the precise behavioural response is seldom fixed for all individuals of the species. Unconscious cues and responses, including attraction and aversion, provide good examples of how the neural processing of sensory signals outside the sphere of consciousness can have a large impact on what takes place in consciousness, but all of these effects can be discussed without positing human pheromones. In what follows, we shall be concerned exclusively with the chemical senses of taste, touch, and smell—and their interactions.

3 Taste, Smell, and Touch

Taste, smell, and touch are among the most basic senses with which we explore the world. We rely on them to assess our environment and to guide successful food choice. These responses are active in us at birth, and perhaps even earlier. Taste and smell serve as the gatekeepers to the environmental odours and substances that enter our bodies, and, as we shall see, the chemical senses play a key role in mating and feeding, avoiding danger, laying down memories, regulating mood, and maintaining quality of life. As such, they play a continuous role in everyday conscious experience.

Deliverances of the chemical senses typically have hedonic value, giving us sensations we find appealing or aversive, and a key question for us will be whether their hedonic values are intrinsic parts of the chemical senses or just accompaniments. For example, sweet tasting foods are innately desirable, while bitter tasting ones are initially unpleasant. This helps to identify energy-rich nutritional sources and to protect us from toxins, many of which are bitter. In this way, taste promotes homeostasis. In addition to the above, saltiness is used in maintaining electrolyte balance, sourness to guard pH levels, and savouriness (umami) to motivate protein intake (Small et al., 2007).

Smell functions in a similar hedonic way though there is no evidence that we have innate preferences for particular odours in the way we have innate preferences for tastes. Although we are not usually aware of it, the sense of smell is constantly at work. As J. J. Gibson pointed out, we smell because we breathe. The sense of smell guards the quality of the air we breathe and is connected to limbic areas of the brain responsible for memory and emotion. Thus it plays an important, though often unrecognized, role in our affective lives.

Touch too has its hedonic side. Mild tingling sensations are pleasant when consuming spices; they work by stimulating the trigeminal nerve: the fifth cranial nerve that serves the eyes, the nose, and mouth. (This makes mustard feel 'hot' and peppermint feel 'cool' in the mouth, even though there is no change of temperature.) Such sensations enhance our enjoyment of food, but can become aversive when they sting or burn. Chemically mediated touch also plays a role in safeguarding us. Specific irritants to the trigeminal nerve endings in the nose can be dangerous, and need to be avoided, while others, such as the mild prickle on the tongue from CO_2 in fizzy drinks can boost aroma perception and increase the pleasure of drinking.

So far, we have been speaking about *smell, taste*, and *touch*, but care is needed when talking about the chemical senses because these terms are not being used in their colloquial sense. In colloquial use, terms like 'taste' and 'smell' usually pick out experiences that, as we shall see, combine sensory inputs from more than one chemical sense. So, from time to time, it will be necessary to use the more precise, scientific terms *olfaction, gustation*, and *chemesthesis*, especially when speaking about the interaction of the chemical senses.

4 The Interaction of the Chemical Senses

Of particular interest in what follows, and distinctive of the chemical senses in humans, is the way they collectively conspire with other senses to give us experiences of tasting something. For what we ordinarily call 'taste' involves input not just from the tongue, but from touch and smell. Our failure to recognize the complexity in our tasting experiences has prevented progress not just in our understanding of what we call taste, but in our understanding of the senses more generally. For:

> Although the experience of the sensory qualities of a food are often described in terms of how it 'tastes'; in practice, this experience of flavour is a complex interaction.
>
> (Yeomans et al., 2008)

The experience often described in unisensory terms as 'taste' depends on the multi-modal combining of inputs from different sense modalities into a unified flavour percept: a percept produced by acts of tasting. Volatiles rising from the mouth pass over the olfactory receptors; this accounts for our ability to distinguish between the equivalently sweet essences of strawberry and cherry. Touch gives us information about the texture of food—whether something is creamy, oily, chewy, sticky, or crunchy; smell can affect what we taste on the tongue and fuse with those tastes to produce complex experiences of flavour. The term *flavour* picks out something perceived conjointly by taste, touch, and smell, and is used to avoid confusion with what is detected by taste proper (gustation). The resultant unity of our experience of a food or liquid's flavour provides little clue that it is a complex interaction effect. This may be why people think of it in simple terms as an experience of 'taste'. It may also have to do with the crucial component of smell going missing in the phenomenology of taste experiences. It takes experimental or clinical findings to reveal the indispensable role that smell plays in what we call 'taste'.

The real nature of these multimodal experiences and the character of our awareness of them (or lack of it) is where the chemical senses hold greatest interest for philosophers of perception. The example of flavour perception as a kind of multi-modal, yet unified perceptual experience puts pressure on the traditional idea that perceiving is always done by means of *either* seeing, or hearing, touching, tasting, or smelling. Moreover, the study of flavour perception in sensory science has yielded significant insights into multisensory integration—something increasingly seen as the rule and not the exception in perceptual processing. Thus, the chemical senses far from being peripheral to the concerns of the philosophy of perception, may hold important clues to the multisensory nature of perception in general. But before we look at the mechanisms of multisensory integration underlying flavour perceptions let us review the traditional assumptions about perception that they challenge.

5 The Senses Working in Isolation

From the time of Aristotle to the present day, people have thought of themselves as having five distinct senses that enable them to see, hear, taste, touch, and smell; a classification that became further entrenched in the nineteenth and twentieth centuries (Matthen, this volume, V.1.) Aristotle thought that each sense had a proper object, a kind of quality that could only be perceived with that sense: e.g., colour for seeing, sound for hearing, taste for tasting. There were, in addition, qualities or properties that could be perceived by more than one sense. For example, size and shape could be perceived by both sight and touch; these were called common sensibles. Some philosophers are tempted to think of common sensibles as having more objectivity than qualities which could be detected by one sense alone. These are the classic primary qualities of John Locke, whose natures, unlike colours, tastes, and smells, are independent of perceivers (Ross, this volume, chapter IV.2). This picture of the senses and their proper objects encourages us to think of the senses as working in isolation. The experience of sounds comes to us via hearing, the experience of colour via seeing, and the experience of tastes via our sense of taste.

In the science of perception, the largest focus was on seeing. The occipital cortex occupies about a third of the processing capacity and this may have led to the dominance of vision science. But it may not only be science that explains this dominance. Seeing occupies so much of our attention that it is not surprising, perhaps, that it dominates discussions of perception. This may be why so many philosophers treat problems of perception as if they were exclusively questions about visual perception, assuming, not always explicitly, that the correct account of visual perception will just apply with minor modifications to perceiving by means of other senses.

The prominence of the occipital cortex also encouraged a misplaced generalization. Surely, so the argument goes, if we could point to activity in specific brain regions as being responsible for processing information from other sensory receptors, then we would be entitled to study the senses in isolation. This strategy for studying the senses in isolation seemed at first to have anatomical support from the brain sciences. The advent of neural imaging led to better identification of separate cortical and sub-cortical regions responsible for different functions, and particular areas were identified as the visual cortex, the auditory cortex, the primary smell and taste cortices, and the somatosensory cortex. This encouraged the idea that significant areas of the brain were devoted to unimodal processing by analogy with early vision

6 The Merging of the Senses

The picture just described is no longer dominant in the sensory neurosciences, for it has been repeatedly demonstrated that perception relies on combining information from many sources (Bayne and Spence, this volume, chapter IV.3):

> Our brains are continuously inundated with stimulation arriving through our various sensory pathways. The processes involved in synthesizing and organizing this multisensory deluge of inputs are fundamental to effective perception and cognitive functioning.
>
> (Talsma et al. 2010: 400)

This means that

> focusing solely on unisensory processes will continue to provide us only with an impoverished view of both brain and behavior.
>
> (Ghazanfar and Schroeder, 2006: 278)

The field has been transformed through a recognition that

> the coordination and integration of information derived from different sensory systems is essential for providing a unified perception of our environment, and for directing attention and controlling movement within it. The capacity of the central nervous system to combine inputs across the senses can lead to marked improvements in the detection, localization and discrimination of external stimuli and to faster reactions to those stimuli.
>
> (King and Calvert, 2001: 322)

Many neuroscientists believe that ‘Perception is multisensory’ because ‘no single sensory signal can provide reliable information about the three-dimensional structure of the environment in all circumstances’ and ‘ … if a single modality is not enough to come up with a robust estimate, information from several modalities can be combined' to provide a better fix on external events or objects (Ernst and Bulhoff, 2004: 162). In their important review paper Ernst and Bulhoff continue:

> To perceive the external environment our brain uses multiple sources of sensory information derived from several different modalities, including vision, touch and audition. All these different sources of information have to be efficiently merged to form a coherent and robust percept.

And:

> The key to robust perception is the combination and integration of multiple sources of sensory information.
>
> (Ernst and Bulhoff, 2004: 162)

For example, we sometimes just see, and sometimes just hear, a plastic bottle being crushed, but when we both see and hear it, this gives more neural activation than the sum of activation involved in the seeing and the hearing. This superadditivity in the neural pattern of responding to combined information is one sign of multisensory integration. It is as if the brain has learned to pay attention to, and mark out, complementary multisensory information to help it track environmental events.

Philosophers have been, until recently, slow to recognize this important shift in the science of sensory perception, but one who has stressed its importance is Casey O'Callaghan:

> an adequate, complete understanding of perception requires comprehending the ways in which what goes on with one sense modality *impacts* what goes on with another. Theorizing about perception is not just a matter of assembling independently viable stories about vision, audition, olfaction, and the rest. Considering the relationships and interactions among perceptual modalities sheds light on what is most striking about perception: its capacity to furnish a sense of awareness of a world of things and happenings independent from oneself.
>
> (O'Callaghan, 2008: 316)

The prolonged failure to appreciate the significance of multisensory interactions is surprising. As DeGelder and Bertelson put it:

> Research on perceptual processing, whether behavioural or physiological, has generally considered one sense modality (sight, hearing, touch, smell, etc) at a time. Yet, most events in the natural environment generate stimulation to several modalities. An explosion simultaneously emits light, noise and heat, and experiencing all of these together make for a richer percept than each individually; a speaker produces facial movements in a predictable temporal relationship to corresponding speech sounds and experiencing both together can provide a more adequate percept.
>
> (DeGelder and Bertleson, 2003: 460)

The two cases mentioned here are somewhat different, but the contrast between them provides a clue as to why it has taken so long to discover how sensory systems interact to shape our perceptions, not least our perceptions of flavour. The case of the explosion is one in which we are consciously aware of the light, the noise, and the heat of the event, though perhaps not aware of how the interactions of the sensory inputs intensify overall experience. The second case is one in which we are entirely unaware of how, and how much, visual information about a speaker's lip movements contributes to the speech sounds we hear, and in particular the way vision dominates audition when there is sensory conflict.

It is clear, from the case of speech perception that the workings of one sense can affect not just the intensity of another sense, but the contents of the perceptions that rely on it. (See O'Callaghan, this volume, chapter IV.6) In the cinema, for example, we experience the voices as coming from the mouths of the actors on the screen, even though the sound comes from loudspeakers located at the sides of the movie theatre, under the seats, or even behind the viewer. When lip movements are seen in synchrony with the heard speech sounds, we get visual capture of auditory attention, making auditory perception present things as if the mouths on the screen were the sources of the speech sounds. Known as the ventriloquism effect, this illusion provides a clear case where vision dominates audition in specifying the (apparently) common source of sights and sounds (Allais and Burr, 2004). Often we are not even aware of sensory conflicts and simply assume that we are enjoying complimentary though distinct sensory experiences.

A different case, though relevant to the interactions of the chemical senses, is where a new multisensory quality results from the joint upshot of different senses working together to produce something that could not be produced by any of the contributing senses alone. The McGurk Effect in speech perception is one such example, where one is looking at a film of a face making the speech gesture /ga/ while hearing a synchronized audio feed of the speech sound /ba/, resulting in the percept /da/, which is acoustically and production-wise intermediate between /ga/ and /ba/; something that one neither saw nor heard. The significance is that a new item in experience has been produced by cross-modal interaction between the senses, although it is not recognized as such by subjects of the experience.

Many will say that the McGurk Effect is a carefully arranged illusion, and as such, it is not a natural phenomenon. And so we may want to ask if there are any natural cases of such new multisensory phenomena. Experiences of flavour from tasting foods or drinks provide just such a case from everyday life. The objects of perception in tasting are flavours, though we classify them as tastes. How should we understand such phenomena given how are they produced? We will examine that question in some detail. But at the outset it is worth noticing the considerable challenge flavour experiences pose to the traditional picture of perception. If it is possible to experience a quality like flavour *only* through the conjoint exercise of several senses, then we have a category of perceptual quality for which Aristotle's classification made no room. Flavours are not common sensibles accessible by more than one sense; we need many senses—chemical and contact—working together to produce flavour perceptions. The only way to restore Aristotle's idea of there being proper objects of the senses in the case of flavour perception is to claim that we have a single sense of flavour, albeit one that draws on the interactions or integration of other senses; a position some have proposed in the empirical literature (Auvray and Spence 2008; also Matthen, this volume).

Let us now examine the senses that contribute to the multi-modal experience of flavour, and try to say more about why we fail to recognize the complexity in the experiences of tasting food and drink.

7 What Do We Mean by Taste?

It's difficult at first for us to focus on what happens when tasting a food or liquid. We pop something in our mouths; we sip, or chew, then swallow, and the sequence of experiences we undergo is fleeting and ephemeral; gone in an instant and hard to focus on. The transient nature of these experiences often means the temporal dynamics of tasting go unnoticed until they are pointed out. Mostly, we are left with an impression of liking or disliking, and often people behave as if the whole point of tasting was to come up with a verdict about liking. Though as we shall see liking can be a distraction.

Like seeing and listening, tasting is an activity that generates experiences of a distinctive kind: experiences of the flavours of the foods and drinks we consume.

What is it for something to taste a certain way? Begin with the experiences themselves. They occur when eating or drinking, but we also think of tasting as the having of those experiences. In this sense, tasting is itself an experience, and many philosophers will say that it is a subjective experience in the individual taster. In one sense, of course, this is correct. Tasting experiences happen to individual subjects of experience. So do episodes of seeing and hearing. These, too, are going on in subjects of experience. It does not follow that *what* one sees or *what* one hears is subjective; nor does it follow that tasting is all about the subject. W*hat* we taste—*its* taste—need not be purely subjective.

For it to be purely subjective requires treating *how something tastes* as no more than a fact about the taster, about how it tastes to him or her. So there would be as many ways something tastes as there are tasters, or ways that tasters taste a given food. And yet, ordinarily, we don't talk that way. We speak not about my tastes and your tastes, but the *taste of* a dish or of a wine. The *milk* tastes sour, the *anchovies* taste salty, the *wine* tastes overly sweet. These are not ways of talking about me, but about the items we are tasting.

The subjectivist is unmoved by the linguistic data, and will rightly point out how promiscuous our use of the word 'taste' is. It is variously used to mean: a quality of a food or liquid, like the sourness of a lemon; the characteristic experience we have when eating a lemon; the sense by which we detect that quality or generate that experience; and even, when used in aesthetics, a refined sensibility. Subjectivists treat all as aspects of subjective experience, deriving from mere sensations occurring in tasters. According to the subjectivist, we may talk of the taste of an apple or an onion, but they don't really have tastes; rather, they give rise to tastes *in us*. Tastes are just sensations we undergo when chewing or sipping foods or drinks. (A more objectivist view about taste would distinguish between *tastes* as properties a food or wine has, and *tasting* as an experience that a subject has.)

8 Tastes as Sensations?

There are simple and more sophisticated views of *tastes and tasting* as subjective.[3] The simple view sees tastes as sensations on the tongue, inseparable from the subject who has those sensations, immediately available and knowable through and through for what they are. However, to think of the tastes of a wine as exhausted by sensations on the tongue precludes the idea that not every tasting experience is as good any another. When we taste a wine before and after eating a lemon, or brushing our teeth, it doesn't taste the same way; yet we know that the wine hasn't changed. We are just no longer able to taste it properly. The simple subjectivist has to say there are as many tastes to a wine as there are tasters and moments of tasting. But a wine's taste is not exhausted by the sensations one has at a moment.

Dispositionalists might say that what matters is how a wine or a dish tastes under ideal conditions. But independently of matters of taste how are we to spell out the ideal conditions, and why should they be the same for different individuals? As we'll see, they are not. Individuals vary considerably in their responses to the same stimuli.[4]

Should we, then, regard tastes as properties of foods or liquids that we are able to perceive *by tasting*? This objectivist stance appears closer to common sense. For we seem to rely on tasting to give us knowledge of the taste of things we eat and drink, to tell us whether the strawberry is sweet and ripe, whether the coffee has sugar in it and whether the soup is salty. Taste predicates like these are attributed to food and not to the sensations we have when eating them. The subjectivist is unable to give a convincing account of these attributions. Can we even be sure of the experiences we have when tasting food and wines? And are these experiences just as they seem to us?

To some philosophers, this last question will be unintelligible since they believe that how things appear to us in experience is how they are. There is no appearance–reality divide for conscious experience; experiences just are as they appear to be. This line of thought is part of a residual and unquestioning Cartesianism. That we undergo an experience is unmistakable, but that doesn't guarantee that we know that experience for what it is. Being in a mental state is one thing: knowing what kind of mental state we are in is another. As we shall see, subjectivists who treat tastes as simple sensations take how their experiences appear to them, or how they *take* them to be, as the only way to individuate those experiences. However, as we shall see, the modal signature of our flavour experiences is far from clear, nor is it clear what gives any of our experiences the modal signatures we take them to have.

9 The Hidden Complexity of Tasting Experiences

It is a remarkable fact that we fail to recognize the complexity of our own tasting experiences, and remarkable that philosophers still readily assume that we have transparent access to those experiences, allowing us to know their natures through and through. It is this assumption of self-intimating experience that is supposed to enable us to know that what we ordinarily call 'taste' is a matter of simple sensations on the tongue, something clearly unisensory. And yet, it has taken psychologists and neuroscientists to reveal to us the full extent of the complexity of our tasting experiences.[5] Brillat-Savarin understood this point early on. Writing in the nineteenth century, he 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' (Brillat-Savarin, 1825: 41). These comments are much in line with the recent findings of neuroscience and psychology, which sees the experience of tasting as the product of multisensory integration: a fusion (confusion?) of inputs from different sensory modalities that gives rise to a unified percept (see Auvray and

Spence 2008). Once taste and smell fuse into an experience of flavour, it is no longer possible to separate out the different components by phenomenological decomposition.

Certain things go missing from our awareness of our tasting experiences because, at first, we don’t recognize that ‘flavour perception is not a single event but a dynamic process with a series of events’ (Piggott, 1994: 167). Tasting has a dynamic time course and slowing it down makes a difference to what we notice and what we can pick out. In this way, *how* we taste affects *what* we taste; and attending to each aspect of the dynamic time course changes the temporal scale of the tasting experiences we have. Through attention, we can focus on particular qualities of the taste, texture, and aroma of the foods and liquids we ingest. (It does not, however, mean that we can separate taste and retronasal olfaction.)

Despite such careful scrutiny, we tend to think of the unified experience of flavour as coming just from the tongue or the oral cavity. In fact, the tongue gives us very little. All it provides is awareness of the basic tastes: salt, sweet, sour, bitter, umami (savoury), and metallic. But think of all the flavours we can experience when tasting: ‘ripe mangoes, fresh figs, lemon, canteloupe melon, raspberries, coconut, green olives, ripe persimmon, onion, caraway, parsnip, peppermint, aniseed, cinnamon, fresh salmon’ (Sibley, 2006: 216). We don’t have taste receptors on the tongue for mango or raspberries or chicken or lamb. Nor are these recognizable flavours concocted from the basic tastes, as philosopher of aesthetics Frank Sibley perspicuously pointed out:

> how could one construct a blend of distinguishable tastes … to yield that of coconut, or lemon, or mint? Try to imagine a recipe: ‘To make the flavour of onion (or pepper, or raspberries or olives) add the following [basic tastes] in the following proportions …
>
> (Sibley, 2006: 216–17)

Clearly, there is no such procedure, and yet, the act of tasting gives us knowledge of all these recognizable flavours. The objects of perception in tasting are not *tastes*, but *flavours*, and as Sibley points out flavours are *single*, not *simple*. Tasting flavours involves much more than the tongue, and tastes proper make only a limited contribution to our experience of flavours. Properly speaking, taste exclusively concerns the gustatory inputs due to firings from taste receptors in the oral cavity, the soft palate, and the gastrointestinal tract. The sensations that the tongue produces—gustatory sensations—are hard to experience alone save in experimental settings, for example, when drops are put on parts of an anaesthetized tongue and we prevent any other sensations, of smell or touch, say, from contributing to the subject’s experience. What we call ‘taste’ is due not to sensations from the tongue alone but to the multisensory interactions that produce flavour experience.

Smell plays a fundamental role in forming these flavour experiences. But not smell, as we ordinarily think of it: as a matter detecting the odours we inhale. Rather it is smelling by processing of odours that reach the nose from the mouth when they are released from the foods or liquids we chew, sip, and swallow. This is due to retronasal olfaction, mentioned above, where odours rise from the oral cavity through the nasopharynx to the olfactory epithelium in the nasal cleft. Should we treat this other route to the olfactory receptors as part of smell or a second sense of smell?

10 The Duality of Olfaction

Olfaction takes place when odour molecules reach the olfactory epithelium in the nasal cleft. In humans (and rats) there are two different pathways by which molecules reach the olfactory epithelium: via the nose when inhaling, and via the mouth when eating or drinking. The orthonasal route is when chemical stimuli from the external environment travel to the nasal mucosa during inhaling or sniffing. This is what we commonly think of as ‘smell’. In addition, there is the retronasal route by which odour molecules released during the mastication of food reach the olfactory epithelium via the mouth. The act of swallowing pulses the odours up to the olfactory epithelium via the nasopharynx. Should we take these two routes as just different directions in which stimuli are presented in olfaction; or should we treat them as giving rise to different modalities?

Retronasal olfaction is fundamental to the formation of flavour experiences. Its inputs combine with inputs from taste to create unified flavour percepts. And yet as human tasters we don’t recognize this olfactory component. Although we smell or detect odours via retronasal olfaction, it seems us as if we taste them. That is, the qualities of fruitiness, or more precisely, pineapple or cherry, that olfaction contributes to the flavour we are tasting appear to occur in the mouth. The event of swallowing creates the most intense moment of flavour release due to odours being pulsed to receptors in the olfactory epithelium. In fact, when food-related odours reach the olfactory epithelium from the mouth, the qualities detected and the sensations generated are typically felt to be experiences of tasting in the mouth. This location illusion is due to oral referral, a phenomenon analogous to the case of pain referral or phantom limb, where a sensation is felt in a part of the body other than where the stimulus is being applied (Soler et al., 2010). Because the resultant flavour experiences are classed as tastes the dimension of smell goes missing (or unnoticed) phenomenologically. That smell doesn't appear as a separable part of the complex experiences generated by the interaction of taste (and touch) and retronasal olfaction doesn't mean that we can't focus our attention on the dimension it contributes (e.g., fruitiness). Perhaps the fact that we don't recognize it as due to olfaction provides a prima-facie reason for thinking that retronasal olfaction should not be counted as part of our sense of smell. But this is too quick.

We *can* experience the products of retronasal olfaction *as* smells under certain carefully controlled experimental conditions. In 2004, Heilman and Hummel developed a device for directly delivering odours above the soft palate to the olfactory epithelium by inserting nasal cannula endoscopically into their subjects' noses with one outlet at the nares and the other at the epipharynx. This allows experimenters to pulse odours to the nasal cleft without interference from gustatory, trigeminal, or thermal mechanisms, thus allowing the study of retronasal olfaction in isolation (Bender et al., 2009a). Non-food odours such as lavender delivered via this retronasal route will be experienced as smells not tastes (Small 2005).

With this technique it is possible to show that despite having the same volume of odour in the olfactory cleft, thresholds for detection and intensity are different for orthonasally and retronasally delivered odour stimuli. Less invasively, participants can inhale the vapour state of an odorous liquid from a straw inserted into the headspace of an otherwise sealed glass jar. By means of the straw, participants inhale the odour in the headspace above the liquid and exhale the odour through the nose. In one study vanilla odour was presented alone and 54.7 per cent of participants reported the location of the vanilla experience as in the nose (Lim and Johnson, 2011). When there were incongruent tastants such as NaCl or caffeine in the mouth, this made little difference to the location of the vanilla odour. However, when the inhaled vanilla was presented with sucrose in the mouth, 69.4 per cent of participants localized the vanilla to the tongue or oral cavity. This indicates that if retronasally presented odours are combined with *congruent* tastes (i.e., taste-odour combinations they have encountered before), then most people experience these stimuli not as separate smells and tastes but as unified flavours.

The separately experienced smells from retronasally delivered odours are laboratory created, in contrast to the everyday cases where the phenomenologically individuated experiences of flavour give us no clue as to the influence of olfaction in generating these experiences, so we may want to draw a distinction between the sense of smell and olfactory processes in general, restricting the sense of smell to orthonasal olfaction alone.[6]

Another option is to treat olfaction with its orthonasal and retronasal pathways as a dual modality, and on that basis try to identify two separate senses of smell.

11 Two Senses of Smell?

The first person to propose olfaction as a dual system was Paul Rozin (1982),[7] who spoke of different evolutionary functions for orthonasal and retronasal olfaction: to sense objects in the world and sense (or assess) objects in the mouth, respectively. He saw these in Gibsonian terms as two perceptual systems subserved by olfactory processes. One system is to perceive things in the environment such as food sources, predators, smoke, and potential mates. The other system is to perceive and evaluate the quality of what we are eating or drinking in order to know whether we should continue to eat it or expunge it. Rozin hints at a reason why 'the olfactory [retronasal] component loses its separate identity [when] combined with available oral inputs into an emergent percept' (Rozin, 1982: 400). This, he thinks, is due to the fact that the

> olfactory *stimulus* may differ qualitatively in the in-mouth and out-there cases … It seems very likely that the olfactory component of flavour differs markedly from the olfactory consequences of the same substance in the external world.

(Rozin, 1982: 400)

Neuroanatomy lends support to this idea and explanations have been offered as to why the same molecules, reaching the same olfactory receptor cells in the epithelium, are experienced differently depending on the route by which they got there. One explanation is that the brain distinguishes the direction of airflow and projects the pattern of receptor firings to slightly different cortical areas of the piriform, insular, and orbito-frontal cortices depending on whether the molecules come from the nose or from the mouth (see Small et al., 2005).[8]

A more psychologically convincing way to confirm Rozin's idea is by pointing to our experiences of matches or mismatches between smells and flavours. We often have expectations about how something will taste from how it smells; at other times, we may be surprised by the mismatch between how something smells and 'tastes', as when a wine's aroma gives no guide to its performance on the palate. There are two considerations here. Why should smells provide any expectations about how things *taste*? Smells are one thing, tastes are another. We can't smell saltiness or bitterness; so smelling a dish or a wine may not give us enough information to discover its flavour. This would argue that whatever olfaction may contribute to flavour, it is sufficiently unlike things we sniff, to see these as different senses (and as the sceptic would say, to accept only one of these senses as involving smell). However, there are other cases too—we talk about sweet smells, although sweet is a taste. Compare this with our talk of an acidic wine as tasting sharp, although sharp is a feel. These cross-modal attributions indicate how easy it is for us to confuse taste and smell, and perhaps to see aspects of flavour as resembling what we can smell orthonasally. Smells tend to acquire the characteristic properties that belong to tastes—sweet, sour, etc.—because they are so closely associated with things which when put in the mouth have a sweet or sour taste. Why should a smell be so closely associated with something that tastes sweet or sour? It is because the smell is so closely associated with the retronasal smell that a sweet or sour smelling food or liquid has in the mouth and that contributes to its flavour. Smell is a part of the flavours we 'taste': the wonderful perfume a ripe strawberry gives off is a pretty reliable guide to the experience we'll have when we eat it. How is this to be explained except by supposing that the aroma detected by orthonasal olfaction is similar in quality to, though less intense than, some part of the flavour (detected by retronasal olfaction) we get when we put the strawberry in our mouths. The idea that the heady strawberry smell is sweet-smelling is intricately connected to the olfactory dimension of its flavour. What is unpredictable on occasion about flavour from orthonasal olfaction shows the difference between the orthonasal and retronasal olfactory contributions, and what is predictable and shared suggests that they are both senses of smell. We can reconcile these claims by claiming that there are two senses of smell. The idea that the heady strawberry smell is sweet-smelling is a projection back onto the inhaled smell of some retronasally detected olfactory property intricately bound up with the gustatory element in its flavour.

This idea of matching, or sometimes mismatching, in terms of odours and smells, experienced by the orthonasal or retronasal route, helps to explain asymmetries between smell and 'taste' (flavour) recognizable in our ordinary experience. When you smell a ripe Epoisse cheese, for instance, it can be pretty off-putting. (That's the smell of isovaleric acid.) Yet, when you put it in your mouth, it can be surprisingly good. The cheese's odour when processed externally and internally via the mouth lead to very different experiences. The reverse case is coffee, where the aroma of freshly brewed coffee always smells so wonderful though it is slightly disappointing in the mouth. Many of the volatile compounds are stripped off by saliva, and many are not experienced the same way as they are when inhaled through the nose.[9]

The connections between the experiences of odours and the experiences of food flavours play a key role in considering retronasal olfaction to be a part of smell. For instance, loss or deterioration of our ability to smell—identified phenomenologically by changes in our experience of odour—coincide with the loss of flavour perception. At first, the reduced experiences of anosmia sufferers are regarded as loss of taste not smell.

> For a clinical example, where patients lose olfaction, they often report that they cannot taste or smell. However, when questioned, patients acknowledge that they taste salty, sweet, sour and bitter, but 'nothing else'. The 'nothing else' is the contribution of retronasal olfaction to flavour.
>
> (Bartoshuk and Duffy, 1998: 284)

More evidence of smell's contribution to flavour experience comes from normally functioning subjects. Just about all normonosmics have specific anosmias—that is, despite having a fully functioning sense of smell, there is some small set of odours which they cannot detect at all. When this is the case they will be unable to detect certain elements in airborne molecules, and also be unable to detect the contribution these volatile compounds make to flavour. For example, several normally functioning subjects are anosmic as far as Trichloranisole (TCA), or cork taint goes. If it is undetectable by the nose, drinkers will also fail to find any fault with a corked wine on the palate. The selective loss of smell is responsible for a corresponding deficit in flavour perception.

Another similarity between everyday smell and retronasal olfaction as it contributes to the perceptions of a food's flavour involves the Proust Phenomenon where the sudden whiff of a long forgotten scent seems to take us right back to a past time or a scene we didn't know we had stored in our memories. Smell has a special capacity to trigger episodic memories—especially emotionally charged memories—because of the direct connections olfaction has with parts of the limbic system involved in emotion and memory. Olfaction is unique in being the only sensory system that projects directly to the amygdala without going via the thalamus. As a result, odour memories are long-lasting and less susceptible to interference. This may account for the Proust Phenomenon, which takes its name from the famous episode where Proust's narrator, Marcel, tastes a madeleine soaked in lime-blossom tea and is suddenly jolted by the pleasure, which gradually evokes a memory of his aunt on Sunday mornings dipping crumbs of madeleine into tisane, which she presented to him. Experimental attempts have been made to confirm the phenomenon (Chu and Downes, 2000; Hertz and Schooler, 2002).

Are there any reasons to think the duality of olfaction just discussed gives us *two* senses of smell? There are number of things to be said here.

a. The cases mentioned above involving cheese, coffee, and chocolate show how orthonasally and retronasally presented odour stimuli lead to different experiential effects. Anecdotally, people often prefer the smell of cigars smoked by others to the experience of smoking them themselves. This is possibly due to the different qualities of the smoke when experienced orthonasally or retronasally. Retronasal olfaction also plays a crucial role in the perception of food flavours and when these are compared to the smell of foods, the comparisons are between, not smell and taste, but smell and a different olfactory dimension that contributes to flavour. Moreover, neurophysiologically, orthonasal and retronasal stimulation of the olfactory receptors project to slightly different cortical areas, and detection thresholds and intensity ratings are also different.

b. There is also a non-clinical way to demonstrate how olfaction contributes to flavour, not by phenomenological decomposition but by subtraction. It is to hold one's nose pinched tightly shut while popping a jelly bean into one's mouth to chew. Keeping the nose and mouth tightly closed, one has no clue at this stage as to the fruit flavour of the jelly bean. All one experiences at first is some sweetness and perhaps some sourness. However, when one releases the nose there is a rush of odours to the nose from the mouth, and immediately one can tell which flavour—cherry, strawberry, or orange—the jelly bean has; and although the nose is evidently involved in supplying the additional flavour component, the fruity flavour now seems to be coming from the tongue. One knows this can't be the case since just a moment ago when the nose was closed, one learned that all the tongue provided was sweet or sour. Only when the nose is unblocked can one have an experience of flavour. What we have here is a clash of appearances. Normally, it seems as if the fruit flavour is experienced in the mouth, on the tongue; and yet, with the nose blocked it appears that the tongue only provides awareness of sweetness, sourness, saltiness, etc. The way to resolve the tension is to recognize the contribution that smell makes to the experiences that *seem* to occur on the tongue. When people discover this for themselves they express surprise that the nose is required to have full flavour experiences, but they have no difficulty in updating their commonsense conception of tasting to incorporate the part smell plays in the experience of flavour. They do not—as those who resist the idea that tasting involves smell would have to suppose—conclude that these flavour experiences of tasting indicate that smell is not involved but that the single sense of taste is implemented at the neural level by among other things receptors that also serve in olfaction.[10]

c. Although retronasal smell is usually only experienced through its contribution to flavour, we can sometimes engage in phenomenological decomposition as well. The key case involves the flavour of menthol, normally experienced as a single percept. On reflection, we recognize that an experience of menthol comprises (i) a slightly bitter taste, (ii) a minty aroma, and (iii) a cool sensation in the mouth, and we can attend to each of these features in turn. Remove any one of them and you no are longer tasting menthol. The three chemical senses work together to produce a single unified flavour experience, and yet the reason why we can separately attend to the contributing sensory components in this case but not normally may be due to l-menthol's exceptionally strong trigeminal stimultaion whose cooling sensations may keep one keenly aware of a minty aroma in one's upper airways. But even in this case, one has to be prompted to attend to the parts separately and recognize the complexity of the experience.

d. In a food context, we can think of the two senses of smell as associated with two different sorts of pleasure: the pleasure of anticipation when we smell foods orthonasally; and the pleasure of reward when we assess the flavour of the food as we chew and swallow. This hedonic distinction between the two senses of smell is closely related to Kent Berridge's distinction between wanting and liking (Berridge, 1996). This distinction supports the idea that olfactory cues given orthonasally can trigger appetite and a salivary response, anticipating the reward of the food we can smell. If one continues to receive stimulation without having the food the salivary response diminishes as a result of habituation. But if the same stimulus odour is presented retronasally—controlling for the same intensity judgement—the salivary response returns, suggesting that these different presentations of the same odour are perceived differently, just as different odours are, where repeated presentation of the first leads to habituation that is reversed with the new stimulus (Bender et al., 2009b). A distinction between the two pleasures associated with each sense of smell fits well with Rozin's claim about the different evolutionary functions of the two senses of smell: to sense food sources (or danger) in the environment; and to assess the quality of what we're consuming and are about to ingest. It also contributes to the explanation of the match and mismatch between orthonasally and retronasally experienced odours.

e. There are other experiential differences between orthonasal and retronasal olfaction when we look at cross-modal interactions with further senses. A congruent colour cue enhances the intensity of our experience of odours orthonasally, but suppresses their intensity retronasally (Korza et al., 2005). Texture-odour interactions also showed differences in experience depending on route of odour delivery. Certain odours can increase the perception of thickness and creaminess but only when presented retronasally (Bult et al., 2007).

f. Finally, there are dissociations between orthonasal and retronasal olfaction that show up in pathological smell experiences. There can be deficits in retronasal smelling without orthonasal deficits (Cowart and Halpern, 2003). Conversely, there can be intact retronasal smell shown by preserved flavour perception, but where 'ordinary' orthonasally derived smell is impaired because of nasal polyps. (Landis et al. 2003). And even without evidence of polyps, there is a population of patients who show event-related potentials for retronasally but not orthonasally presented stimuli who experience flavours but do not discriminate smells in the environment (Landis et al., 2005).

Together, these considerations provide behaviour, neuroanatomical, phenomenological, hedonic, and pathological evidence in favour of counting olfaction from either route as belonging to the sense of smell, and provide motivating reasons for crediting humans with two senses of smell.

It is worth noting that we are not, here, distinguishing between a unimodal experience of smell and smell as a component of a multisensory experience of a food's flavour. Our ordinary sense of smell may seem intuitively to be unimodal; however, orthonasal olfaction produces experiences of odour mostly in concert with stimulations of the trigeminal nerve (Frasnelli and Hummel, 2005). The experiences we recognize as smelling are typically the joint upshot of olfactory and trigeminal processing; so are themselves multi-modal experiences. Of course, we can smell pure odorants such as phenol ethyl alcohol that do not activate the trigeminal nerve, but we don't consciously distinguish experiences of these odours from other odour experiences although they can be distinguished behaviourally because we are less good at localizing odour sources when odours are non-trigeminal stimulants.

12 What Does the Tongue Contribute to Tasting Flavours?

So far we have acknowledged the hidden complexity of our tasting experiences and the fundamental contribution smell makes—especially that due to retronasal olfaction—to our experiences of flavour. Tastes rarely occur alone. Putting aside contributions from smell, there is still touch. We speak of foods as creamy, or chewy, crunchy, sticky, or oily. To experience just tastes proper without any other sensory additions one would need to anaesthetize the tongue not just for feel but from movement or pressure: something that cannot be achieved save in clinical settings. Nevertheless, pure taste plays a vital role in our tasting of flavours. So at this stage it is worth asking just what the tongue does contributes to the experience of flavour, and whether it contributes the same in each of us.

Remember, taste proper concerns gustation alone where this covers a range of responses to chemical stimuli, including salts, sugars, acids, and toxins by different classes of taste receptors on the tongue, in the oral cavity, and in the gut. (Sweet taste receptors in the gut play an important part in insulin regulation.) Receptor firings on the tongue code for the so-called 'basic tastes' such as salt, sweet, sour, bitter, as well as the fifth taste, umami (savoury). To basic tastes we can add a sixth taste, metallic, and perhaps a fatty acid taste, although there is still controversy about fat as a basic taste (see Mattes, 2009). The list is determined in part phenomenologically—by characteristic experiences of human tasters associated with different kinds of stimuli—and in part neurobiologically—by the discovery of specific receptors for detecting each of these tastes. It is the task of psychophysics to align these two ways of picking out qualities like sweetness, bitterness, or saltiness.

How well *are* they aligned? It took discoveries in neurobiology to convince many Westerners to accept the positing of a fifth 'basic' taste, umami.[11] Although tasting it everyday, the fifth taste remained unknown for some time, and even now it is still not easy for people to recognize umami as a common element in the flavour of tomatoes, mushrooms, soy sauce, peas, parmesan cheese, and seafood, though it is a natural category for the Japanese. By contrast, English-speaking countries often confuse sour and bitter; leaving open the question of whether they cannot tell experiences of these two tastes apart, or whether they use the term 'sour' for instances of either. With training it is easier to distinguish sour and bitter by use of examples like lemon juice and quinine (or caffeine). Part of the problem may be that bitter-tasting substances like coffee can also exhibit sourness.

The list of basic tastes has also changed through history. In medieval England, cooks recognized at least eight basic tastes with two categories for salt: *salty* and *salty like the sea*, as well as *sour* and *vinegary* (Woolgar, 2006). Even now, there are good grounds for saying there is no single taste of sour, or of bitter. We have several different types of receptors for detecting bitter chemicals. There are also reasons to worry about identifying the basic tastes by a subject's experience of tasting, since gustatory tastes are modified by other influences. Mojet and her colleagues (Mojet et al., 2005) have shown that the basic tastes differ in perceived intensity when subjects taste them with and without a nose clip, thus showing that smell makes a contribution to the normal experience even of the so-called basic tastes.

As we saw above, subjects who lose their smell tend to believe, falsely, that they cannot taste. This shows how unusual it is to experience salt, sweet, sour, and bitter just as tastes in the absence of smell, and how unrecognizable such experiences are at first to those who lose their sense of smell. The ordinary experience of a supposed basic taste is probably in fact the experience of a flavour: the result of combining taste and smell (see Spence et al., 2014).

We are equipped physiologically to respond to the basic tastes and some researchers have suggested that labelled lines of neural relay from these distinct receptors carry information about particular groups of stimuli, such as salts, acids, toxins, to the primary taste cortex in the insula and from there to the orbitofrontal cortex. The separation of the basic tastes would seem to follow from the labelled line hypothesis: that receptors for salt, sweet, sour, bitter, etc., carry discrete information about each of these tastes to the brain. But how are they separately experienced phenomenologically? Philosophers often speak of experiencing a taste, such as the taste of honey, as if it were an irreducible item of our phenomenology. In fact we can dissect the tasting of honey, and even more basic flavours, into (i) the quality by which the experience is identified (here, its sweetness), (ii) the intensity of the experience, (iii) its temporal duration, including its onset and offset times, and (iv) its spatial location on the tongue. Let's explore these aspects of tasting further.

Just what are we perceiving by means of basic taste detection? Unlike some other component of flavour mixtures, salt seems to retain a recognizable identity. We can often discover whether foods contain salt just by tasting them, and on the basis of intensity determine whether foods are too salty. Do we therefore perceive salt when the response to the stimulus is above our individual detection threshold? Not necessarily: low levels of salt concentration just above threshold can appear sweet to a taster, and 'concentrations of salt that are weaker than levels in saliva may give rise to bitter tastes' (Breslin, 2000: 435). If we take the function of such taste sensations to be to generate perceptual experiences of salt, then these cases count as misperceptions. In these cases, the quality of the experience is modified by differences in the intensity of the stimulus. Moreover, saltiness is a response not only to sodium chloride but also to other salts, like potassium chloride. We can discriminate these by tasting, because potassium chloride has not just a salty taste but also a slightly bitter taste. Again, with sweetness, we can distinguish between sucrose and artificial sweeteners, because Aspertame has a later onset time and longer offset time; here it is the temporal difference in the onset and duration of receptor firing that allows us, phenomenologically and perceptually, to distinguish between the two. Hence, the different aspects of taste sensations identified above play a crucial role in determining the character and object of the resultant perceptual experience.

Tastes also differ in their perceived location on the tongue. The receptive fields of the different taste receptors are not uniform in their sensitivity on all parts of the tongue (Collings, 1974). So we can localize our greatest sensitivity to bitterness at the back of the tongue, to sourness at the sides, and sweetness at the front, even though we have greater receptor capacity to detect bitterness at the front. Detecting bitterness at the back of the tongue gives us a last resort to reject before swallowing potentially toxic, bitter tasting compounds. Other changes to the experience of a taste result from increase in perceived intensity or concentration of the stimulus. When salt concentration is too high the perceived intensity creates a burning sensation, which is more accurately described as feel or touch, rather than a taste.

There are other cross-modal effects involving taste. Cruz and Green (2000) have found that thermal stimulation of the tongue can evoke sensations of taste in about a quarter of the population. Warming an area of the tongue can give rise to a sweet taste, while cooling it can give rise to a salty or sour taste. Green calls these subjects thermal tasters and although the effects among this population are quite stable and affect their tasting of foods and drinks, we can think of these as illusions of taste.

There are other ways of producing taste-like sensations through other modalities, including electrical stimulation of the tongue, odour-induced tastes, and colour-induced tastes. The latter occurs when subjects are given coloured drinks to rate for sweetness or sourness. The drinks do not contain any tastants. They are tasteless and odourless, and yet a significant proportion of subjects rate the lime green drink as sour and the cherry red drink as sweet (Spence et al., 2010).

The case of odour-induced tastes is crucial for our understanding of the extent of flavour perception (see below):

> To experience odor-induced tastes, one need simply sniff odors such as strawberry, vanilla, mint, or chocolate, all of which are routinely described by Westerners as 'sweet smelling'.
>
> (Stevenson and Tomiczeck, 2007: 295)

This is a case of sweetness enhancement, where the orthonasal presentation of a congruent odor in the presence of a taste can increase the perceived intensity of the taste, and suppress sourness, thus functioning like taste proper. Some researchers have even reported that subjects can, under certain circumstances, experience sweet taste in a water solution with no sucrose when it is accompanied by a retronasally administered odour of isoamyl acetate (banana) (Hort and Hollowood, 2004). This phenomenon of sweetness enhancement is a cross-modal effect where the workings of a single modality, taste, is modified *in that modality* by stimulating another modality, olfaction, without the later being fused with taste into a single more complex flavour percept.

The increase in perceived sweetness for the same item tasted and rated for sweetness before and after accompanying with a sweetness-enhancing odour (vanilla, or strawberry) is superadditive. The result of combining a sucrose solution with the odour is greater in terms of neural activation and experiential effect than the summation of activation of the two components. This phenomenon of sweetness enhancement is a cross-modal effect but in this case we do not get the multisensory integration or fusion of ordinary (orthonasal) smell and taste into a single percept, but merely the influence of one modality on another. We still recognize the distinct components of orthonasal olfaction and gustation. Temperature has cross-modal effects on taste too: when coffee gets cold this increases its perceived bitterness.

All of these taste-altering effects can be induced under special conditions, but in normal conditions of perception do we tasters perceive the same things? Does the psychophysics give us grounds for intersubjective agreement about the basic tastes? As we saw earlier, there is cross-cultural variation in taste experience. In addition, there are complexities introduced by blending stimuli with the basic tastes in mixtures. Sometimes, combined tastes don't blend but keep their separate identity, as in sweet and sour sauces. At other time, sweetness suppresses sourness. Umami can enhance saltiness: so by adding monosodium glutamate to a dish it can taste saltier. Combining different types of umami creates synergistic reactions to intensify flavour. These produce greater intensity and are the basis for popular flavour pairings such as anchovy and tomato in pizza, and scallops and pea puree. Combining all the basic tastes usually leads to an overall suppression in taste intensity, unless one includes umami. This is maybe why tomato ketchup is so popular since it combines all of the five basic tastes.

Despite being able to recognize salt, sweet, sour, and bitter, people often disagree about the intensity of these tastes in a dish, arguing about whether the food has enough salt or too much. Does this show that tasting something as salty is a wholly subjective matter? Not necessarily; their tongues could have different numbers of fungiform papillae or taste buds. Those who have dense clustering of papillae on the tongue often show a quick and intense reaction to salt, sour, or bitter compounds. The explanation is clear in the case of salt. What makes something taste salty is the number of salt receptors that are simultaneously touched by NaCl molecules. So if an individual’s taste buds are densely packed they will need little salt, whereas those whose taste buds are more widely spread out will need lots more salt to get the same effect. Using this fact, nanotechnologists have been working on a salt molecule that will unwrap itself and touch more receptors simultaneously leading to the use of less salt for the same perceived effect. So, while individuals have different sensitivities, they are picking up on the same quality and perceiving it differently.

Those who show an increased sensitivity to basic tastes are the so-called super-tasters. The term was coined by Linda Bartoshuk (see Bartoshuk et al., 1994) who fashioned a quick test to sort people into three groups: super-tasters, tasters, and non-tasters. The test is based on their sensitivity to tasting strips soaked in PROP (propthiouricil) or PTC (phenylthiocarbamide). When the strip is placed on the tongue people show one of three reactions—they find it intensely bitter, mildly bitter, or tasteless. There is a normal distribution with more people being (mild) tasters, 25 per cent being super-tasters and 25 per cent being non-tasters. General conclusions have been drawn from the test about how sensitive these groups will be to other basic tastes, but the conclusions have been overdrawn. Juyum Lim and Barry Green (2008) have shown that while high sensitivity to PROP correlates with sensitivity to other tastes, there is no evidence that non-tasters have lower sensitivity to other tastes. Some PROP tasters do not even show increased sensitivity to bitter tasting quinine. Lim and Green suggest that we may need to distinguish between PROP tasters and general tasters, and that only the latter category is useful for predicting oral sensitivity and preferences. General super tasters are often conservative eaters, finding some foods too bitter and white wines too sour; whereas low sensitivity (non-)tasters are more adventurous eaters and enjoy spicy foods. Super-tasters with more taste buds on their tongue will have more trigeminal nerve endings exposed to irritation by spices, which may explain why they tend to avoid spicy food and strong alcohol. Bartoshuk is right, though, that such sensitivity is a spectrum and at the lowest end we find people for whom no dish is too sweet or too salty. So before we try to draw conclusions about the subjectivity of taste from disagreements in judgements about the saltiness or sweetness of a dish we need to be sure we are comparing like with like and that the same phenomena are in dispute.

Finally, we must not confuse the subjective experience of tasting that depends on detecting a basic taste, with the hedonic reaction to it. What we taste is one thing, and what we feel about it is another. The liking for sweetness and the disliking for bitterness are innate but they are not fixed and may be changed by experience or conditioning.[12] Disagreements about taste are harder to establish than is commonly thought, and attempts to make philosophical hay from then have to be treated with caution (see MacFarlane, 2007; Smith, 2010).

13 Flavour as a Psychological Construct—the Sophisticated Sensation View

As we saw earlier, the simple sensation view of tastes as the experiences we have when we eat or drink is hopelessly flawed. The items we consume strike us as fruity, creamy, spicy, sour, meaty, oily: and these properties, or our experiences of them, can only be had through the combined workings of the chemical senses and touch. So the simple sensation view of tasting is too simplified to cover the range of phenomena we include under experiences of tasting flavours.

The sophisticated sensation view denies that ‘taste’ (flavour) experiences are simply complex bundles of sensations. Flavours are experienced as unified wholes without a part-whole structure. Despite their unified appearance, flavour experiences arise through the multi-modal integration of taste proper with retronasal olfaction, to which we have to add somatosensory sensations of texture and temperature, mechanoreceptors triggered by chewing, and often the chemical irritation of the trigeminal nerve. The unity of flavour percepts seems to be created by the brain, so, on this view, there need be no flavours in nature: the flavours we experience only come into existence when our brains combine information from these different sensory systems. They are just psychological constructs, or brain products. This is psychologist John Prescott's position (1999) and many others in psychology and neuroscience have followed suit. A fairly typical statement of the view is given by Dana Small, echoing remarks made by sensory scientist Gordon Sheppard:

> Flavour is in the brain, not the food. It is the brain that unites the discrete sensory inputs from the food and drinks we ingest to create flavour perceptions.
>
> (Small, 2012: 540)

In what follows, I will resist this position and make out a case for the objectivity of flavours and flavour perception. But first let us take a critical look at the view of flavours as constructs.

There is a slip in the immediately preceding quote between the first and second sentence. Small is right that the brain binds discrete sensory inputs to create *flavour perceptions*, but this doesn't support the claim that *flavours* are made by brains. *Flavours* are one thing, *flavour perceptions* are another. Many empirical scientists simply elide them, but without a distinction between the perceptions and what they are perceptions of, it becomes hard to draw a line between veridical and non-veridical perceptions, and harder still to know which aspects of the overall experience of eating and drinking contribute to flavour perception. What is it that makes an experience one of *flavour*?

When it comes to defining flavour experiences, psychologists tend to be maximalists. Here is Martin Yeomans:

> arguably, multi-sensory integration may be at its most extreme in the case of flavour perception since few other experiences offer the opportunity for concomitant stimulation of all the major senses: gustation through the five primary tastes, olfaction through both ortho- and retronasal stimulation of olfactory receptors by volatile compounds released from food, mechanoreception contributing to our perception of texture and providing information on temperature, pain arising from oral irritants and hearing that results from sounds and vibrations coming from the mouth contributing to our perception of aspects of texture.
>
> (Yeomans et al., 2008: 565)

Notice that we can selectively attend to *some* of the multisensory components of flavour experience, such as the contribution of touch: i.e., when a food or liquid is described as being creamy, oily, crunchy, or melting; these seem to be part of flavour experiences. But what of the look of a dish, or the sound of a crunchy food? Are they part of flavour? They can affect how we experience foods and drinks. For example, the colour of liquids can influence our perception of sweetness or sourness (Spence et al., 2010). So should we speak of a visual component of flavour? And in a classic experiment by Zampini and Spence (2004), participants who ate stale potato crisps while wearing headphones that amplified the high frequency sound of their own crunching found the crisps to taste fresh. So is sound part of flavour?

Often we don't know that these visual or auditory inputs are changing our perceptions of flavour. We cannot phenomenologically separate them from the flavours we would experience anyway, nor can we attend to the contribution they make, as we can do with say the effect of the touch or texture of foods. Notice, though, that the contribution of touch is not always so easily phenomenologically separable. We say biscuits 'taste' stale, but these have the same taste and smell properties as fresh biscuits; but crumble differently in the mouth. It is this texture clue that leads to us say they 'taste' stale. And while, without input from sight and sound we still taste flavours, it would be hard to experience tastes or flavours without touch. But is touch part of flavour? To experience tastes without a sense of touch, pressure, or localization in the mouth requires one to have the chorda tympani nerve anesthetized. How would the free-floating tastes be experienced? Too little is known. So touch usually accompanies taste and smell, but is it part of flavour? Calling something creamy is attributing something to its flavour. Also, the creaminess of a food can affect its smell and therefore it's flavour, and, conversely, certain odours can increase the perception of creaminess and richness of a food in the mouth (Bult and Hummel, 2007).

An example of tactile inputs to tasting, though not recognized as such, is the experience of black pepper. The tongue doesn't have taste receptors for black pepper. It activates nerve endings that belong not to taste but to touch, though they make a genuine contribution to our experience of the flavours of food and drinks. The chemical irritants in mustard oil and peppermint oil (or l-menthol) elicit different responses in the trigeminal nerve. Mustard feels hot and peppermint cool, although there is no change of temperature in the mouth. These effects are due to chemesthesis. The extension of the burning and stinging to other places on the skin shows that chemesthesis is not a single sense but overlaps with nociception and thermoreception and is part of somatosensation.

The trigeminal nerve, though, is crucial to flavour experience and one of the hidden flavour senses. It governs our response to carbonation in fizzy drinks and sparkling wines. CO_2 is a trigeminal stimulant that produces the prickle we feel on the tongue and around the mouth. The stimulation of trigeminal nerves in the nose accompanies most but not all odorants and boosts olfaction. Thus those who lose smell can sometimes continue to detect strong odours by means of trigeminal stimulation. (Should we think of this as smelling by feel?)

Does the sense of touch play a role in flavour and flavour perception, and is it just a single sense of touch that is involved, including as it does tactile sensations, haptic explorations, thermal responses, pain, and chemical irritation? This just shows, perhaps, how difficult it is to think of touch as single sense, let alone flavour as a single sense.[13]

14 The Nature of Flavours and Flavour Experiences

Taking all these factors into account, how should we understand our experiences of flavour? How should we react to the claim that there are non-phenomenologically distinct components that contribute to the experience of tasting a single flavour? Should we let the phenomenology dictate the ultimate nature of flavour experiences, or should we individuate flavours via the interacting factors that give rise to our experiences of flavours? Should we view them as the complex products of multisensory integration? Or, as conscious experiences, should we take them to be just *as* they seem to us: whole, unified, unimodal experiences being just as they appear? The trouble with both of these ways of proceeding is that they seem to let in all sorts of contributions from external touch, sound, and sight to the constitution of flavour.

Let us consider the scientifically informed way of individuating flavours and flavour experiences as constructs of the brain by looking at the following definitions:

(1) Flavour is 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’ (AFNOR, 1992).
(2) ‘Flavour perception should be used as the term for the combinations of taste, smell, the trigeminal system, touch, *and so on*, that we perceive when tasting food’ (Auvray and Spence, 2008, italics mine).
(3) ‘Flavor perception arises from the central integration of peripherally distinct sensory inputs (taste, smell, texture, temperature, sight, and even sound of foods)’(Small et al., 2004).
(4) ‘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 (Bartoshuk and Duffy, 2005: 27).

Each of (1) to (4) acknowledges that the flavour experiences we have when tasting depend on sensory interactions, but they vary in mentioning different elements in the interactions. And despite being offered as definitions of flavour, what they actually describe are flavour experiences or flavour perceptions. (The definition of Auvray and Spence in (3) is more careful though elsewhere they collapse flavour and flavour perception.) If this conflation is deliberate then flavours should be inseparable from our experiences of flavours. However, the objectivist who seeks to distinguish flavours from flavour perceptions can appeal to cases where something can causally affect our perception of a food or liquid’s flavour without it being a contributing factor to flavour perception. Certain elements can influence, without being part of, flavour perception. Here, we need a distinction between *constitutive* and *causally affecting* factors in flavour perception: i.e., between components that contribute to what a flavour perception is and those that merely have a causal effect on flavour perceptions. This is not an easy distinction to draw, but before we try to do so, let us look at the problems that arise for those who take flavours to be exhausted by flavour experiences. What can they tell us about the boundaries to flavour experiences? What does and doesn’t belong in the list of contributing factors?

Researchers in psychology and neuroscience agree on what is going on when we eat and drink and which factors are present. What they disagree about is which factors belong to flavours and which don’t. For Auvray and Spence, taste, smell, touch, and the trigeminal systems are involved and maybe more; while for Bartoshuk, touch is not part of flavour. It merely plays a role in helping to combine taste and retronasal olfaction. For Yeomans, and maybe Small, sight and sound are also in there.

Why stop there? Is the hedonic value of the experience part of flavour? After all, when we eat something we immediately assess it for pleasantness or unpleasantness. Tasting is an evaluative activity, letting us judge whether something is delicious, bland, or disgusting. Some people take the whole point of tasting not to be about discovering the flavours of the food or drink, but about arriving at a hedonic rating: they like it or don't, which will decide subsequent behaviour. It is also difficult to separate the unpleasantness of what we're tasting—sea urchin, say—from the food itself, which is why we find it so hard to understand how others can overcome this flavour and enjoy it. So should we include the hedonic dimension of eating or drinking in our account of flavour making that notion even more subject to the varieties of subjectivities among tasters? For Yeomans, the issue of whether hedonic value is part of flavour is indeterminate since they go together and are tested together. Even expectations of the same food generated by different words can have an effect on its acceptability. Here is how it works. Yeomans et al. (2008) gave two groups of subjects smoked salmon ice cream to taste: one group was told that it was ice cream, while the other was told it was frozen savoury mousse. The first group liked it less than the second and reported it as tasting saltier and more savoury than the second group. So according to Yeomans:

> flavour perception is an integration of sensory information with past memory of similar stimuli predicated by the visual qualities, *and accompanying written descriptor*, for the rated food. (2008: 569, italics mine)

Verhagen (2007) argues that we should include hedonics in flavour since the processing in the food recognition network is paralleled by processing in a different but overlapping reward value system. The neural evidence is mixed, however, and does not entirely support this verdict, as we shall see below. But why stop here? The experience of eating and drinking responds to the posture of our bodies, the ambient temperature, sounds we are listening to, as well as other affective states. Why not consider the total sensory input to the overall experience of eating or drinking as part of flavour? What are the constraints on the combination of co-occurring sensory inputs?

We know some of the rules of binding across sensory modalities. In the case of multi-modal flavour experiences, the key idea is *congruence*. Lim and Johnson (2011) show that it is *congruent* tastes and retronasally presented odours that lead to the referral of the olfactory component of flavour perception to the oral cavity. The subjectivist who thinks flavours are in the brain owes us an account in purely internal terms of what makes inputs from different sensory modalities congruent or incongruent. (This will be a more or less notion for the sophisticated subjectivist.) Perhaps, it will be said that it is a matter of their occurring together, but this would include all the cases of potential illusions we worried about above. The objectivist can better explain congruence in terms of the configurations of odorous and sapid properties in the foods that make up the naturally occurring flavours. Banana odour and sweetness are combined in bananas, and they are integrated when one is retronasally and the other is orally registered. So why not think of bananas as having a flavour which it is the job of the flavour perceptions produced by the brain to track?

No such appeal is possible for the 'flavour is in the brain' theorist. She still hasn't told us what flavours are. Do they include sounds and colours? As pointed out above, researchers agree about the nature of co-occurring inputs. They disagree about which inputs count as parts of flavour. Empirical inquiry will not settle this matter. So, if there is a line to be drawn between what constitutes flavour experience and what merely causally affects it, this will be drawn theoretically or philosophically by deciding on the best overall account to make sense of the phenomena in the light of the underlying facts about neuroanatomy, neural connections, behaviour, experience and stimuli.

One might, at this point try to argue for a single flavour sense, whatever the underlying processing story, and try to pick out experiences generated by that sense on the basis of their characteristic phenomenology. But how sure are we that we can focus on our experiences for the purpose of picking out what is flavour and what isn't, and how sure are we about what belongs exclusively within that category? Touch contributes to how things taste to us and certain aspects of touch, temperature, stinging, and burning sensations from trigeminal irritations can be attended to in isolation. So how does this sense relate to the single flavour sense? In one way, it seems to be part of it, and in another it is a separate but overlapping sense. There is also the experience of a menthol flavour that we can break down into a minty aroma, a bitter taste, and a cool sensation. So is flavour perception, or more accurately, the sense that generates flavour experiences, unimodal or multi-modal?

Consider the four definitions of flavour (perceptions) just given. *How* are the different components mentioned in each definition bound together, integrated, or blended? More importantly, *what* are the components that get bound together in flavour perceptions? The different definitions of flavour quoted above go different ways on the how and what questions. Answers given to the *how* and *what* questions constrain one another: what is the ultimate product of combining inputs from different sensory systems, and how do the different sensory inputs combine?

We do not yet have a full explanation of multisensory integration or flavour binding, but various proposals, principles, and criteria have been offered. These include:

(i) Spatio-temporal unity
(ii) Superadditivity
(iii) Semantic congruence

(i) *Spatio-temporal unity hypothesis* treats the unity of flavour as arising from the fact that sensory information of various kinds, from various sources, are put together when presented close in space and time. This leaves open *how* we arrive at a unified percept. Perhaps it is no more than that what fires together wires together. But this is not sufficient. Interactions between multi-modal components go far beyond mere co-occurrence in consciousness.

Is the hedonic component of eating and drinking a constitutive part of flavour or flavour perception (Smith, 2007, 2010)? It would be hard to exclude it on the spatiotemporal unity hypothesis. But we should exclude it. Even if the main purpose of eating and drinking is to determine whether particular foods are pleasurable, this is nonetheless different from how the food or drink tastes and what its qualities are. If force-fed the same food repetitively, even a food we like such as chocolate, may disliked after excess consumption. The identity of the stimulus stays the same even when the hedonics vary, for if you were suddenly offered a different type of chocolate you would notice the difference (Kringelbach and Stein, 2010; O'Docherty et al., 2000).

(ii) *Superadditivity* occurs when the neural activation level of two or more sensory inputs is greater than the sum of their individual activation levels, as we saw above when both seeing and hearing a water bottle being crushed leads to greater neural activation in the perceiver than the sum of the separate activations for the visual and the auditory stimuli. Some take superadditivity to be a clue to multisensory integration, signalling how significant it is for the brain to link these pieces of information to track single objects or events. Perhaps, the integration that gives rise to unity of experience starts from a unity assumption about the different sensory inputs coming from a *single object or event*. The problem is that superadditivity can also occur without integration. The perceived creaminess of a food or liquid in the mouth can be affected by aroma. This does not yet create the kind of multisensory experience that results from the integration of information from different sense modalities.

What of the perceived weight of a bottle or feel of a food in the hand? These factors can causally affect our perception of flavours (Piqueras-Fiszman, 2011), but they surely are not constitutive of flavour. This is the philosophical point that needs to be stressed. Not every component of our *experience* of flavour reveals a component of flavour itself. The difficultly is that although there may be agreement about all that takes place during eating and drinking, there is no empirical agreement about which parts of the overall experience constitute flavour. We need a philosophical account sensitive to the empirical facts.

(iii) *Semantic congruence*. Does semantic congruency reveal a necessary feature of the relations that constitutes flavour? For example, strawberry odour + (congruent) sweet taste are combined into a flavour, but strawberry odour + (incongruent) salty taste are not, or less so. Congruency could also explain the role of expectation in flavour experiences. We get oral referral—by which flavour is experienced as located in the mouth, even though some components originate from the olfactory cleft and elsewhere (Lim and Johnson, 2011)—most for congruent taste-odour pairs. So congruency could help explain localization. Can the congruency hypothesis explain flavour perception by explaining the referral of retronasal olfactory components to the oral cavity?

The full congruency hypothesis would be as follows: unified flavours are constituted by congruently related sensory cues. Congruency is not to be thought of as 'all or nothing'—a sensory cue S1 is more or less congruent with sensory cue S2. Flavours would be constituted by these various 'more or less' congruency relations. Their role in determining flavours suggest that they intervene at the level of processing and (somehow) determine categorization resulting in determinate flavours (e.g., chicken); or they can be manifested as flavours with more or less resolution (e.g., chicken-like flavours).

If the congruency of different sensory stimuli or inputs is supposed to explain the unity of flavour experiences, we need to ask what explains congruency? How is the notion to be understood by the subjectivist who thinks of flavour as in the brain: the result of combinings?

It would be easy to explain congruency by saying that congruent features are considered to be attributes of the same kind of object. This is the idea offered by Lim and Johnson (2012), who argue that one needs an ecologically appropriate taste in the mouth, not just touch, to get oral referral of retronasally sensed olfactory components like fruitiness. This presupposes a unity and category to which these features belong as an ecologically valid part of the environment. This implies that flavour is not made in the brain, since the basis for congruence is ecological. Subjectivists can, however, fall back on *sensory congruencies.* They can say that two features ‘match’ when the estimation of the one affects the estimation of the other: e.g., the darker the colour, the more intense the flavour (ripeness), the heavier, the thicker the yogurt (density). Without resort to semantic congruencies, determined by naturally co-occurring configurations of texture, taste, odour, and irritant properties of foods and liquids, we just have these subjective, internal, and unexplained experienced sensory congruencies to determine which bundles of inputs are flavours. On such an account, flavours would reveal nothing beyond themselves.

But rather than settle for this unexplanatory stopping point, with no way to prescribe precisely the extent of flavour experiences, there is the objectivity strategy of positing flavours as properties of foods and liquids. On this view, we could see flavours as affordances which our capacities for multisensory flavour perception tracks so as to guide successful food choice.

By recognizing that flavours are external features of the environment we need not see flavours and flavour perceptions as always coinciding. The term *flavour* does not describe a construct of the brain, but it is a technical term used to describe the sapid and odorous properties of a solid or liquid, including properties of its temperature and texture, as well as the power to irritate the trigeminal nerve. On this view we can distinguish the hedonics of eating from the perceptual experience of tasting.

15 Flavours and Flavour Perception

Flavour is a configuration of the sapid and odorous properties of a substance, including its temperature and texture, as well as its power to irritate the trigeminal nerve. So when speaking about the taste of a food, we are actually speaking about its flavour. This point is often missed because we fail to notice all the components of our tasting experiences and because we are unaware of the large role smell plays in sustaining them.

Flavours are perceived when retronasal olfaction and gustation jointly give rise to a fused percept of flavour as a result of multisensory integration at the sub-personal level. We perceive flavours by the mechanisms of olfaction and gustation, under the right conditions, involving touch and sometimes irritation of the trigeminal nerve.

What is flavour perception for? The flavour perception system guides successful food choice. It needs to pick out and track perceptible properties, or sensible qualities of foods and liquids. And to explain why we bind the sensory elements we do and not others we rely on inference to the best explanation. Multisensory integration tends to take place when there is a common environmental source or unity responded to by many modalities. These are flavours —configurations of properties—that can give rise to multisensory responses in creatures like us.

Having dwelt a great deal on the role of smell in flavour perception, the next section will deal with remaining issues about our ordinary, orthonasal sense of smell.

16 The Sense of Smell and its Role in Experience

The role of the sense of smell in perception and conscious experience is subtle and elusive and this creates a puzzle for philosophy of perception about the nature of olfactory experience. Many say that they hardly notice their sense of smell and imagine it would be easy to give it up if they had to lose one of their senses. But smell is always with us: we smell because we breathe and we live in a world full of odours that subtly shapes our moods, influences our eating habits, our choice of sexual partner, recognition of kin, and our response to one another’s fear or aggression. Odours and our responses to them play an important part in generating memories, particularly early memories; and these responses to odours help to create feelings of familiarity and presence in certain surroundings. Given this wide role that our olfactory system plays in the conscious experiences of daily life, it is surprising that we pay so little attention to smell. Often, it is only when people sniff at something that they become aware of their sense of smell. All the other ways odours contribute to, or condition, our experience are perhaps mediated by the unconscious workings of the olfactory system? Or is it that smell is so much part of the fabric of experience—so much a background to our conscious states—that we are unaware of it until we attend to it? There is no straightforward answer to this question, which is why smell creates a puzzle for the philosophy of perception.

Consider, the connection between smell and memory. The highly emotive character of many odour memories is thought to be due to the direct connection between the primary olfactory cortex, the amygdala, and the entorhinal cortex that are involved in emotional and memory processing. When we get a whiff of scent that suddenly triggers a memory of a far distant time, it seems to take us right back there. The feeling of recognition is surely a way of tapping into a remembered episode of which the triggering odour was a part, whether noticed at the time or not. It is worth noticing that the odour-memory does not simply conjure up a past experience of smelling, but rather a multisensory scene with sights and sounds.

Reasons given for thinking we don't experience smells all the time include our supposedly poor sense of smell. But how good or poor is the human sense of smell? It can be trained and shows improvement (until old age), unlike our senses of sight and hearing. The increased sensitivity to and ability to discriminate and recognize odours shown by perfumers and wine tasters attests to the fact that humans may have a reasonably good sense of smell but simply fail to use it. As Sela and Sobel put it: 'Paradoxically, although humans have a superb sense of smell, they don't trust their nose.' Navigation is an interesting case. As upright creatures, we rely more on our eyes and our ears. Nevertheless, we retain olfactory navigational capacities. Noam Sobel and colleges have demonstrated that when blindfolded and on all fours, humans can navigate by using odour (chocolate) trails (Porter et al., 2007). People will take longer than dogs, but they will succeed. Sobel's research group also demonstrated a limited human ability to locate odour sources in space (Porter et al., 2005). Participants were fitted with a mask that had an artificial septum to exaggerate the separation of the nostrils. When using the mask, participants showed a rate of accuracy for the spatial location of odour sources of around 70 per cent, suggesting that the brain was using a mechanism akin to bi-aural hearing in audition. In commenting on these results Jay Gottfried asks the relevant question: whether the apparatus endows participants with a new ability or just uncovers an old one (Gottfried 2007). The lack of training and the immediate improvement in olfactory spatial awareness, lost again when the mask is removed, strongly suggests the answer is the latter.

Smell is constantly with us, and unlike other animals we don't need continuous sniffing to smell odours in our environment (pace Richardson 2013, though see Sobel, 2006). Active sniffing may be useful when we are trying to locate the source of an odour, or making special efforts to take in, or attend to a particular smell. Normally, odours simply reach the nostrils through the dispersal of volatile molecules. Pleasant and unpleasant smells aside, above-threshold odours often go unnoticed because of sensory adaptation. You no longer notice the smell of your own home, though you register it well enough to notice change straightaway. (Is something burning?) Normally, it is only when you return after a period of time that you become consciously aware again of the smell of your home.

How much of olfactory processing results in the conscious experiences of odours? Is ordinary olfactory experience just unattended to, or is there less olfactory experience than, say, visual and auditory experience? To answer these questions let us look at the role smell plays in perception and conscious experience more generally. Jay Gottfried holds that the function of the olfactory system is to track behaviourally relevant smells in the environment and extract meaningful information from them. To do this, higher-order brain regions, such as the orbitofrontal cortex, are recruited to assemble patterns of odour qualities encoded at the level of olfactory receptors. The receptors activated by an odorant do not map onto the odour percept directly; the olfactory receptor neurons will code for thousands of different volatile compounds that get synthesized into a unified whole. Coffee has over 800 volatile compounds, chocolate over 600, and yet they are perceived as a whole. The route from odorant to odour quality coding and categorization to conscious percept is largely unknown for a variety of reasons. Over 1,000 different receptor types are attuned to aspects of particular odorants, but these do not determine the resulting percept: 'the same olfactory input may generate different odor percepts depending on prior learning and experience', and perceptual learning will continue to modify odour percepts: 'neural representations of odor quality can be rapidly updated through mere perceptual experience' and '[l]earning also changes odor quality. For instance, cherry odor becomes smokier in quality after being experienced together with a smoky odor' (Stevenson, 2001 quoted by Li et. al. 2006: 1097). Experience and familiarity significantly enhance odour quality discrimination, while exposure to odour mixtures alters the perceived quality of the individual components

(Gottfried, 2007).

Wilson and Stevenson (2006) also subscribe to the view that the brain's job is to synthesize olfactory objects that correspond to collections of volatile molecules in the perceiver's environment. They term this the Object Recognition Model. There is evidence that the brain's ability to represent the wholes of olfactory processing is configurational, like face recognition, rather than analytical, in terms of their parts, which may be why we are poor at identifying an odour's constituents. We can still recognize mixtures, though we seldom identify more than two or three constituents in a mixture of six or more elements (Laing et al., 2002). We can also recognize the simultaneous presence of many odours. For example, it is possible to smell fresh coffee and bacon frying, without these blending into a single odour percept.

Should we think of these as distinguishable odour objects or as representing overlapping properties around us with no definite spatial location? The latter is Clare Batty's (2010) view. The lack of definite objects as sources is due, she thinks, to the smudginess of the odour trails we perceive. However, there are clear cases where we are aware of a source object for an odour, be it a flower or someone's hair. Many sensory inputs may be involved in identifying the odour source, just as there is integration of vision and audition to identify the sound source of a human voice. Gottfried and Dolan (2003) showed, moreover, that subjects detected an odour more quickly and accurately when paired with a semantically congruent image: e.g., a picture of a bus with diesel odour, and of a lemon with citrus odour.

Just as we can experience mixtures, and co-occurring odours, we can tell when an odour is complex (or one is more complex than another), even though we are unable to identify any of the constituent parts. What gives us this cue as to an odour's complexity? It may have something to do with the temporal dynamic of smelling and the differential rates of processing different odorants. We may be unaware of the temporal sequence though it may leave a trace indicating its complexity. What we know, however, is that there is no obvious relation between perceived complexity and the chemical complexity of the compounds involved. Single molecules can be perceived as having parts; that is, a single compound like salicyladehyde can produce multiple smell percepts, appearing to smell both like aspirin and like almonds (Lawless, 1997).

Perceptual constancy for odours is an important feature. Gottfried points out that odour objects are constantly maintained by processing in the piriform cortex despite variations in intensity. However, the perceived quality of a compound will change when the intensity changes greatly. Hexanoate at low intensity in wines can be perceived as pear, then at slightly higher intensity as grapefruit, while at higher intensity still it comes to be perceived as fecal. Notice that odour perception is maintained throughout gaps in perception. As Ophelia Deroy points out (p.c.), we breathe out as well as in, but we nonetheless recognize an ambient odour as present throughout.

Batty's view of the representational content of olfactory experience leads her to deny there can be olfactory illusions. On her view, olfactory experiences merely represent odour properties, not objects. Thus it cannot represent an object as having a property it doesn't have. A problem with Batty's view is its exclusive focus on unimodal olfactory perception. However, in the normal case, perceptual experience is multi-modal. We see, hear, feel, smell, and sometimes taste the objects we interact with, and in that context our overall perceptual experience of a smell can be illusory if it represents a familiar seen or felt object as having a surprising and perhaps disturbing smell. One patient reported (p.c) finding that cartons of orange juice she had bought smelled of fish. The smell was attributed to this multi-modal object; she was suffering from a vivid olfactory illusion. And as Thomas Hummel points out, in clinical settings there is a difference in smell disorders where patients present symptoms of parosmia or phantosmia. The latter is the vivid experience of odours in the absence of a relevant odour source, the former is where patients experience the wrong odour for a familiar odour source. For example, patients with parosmia

> perceive something after being presented with an odour of roses, which is not the expected odour of roses, but rather a distorted and often undefined odorous perception … these 'other' odour sensations are experienced as unpleasant. And they are generally only described in vague terms, for example as 'chemical'.
>
> (Hummel et al., 2011: 2)

By contrast to these representational views, Noam Sobel sees the function of the olfactory system as enabling the subject to arrive at hedonic ratings. The hedonic tone of an odour as pleasant or unpleasant can predict the reward potential of food as a result of learning.

> Humans can detect and discriminate countless odorants, but can identify few by name. The one thing humans can and do invariably say about an odor is whether it is pleasant or not. We argue that this hedonic determination is the key function of olfaction. Thus, the boundaries of an odor object are determined by its pleasantness, which—unlike something material and more like an emotion—remains poorly delineated with words.
>
> (Yeshurun and Sobel, 2010: 219)

Sobel believes sniffing both responds to and affects odorant intensity and therefore affects pleasantness and unpleasantness.

Sobel also shows that although olfactory processing has significant effects on behaviour—much that happens above conscious threshold is simply unattended: ‘although human odorant detection thresholds are very low, only unusually high odorant concentrations spontaneously shift our attention to olfaction’. So:

> whereas vision and audition consist of nearly continuous input, olfactory input is discreet, made of sniffs widely separated in time. If similar temporal breaks are artificially introduced to vision and audition, they induce ‘change blindness’, a loss of attentional capture that results in a lack of awareness to change. Whereas ‘change blindness’ is an aberration of vision and audition, the long inter-sniff-interval renders ‘change anosmia’ the norm in human olfaction.
>
> (Sela and Sobel, 2010: 13)

‘All this, however, does not diminish the role of olfaction through sub-attentive mechanisms allowing subliminal smells a profound influence on human behavior and perception.’ For example, there are odours in women’s tears that lower men’s libido (Gelstein et al., 2011). A great deal of chemical signalling happens without explicit awareness. Betina Pause has shown that humans process body odours of kin differently from non-kin and are surprised to learn that they can tell kinship just by smelling tee-shirts that have been worn by family members. The emotional state of others is also communicated chemically, with effects on the perceiver.

> The role of chemical communication in humans might have been strongly underestimated as chemical communication between humans usually does not reach the level of conscious processing.
>
> (Pause, 2012: 56–57).

Pause also shows that emotional states of others are communicated chemically, with effects on the perceiver. ‘Besides the effects on motor behavior, the [unconscious] perception of stress-related chemosignals significantly alters the perception of visual social signals in humans’ (Pause, 2012: 58). Such important environment signals about others’ emotions are processed in a rapid and automatic way with immediate impact on the perceiver.[14] From all these cases, it is clear that a great deal of olfactory processing goes on unconsciously and with a very specific function. But what is the function of conscious olfactory experience?

We can think of olfactory experience as a background to consciousness: part of the fabric that we no longer pay attention to until it changes dramatically. In that background role, smells can modulate our moods, and condition our responses. This idea has led to an even more radical suggestion put forward by Ep Köster, Per Møller, and Jozina Mojet (Köster et al., 2014) that the function of conscious olfaction is simply to detect change: that is what smell is for. Smelling the same things over a period of time leads to sensory adaption.

Köster, Møller, and Mojet suggest that unlike vision there is no need for the brain to maintain a constant olfactory as well as visual scene. By not doing so, we free up resources for other cognitive activity. However, should something change in the background landscape—smoke, rotten food smells, garbage, the perfume from a dress—this will immediately switch on our conscious attention to smell. They call this the Misfit View of conscious odour perception. It has a number of things going for it: it can deal with the effects of sensory adaptation where smell is no longer experienced; but it can also account for why we can smell if someone has been in our room, or if there is a smell of a gas leak. It also suggest that our greatest sensitivity is to subtle changes, which may be just what works to capture our attention and provide us with pleasure in the blends created by perfumers and wine makers.

Those small changes from a predictable to an unpredictable aroma may enthral us (see Smith, 2014).

17 The Nature of Olfactory Experience

This leads us to the vexed question of how we get at the nature of olfactory experience. Is the nature of olfactory experience ultimately answerable to how it appears to us: i.e., is the phenomenology of smell the ultimate guide to the nature of such sensory experiences? Some take this for granted, but it is far from clear either that how things appear in experience is the best guide to how they are, or that we can be entirely sure of bringing the phenomenology of smell sharply into view. Philosophers are wont to ask what it's like to smell a rose, and to think that by this simple locution they have isolated a paradigm example of olfactory experience. But is there such a thing as a pure olfactory experience had in isolation from the rest of conscious experience? Surely, it is more likely that that we are attempting to attend to the olfactory element *in* experience rather than *an* olfactory experience alone.

Smelling is more likely to be a matter of what we take it to be like. Most odours are also trigeminal stimulants and the experiences we have will be integrated products of trigeminal and olfactory stimulation (Hummel and Livermore, 2002). Anosmia sufferers may still be able to distinguish between different chemicals on the basis of the trigeminal sensations they produce, so may think they retain some of their capacity to smell (Bryant and Silver, 2000). This can be demonstrated by testing them with Cognac in a black glass. When smelling they react as if to a foul smell because of the stinging of the alcohol. So, what normal subjects are experiencing is not a unimodal experience. So what exactly is given in an olfactory experience, or an experience with an olfactory component?

All smells can be considered in terms of their particular *quality* ('rose', 'mint'), their *intensity* ('mild', 'pungent'), and their *hedonic tone* ('pleasant' or 'unpleasant'). Each of these dimensions of olfactory experience can interact with the others. An odour can change its quality and hedonic tone with a change in intensity due to an increase in concentration. It can flip from unpleasant to pleasant in a sexual context, say. The identification of the odour's quality and hedonics may change given a different label or priming. For example, isovaleric acid can be experienced as Parmesan cheese or as vomit. So is the phenomenal quality or character the same when we flip from one to the other? It is possible, by reflection, to recognize something unchanging? Should we think about such ambiguous experiences as one or two? The point here is not to answer these questions but to cast doubt on the idea that we have a clear way to move from the phenomenal character of an experience—the supposed 'what it's like'—to any precise characterisation of such experiences. The three dimensions of smell experiences (quality, intensity, and hedonic tone) make it clear that we are not dealing with a simple, ineffable, and unanalysable experience of the sort philosophers usually allude to with simplistic talk of 'what it's like to smell a rose'.

When we try to focus our attention on what we are smelling, we seem to get hold of something about which we can say next to nothing. Famously, we lack odour-specific terms for smells—except for aspects of smell, like acrid, pungent, floral; though some of these might describe effects of trigeminal stimulation rather than smell. Instead, we use the names of the sources of those smells: lemon, rose, tar, leather, cloves, mint; and this may explain our difficulty in being able to name the odorants we are smelling. There may be no special problem finding words for odours, as some have suggested.[15] Rather, the problem may be in identifying the odour source just by smelling the odour itself. Jonsson et al. (2005) suggest that the difficulty may lie not with naming but with finding the object that is the source of this odour. If we were able to identify the odour source there may be no trouble finding a name for the odour, or describing it, but when presented with a colourless odour from a vial—a highly unnatural way to be presented with an odour object in the environment, which are usually encountered in combination with other ways of sensing the odour source—we may struggle to identify it. Presentation of an object with that characteristic odour, such as a pineapple, is usually a multisensory affair, of which its smell is an integral part. Reconstructing the odour source from a unimodal clue may be a very difficult and highly unnatural task that requires training.

Perhaps the best way to understand the constant role that smell plays in our daily lives is to learn what would happen if one lost the sense of smell. Acquired anosmia can result from front-on head injury in which delicate fibres emanating from the olfactory receptor sheet are severed. Other causes include viruses, medication, and also neurodegenerative diseases like Parkinson's disease and dementia. Patients who lose the sense of smell suddenly complain of life's having lost its savour. Affect is flat and the quality of life diminishes. Food loses its flavour and as we saw patients often think they have lost their sense of taste. None of the places or people these patients know smell the same. Sufferers of anosmia often describe themselves as living behind glass, cut off from the world and feeling alienated from familiar settings. This frightening loss of a dimension of our conscious waking lives shows how much smell was contributing to consciousness without our apparently noticing it. The dimension that smell contributes to experience is something we often don't know about until it is gone. Old age also leads to reduction or loss of smell and may be a factor in the widespread depression among the elderly. In fact, people who lose their sense of smell remain depressed longer than those who lose their sight.

Of course, for some people, the dimension that smell contributes to conscious experience was always missing. Those with congenital anosmia may not realize, at first, that anything is missing from their perception of the world. They may think their experience of the world is complete, and that they have the use of all of their senses. This is the position Marta Tafalla was in as a child who was not diagnosed with anosmia until the age of 11. As a philosopher, Tafalla describes her surprise at learning that some part of her access to the world and some perceptible dimension of the world was missing. She has since spent time and attention trying to find out what this invisible dimension people speak about consists in (Tafalla 2013). One of her interesting speculations is that the sense of smell contributes to spatial awareness in normonosmics. She considers our appreciation of gardens and suggests that those who can smell the flowers and plants may have a greater sense of space and immersion. In this way smell contributes to experiences created by the other senses.

18 Conclusions

In contrast to the traditional view of the chemical senses as peripheral and marginal to the main questions in the philosophy of perception, we have seen how our understanding of the interactions among the chemical senses can reveal examples of cross-modal interaction and multisensory integration that we are coming to see as the rule not the exception in perceptual experience. The multisensory perception of flavour displays examples of: smell's effect on taste and vice versa; touch's effect on taste; smell's effect on touch and vice versa, temperature's effect on taste; audition's effect on taste; sight's effect on smell; and the way a multitude of sensory inputs from different modalities are integrated into a single, unified perception of flavour. What these senses demonstrate as well as any is how the brain relies on simultaneous input from many senses to create a coherent unified perception of the world around us and ourselves.

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([2]) Quoted by Johnston, 2000: 120.

([3]) For an objectivist view of tastes and tasting, see Smith, 2007.

([4]) See Jonathan Cohen, 2013.

([5]) Richardson (2013) tries to defend a non-naturalist view in this area by wisely discarding the idea that tastes come from the tongue on the grounds that philosophers don’t have to be committed to this. She does not, however, tell us where tastes are thought to occur, or what makes something an experience of *taste*.

([6]) This appears to be the strategy in Richardson, 2013.

([7]) In his 1982 article, Rozin thought olfaction was the only dual sensory modality, although we can think of other candidates: the dual pathways of vision (Milner and Goodale) and active and passive touch (Marcel).

([8]) fMRI studies reveal that retronasal presentation of chocolate odour produces preferential activation in the medial orbitofrontal cortex, the perigenual cingulate, the superior temporal gyrus, and the posterior cingulate cortex. Orthonasal presentation produces activation in the thalamus, right caudolateral orbitofrontal cortex, right hippocampus, frontal operculum bilaterally, temporal operculum, left anterodorsal insula and right anterior insula (Small, 2005; Negoias, 2008).

([9]) Coffee is all about the aroma and advertisers know it. That’s why we are told to wake up and smell the coffee, not taste it.

([10]) See Richardson (2013) for this philosophically mandated alternative to the commonsense response.

([11]) First posited in 1908 by Ikeda, who wrote, ‘Those who pay careful attention to their tastebuds will discover in the complex flavour of asparagus, tomatoes, cheese and meat, a common and yet absolutely singular taste which cannot be called sweet, or sour, or salty, or bitter … ’Dr Kikunae Ikeda, Eighth International Congress of Applied Chemistry, Washington 1912. It was confirmed as a basic taste with its own proprietary receptors in Chaudhari et al., 2000.

([12]) Things initially found bitter, such as coffee and alcohol, may come to be liked and desired as a result of the post-ingestive reward effects of alcohol and caffeine.

([13]) Many (though not all) would see touch as encompassing several senses (although see Fulkerson, 2014.)

([14]) ‘Fertile individuals prefer the body odors of partners with a relatively dissimilar [immune system] to their own. This preference, in turn, seems to be one of the major reasons for mate selection in many vertebrates (Boehm and Zufall 2006; Restrepo et al. 2006)’ (Pause, 2012: 57).

([15]) Tyler Lorig has suggested that activating the olfactory system interferes with use of the language areas of the brain, which explains our difficulty in naming or describing odours.

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