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Towards a sensorimotor approach to flavour and smell

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Sensorimotor enactivism takes perceptual experience to be constituted by a kind of attunement to sensorimotor contingencies – law-like relations between sensory inputs and bodily activity. The chemical senses have traditionally been construed as especially simple and passive, and a number of philosophers have argued that flavour and smell are problem cases for the sensorimotor approach. In this article, I respond to these objections to the sensorimotor approach, and in doing so offer the beginnings of a sensorimotor account of the chemical senses.

KEYWORDS

chemical senses, flavour, sensorimotor enactivism, smell

1 | INTRODUCTION

Sensorimotor enactivism takes perceptual experience to be constituted by a kind of attunement to sensorimotor contingencies – law-like relations between sensory inputs and bodily activity. This attunement allows the perception of invariant worldly features amid sensory changes, which can be manifested as a kind of duality to perceptual experience. For example, we might notice that a plate viewed from an angle looks elliptical in one respect, while also looking round in another. Several philosophers have argued that flavour and smell[1] are problem cases for this

[1] Flavour perception involves gustation, retronasal olfaction, tactile and trigeminal stimulation, but these components are generally experienced as unified (e.g., see Smith, 2013, 2015a). 'Taste' sometimes refers specifically to the gustatory contributions to flavour but we rarely, if ever, experience gustatory stimulation in isolation from the other aspects of flavour. Thus, as Spence, Smith and Auvray (2014) point out, taste is likely best conceived of as simply an aspect of flavour and here I do not focus in on taste as a separate perceptual/sensory modality.

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approach, and others, while not explicitly targeting sensorimotor enactivism, have offered accounts of the chemical senses[2] that would conflict with its core tenets. In this article, I respond to these obstacles for the sensorimotor approach, and in doing so offer the beginnings of a sensorimotor account of the chemical senses. I do not aim to convince the reader of the sensorimotor account in this article, but rather to show that flavour and smell do not present problems for the approach. Considerations of the chemical senses will also provide positive contributions to our general understanding of sensorimotor enactivism, placing certain constraints on the approach and clarifying what kind of account should be endorsed if it is to be extended to flavour and smell.

The chemical senses have traditionally been construed as especially simple and passive senses, involving mere proximal stimulation rather than the perception of distal objects and properties. I consider two main types of argument, both of which are related to these intuitions: (a) Flavour and/or smell is possible without bodily activity, and (b) sensorimotor enactivism's proposed duality between perspectival and invariant worldly features – for example, the plate appearing elliptical from a certain perspective but also still appearing round – does not apply in the case of the chemical senses. Both arguments, if successful, would show that the sensorimotor approach is inaccurate as a general account of perception. The first type of objection relies upon the idea that flavour and smell can occur without sensorimotor activity. The second relies upon the idea that, unlike the other senses, the chemical senses are devoid of perceptual constancies, thus not allowing for the distinction between perspectival and non-perspectival aspects of experience posited by the sensorimotor approach.

I will respond to these objections and argue that they fail to show that sensorimotor enactivism cannot be extended to the chemical senses. I begin by briefly outlining the central claims of the sensorimotor approach (Section 1), before discussing arguments that flavour/smell can occur without skilful bodily activity (Section 2). This first objection does not present great difficulty for the sensorimotor account as it targets only a particular interpretation of the approach. In Section 3, I respond to (the more difficult) arguments taking our flavour and smell experiences to be devoid of the sort of duality required by the sensorimotor approach. I outline constancies in flavour and smell perception and the way they are manifested at the level of experience as a kind of perceptual duality, highlighting how this approach allows for a kind of objectivism about flavours and smells. Finally, in Section 4, I examine the notion of *sensorimotor understanding*, which is at the heart of my responses to the objections covered throughout this article. Considerations of flavour and smell provide important lessons about how we ought to construe this notion.

2 | THE SENSORIMOTOR APPROACH

The sensorimotor approach was first set out by O'Regan and Noë (2001), but it has been further developed both by the theory's originators and through secondary literature (see, for example, Hurley & Noë, 2003; Noë, 2004, 2006, 2012; O'Regan, 2011; for a collection of secondary works see Bishop & Martin, 2014). The approach takes perception and action to be inextricably tied together: Perception is constituted by a type of bodily skill or *sensorimotor understanding*. This sensorimotor understanding is characterised as a kind of practical mastery of the way bodily

[2] For simplicity, I shall use the term 'chemical senses' to refer to flavour as well as smell but, strictly speaking, flavour involves a combination of chemical senses (gustation, retronasal olfaction, trigeminal stimulation) but also contributions from other somatosensory senses (see Smith, 2015a).

movements induce sensory changes. Our sensory relationship with the world is said to be tied to bodily activity in distinctive law-like ways (sensorimotor contingencies), to which we become attuned through exploration of the environment. This reportedly allows for an explanation of a phenomenon known as *perceptual presence* – the perception of aspects of the world as *complete* despite our limited sensory access to them. We perceive the world as consisting in whole objects, rather than only perceiving those aspects directly stimulating our senses. For the sensorimotor enactivist, an agent's attunement to how their bodily activity would induce sensory changes is what allows for their perception of complete, invariant aspects of the world.

In most respects, in this article I will work within the framework of Noë's (2004) style of sensorimotor account. However, there are different ways to cash out this approach. With some interpretations of the theory, there are consciously experienced sensory changes or 'raw sensations' prior to the acquisition of sensorimotor understanding.[3] According to this kind of approach, it is possible to have *sensory* experience (perhaps experienced as a mosaic of conscious sensations rather than coherent objects) without sensorimotor abilities. With other versions of the approach these sensory changes can only reach the level of conscious experience once the subject has already acquired the sensorimotor skills required for perception (e.g., see Beaton's, 2016 interpretation of Noë's approach, particularly p. 267, fn. 7). With this approach, perception and the experience of sensory change co-arise. According to either of these glosses on Noë's account, once we do have perceptual skills, we can at times attend to the sensory changes that are induced through bodily activity. Here I shall assume that with the sensorimotor approach, sensory changes are experienced (at least largely) as 'perspectival properties' – relational properties between the perceiver and parts of the environment.[4] The aforementioned plate looks elliptical perceived from an angle, and this elliptical shape changes as we move. Likewise, even though the plate is perceived as a uniform colour, there are visible differences in patches of light and shadow. The sensorimotor approach purports to shed light on these aspects of perceptual phenomenology and how they connect to perception's objective import. As we shall see, it is more controversial whether flavour and smell also exhibit this kind of perceptual duality.

I shall not adjudicate between the different interpretations of Noë's style of sensorimotor theory. However, it is noteworthy that if the 'raw sensation' approach were adopted, this would allow for conscious flavour and smell experiences that are not perceptual, and instead merely consist in changing sensations. Thus, this version of the approach allows for the possibility that the sensorimotor approach is true, but simply does not apply to the chemical senses.[5] However, although certain researchers have denied that flavour and smell are perceptual (e.g., Burge, 2010; see discussion in Section 3), dismissing these senses as sensation-based runs counter to the detailed information about the properties of, say, wine or perfume that can be garnered from tasting and smelling. It should not simply be assumed from the outset that flavour and smell are non-perceptual. I hope the phenomenological and empirical evidence I present with regards to perceptual constancies in Section 3 will provide reason to both take these senses to be perceptual and demonstrate that sensorimotor theorists need not dismiss the possibility of extending the approach to the chemical senses.

[3] This appears to be suggested at various points by Noë (2004) in his discussion of changing 'appearances' and 'looks' (e.g., see chapter 3, and pp. 228–230).

[4] In what follows I shall use the term 'sensation' in a manner intended to be neutral between potential 'raw sensations' and these consciously experienced perspectival properties.

[5] See Young (2017) for discussion of the possibility of a sensorimotor theorist making this move in the olfactory case.

According to sensorimotor enactivism, we can experience constant aspects of the world because of sensorimotor skills. For example, we visually perceive a stable world despite continuous saccadic eye movements (sometimes called visual direction constancy). This may be a puzzling phenomenon, but the sensorimotor approach explains it away by arguing that what allows for visual direction constancy, is an implicit grasp of how eye movements induce sensory changes. More generally, perceptual constancies are a crucial aspect of our perceptual interactions with the world. We see objects as being of a constant size and shape, even as we view them from different perspectives. We hear music as being of a stable volume, even as we move away from the sound source. We implicitly understand how to gain sensory access other parts of environment, which allows us to perceive these aspects of the world as unified and invariant, exhibiting constancies. This idea is sometimes described in terms of objects being *present* to us in virtue of being accessible (e.g., Noë, 2004, p. 63). Objects in the world generally are quite stable, and through a mastery of sensorimotor contingencies, we are able to perceive them as such.

The sensorimotor approach is most commonly intended as a general account of *perceptual* experience (but usually not of cognition or consciousness more broadly). It is explicitly non-visuocentric, with Noë (2004) arguing that touch, not vision, should be our model for perception. He also outlines ways the approach might apply to audition (p. 160; see also 2006). Indeed, with this approach, what individuates the senses are the distinct patterns of sensorimotor contingency associated with each modality (e.g., see O'Regan & Noë, 2001, p. 943). These different patterns of sensorimotor dependency are meant to explain the different types of experience associated each sense. It would substantially weaken sensorimotor enactivism if it turned out to only be applicable to, say, vision or touch.

Smelling and tasting involve wide-ranging bodily activities, giving prima facie credence to a sensorimotor approach towards the so-called chemical senses. Smelling involves sniffing, head and body movements to locate odour sources, and so forth. Tasting involves various tongue and jaw movements, sipping, slurping, swallowing and so on. However, for the sensorimotor approach to be true of these senses, flavour and smell experience must be *constituted* by sensorimotor engagement. Research into precisely how the sensorimotor account could be extended beyond vision and touch is limited (though for discussion of its applicability to smell see Cooke & Myin, 2011; for audition see Noë, 2004, pp. 160–161; and Lyon, 2014). Nevertheless, arguments against sensorimotor enactivism have emerged that take certain sense modalities, particularly taste and smell, to serve as problem cases for the theory. In what follows, I respond to two such arguments that threaten the extension of the sensorimotor approach to the chemical senses.

3 | OBJECTION 1: MOTIONLESS PERCEPTION

The motionless perception objection hinges on the idea that skilful sensorimotor activity is not necessary for certain kinds of perceptual experiences, and that sensorimotor enactivism therefore fails as a general theory of perception. These kinds of objections have been posed against the sensorimotor approach since its inception and have been applied even to those senses (vision, touch) that provide the paradigmatic examples upon which sensorimotor enactivism relies. Such arguments feature prominently in the commentaries on O'Regan and Noë's seminal (2001) paper.[6]

[6] See the comments from: Humphrey (2001), Niebur (2001), Nusbaum, Skipper and Small (2001), O'Brien and Opie (2001); Pylyshyn (2001).

This line of argument might seem especially convincing when it comes to the chemical senses. For example, Humphrey asserts:

> When we taste salt on our tongues, or smell musk in our noses ... how can these experiences plausibly be thought to depend on sensorimotor contingencies? There is simply nothing we do by way of exploration with our tongues (or our noses ...) that could provide requisite information. (Humphrey, 2001, p. 987)

For Humphrey, it is clear that taste and smell do not involve complex sensorimotor exploration. Prinz shares the intuition that the sensorimotor approach is especially implausible when applied to the chemical senses: 'Consider two perfumes: they may smell different even if they do not have different consequences for action ... Do we sniff different smells differently?' (2006, p. 11). How could taste and smell depend constitutively upon the mastery of sensorimotor contingencies?

As an initial response to these objections, it is worth noting that olfaction and flavour perception *do* involve a rich array of bodily activities. Olfaction involves sniffing (of changing speeds and intensity), moving one's head and body to seek out odour sources, and so forth.[7] Flavour perception involves tongue, mouth, cheek and jaw movements of various kinds (as well as the motor systems involved in swallowing and respiration), inducing gustatory, retronasal olfactory, tactile and trigeminal stimulation (e.g., see Shepherd, 2015). Without such bodily activity, flavour perception is impoverished (Burdach & Doty, 1987; de Wijk, Engelen & Prinz, 2003) and the movements impact the way the flavour is perceived. For example, Burdach and Doty (1987) found that without mouth movements, flavour intensity is weak. They thus suggest retronasal olfaction is a dynamic process, and 'mouth movements play a role in retronasal odor perception analogous to that played by sniffing in orthonasal perception' (p. 353). Retronasal olfaction can also be enhanced through more advanced tasting techniques (e.g., in wine tasting) such as deliberately keeping the usual barrier between the base of the tongue and the soft palate open (Buettner, Beer, Hannig & Settles, 2001). Swallowing can enhance flavour intensity in contrast to spitting (Burdach & Doty, 1987) and different chewing patterns can influence one's perception of food tenderness (Braxton, Dauchel & Brown, 1996). Moreover, different properties of the food itself can induce distinct types of chewing activity (e.g., Foster, Woda & Peyron, 2006).

Thus, at least typically, the chemical senses do allow for complex bodily exploration of features of the environment. Moreover, plausibly such bodily activities are *skills* we develop. Perfumers and wine tasters seem to have more refined abilities in this area than the untrained population, and are able to pick out aspects of scents and flavours that most of us miss.[8] However, it may still be that these senses are *less* complex and action-involving than the others, and perhaps sometimes motionless flavour and smell is possible. Humphrey's example of salt on the tongue may be such a case. Similarly, Young (2017) argues that olfactory science provides examples where bodily activity is unnecessary for olfactory perception.

[7] See Mainland and Sobel (2006) for a review of the evidence that sniffing is crucial to olfactory perception. See Porter et al. (2007) for a study illustrating human odour trail tracking abilities.

[8] One might argue that wine tasters do not have better perceptual abilities, but only better verbal abilities to describe wine in accordance with standardised terminology. However, evidence suggests wine tasters are better able to discriminate wines even where they lack these trained linguistic abilities (e.g., Melcher & Schooler, 1996).

These objections, however, do not refute the sensorimotor approach. The sensorimotor theorist can concede it is empirically implausible that every instance of perception requires skilful bodily activity *at that time*. Indeed, the implausibility of this has already been highlighted in the visual, auditory, and tactile cases. For example, Prinz (2006) and Aizawa (2007, 2018) highlight instances of paralysis where subjects are still able to perceive. Aizawa (2007, pp. 22–24) discusses surgical patients who recalled experiences of sound, vision, pain and touch despite being under general anaesthetic and neuromuscular blockade. He concludes that 'cases of complete paralysis found in the use of neuro-muscular blockade show that perception is possible without the exercise of sensorimotor skills' (p. 24). Prinz similarly argues that:

> Perception is not impaired by spinal cord injuries that cause paralysis, by paralysis of the eye muscles or brain structures that control them, by atrophy of motor cortex in Lou Gehrig's disease, by destruction of action-control centers in parietal cortex. (Prinz, 2006, p. 10)

Thus, he thinks, making it implausible that perception depends constitutively upon action. For these reasons, Prinz and Aizawa argue that perception only depends *causally* upon sensorimotor activity.

Fortunately, there is a well-known response to this branch of objections. Namely, arguments relating to the apparent non-necessity of bodily activity for perception tend to rely on a specific interpretation of the sensorimotor claim. As has been pointed out elsewhere (e.g., Loughlin, 2014; Shapiro, 2011), there are different ways to interpret the sensorimotor claim and the motionless perception argument only targets the strongest of these interpretations. In particular, it only targets the view that in order to perceive an agent must—*at that time*—deploy sensorimotor understanding by engaging in bodily activity. With a weaker interpretation, it is enough that the subject has *at some point* acquired the requisite sensorimotor understanding through bodily activity, allowing for motionless perception imbued with this kind of sensorimotor attunement. Even in O'Regan and Noë's initial (2001) responses to comments, they clarify that: 'It is not our claim that action is necessary for experiencing. Our claim, rather, is that knowledge of the ways movements effect sensory stimulation is necessary for experience' (p. 1015), and this knowledge does not require *current* movement.

Endorsing this developmentally focused interpretation of the sensorimotor claim can side-step motionless perception cases. Individuals who are currently motionless can perceive because they have in the past engaged in sensorimotor exploration, allowing the acquisition of sensorimotor understanding. According to such an approach, people have engaged in olfaction and flavour perception throughout their lives, thus developing an understanding of how their motor activity will induce olfactory and gustatory changes. With this account, *current* bodily activity (of the varieties highlighted above) may still be required for many types of flavour and smell experience. For example, as we shall see in Section 4.2, complex, temporally extended flavour and smell experiences may necessitate more extensive bodily activity. Yet, cases like perceiving a salty taste while motionless are still consistent with this weaker interpretation of the sensorimotor approach.

One might wonder if the weaker, developmental version of sensorimotor theory is satisfactory when it comes to the chemical senses, because new-born babies exhibit responses to tastes and smells. This may lead to a suspicion that the chemical senses are simple, innate abilities rather than sensorimotor skills that develop over time. Young (2017) presents this style of argument, and I shall tackle this worry in Section 4. For now, let us move on to a second, and perhaps more challenging, problem for the sensorimotor approach.

4 | OBJECTION 2: FLAVOUR AND SMELL LACK CONSTANCIES

With the sensorimotor approach, we detect invariances or constancies amid our changing perspectives on the world and this is what explains 'perceptual presence' – the perceived veridicality and completeness of aspects of the world, despite the limitations of our sensory access. What allows us to perceive a tomato as a complete object is having an implicit grasp of how to gain sensory access the hidden parts of it. We understand how our movements will induce sensory changes. This view requires a distinction between invariant, perceptually present aspects of the world (such as whole tomatoes), and the sensory changes which we manipulate through bodily activity. Researchers such as Gray and Tanesini (2009) and Burge (2010) have argued that the chemical senses fail to exhibit these kinds of perceptual constancies, and thus our experiences lack the requisite duality for the sensorimotor approach.

In vision, we often experience a contrast between invariant perceptual objects and our perspectival sensory relationship with the environment (i.e., *perspectival* properties). I can notice that a plate in some sense appears elliptical from an angle, but also see it as round. Objects remain constant even though our perspectives on the world continuously shift. Noë (2004, pp. 123–161) also applies this idea to colour perception, appealing to the phenomenon of colour constancy. Colour perception is explained by a grasp of how one's own movement or movement of the light source will alter the perspectival properties one experiences. In one sense I perceive the colour of surfaces as invariant in different illumination conditions, but at the same time I notice visible variations in the colour in patches of shadow or bright illumination.

Some researchers (e.g., Burge, 2010; Gray & Tanesini, 2009; Todd, 2018) have argued that the chemical senses do not allow for this kind of perception of invariances. Gray and Tanesini (2009) present a sustained attack on Noë's version of the sensorimotor approach on these grounds, taking flavour perception to provide a counterexample. While they agree tasting is plausibly an *activity* – wine tasters learn techniques such as smelling, swilling and gurgling (2009, p. 725) – they reject the idea that there is a duality to the experience. There is, in their view, no dichotomy between perspectival and non-perspectival aspects of flavour perception. Instead, flavour 'is just a matter of one kind of property' (2009, p. 730).[9]

They admit that flavour varies with circumstances, but do not think these sensory changes are indicative of perceptual constancies. For example, they note that after a meal 'one is badly placed to appreciate the taste of things' (Gray & Tanesini, 2009, p. 731). However, this is, they say, an example of perception in poor circumstances, as opposed to ideal ones, rather than a case of differing perspectival properties. Tasting after a meal is more like looking at things without wearing glasses, than seeing a tomato from a particular perspective. They simply do not think flavour perception involves the kinds of invariances that, say, vision exhibits (invariant shapes and colours, etc.). Although we might notice variations in taste among sips or bites, there is 'no equivalent for taste of the experience that the colour has also not changed' (p. 730).

[9] Although Gray and Tanesini often use the term 'taste' throughout their paper and offer some discussion of the so-called basic tastes (sweet, sour, salty, bitter and umami), for the majority of the paper they are focused on *flavour*. For example, they say: 'Wine connoisseurs might be able to recognize, say, a Riesling by its looks, scent and taste. But they do not experience a homogeneous Riesling-taste; instead, they immediately notice its scent of petroleum' (p. 8). This is a paradigmatic example of flavour perception, and thus, I shall assume they intend *flavour* perception to serve as a counterexample to the sensorimotor approach.

Gray and Tanesini (2009) are not alone in having this intuition. Recently Todd has made similar remarks, also denying that amid flavour sensations we are able to pick out a unified overall flavour or flavour profile:

> Although from one moment to the next we may latch onto, focus our attention on any one particular component – a particular odour or taste or texture – in what sense is that sensation we've latched onto the flavour of X? (Todd, 2018, p. 288)

Todd's primary target here is the kind of flavour realism espoused by Smith (2007, 2013, 2015b, 2016), but many of his comments also challenge sensorimotor enactivism. With Smith's proposed account, flavours are objective features of food and beverages. He states:

> The term flavour does not describe a construct of the brain, but it is a technical term used to describe the sapid and odourous properties of a solid or liquid, including properties of its temperature and texture, as well as the power to irritate the trigeminal nerve. (Smith, 2013, p. 310)

Those who wish to endorse a sensorimotor approach to flavour can agree with Smith's account of what flavours are. A sensorimotor approach to flavour and smell, much like Smith's flavour realism, takes us to access objective parts of the world through these senses. Thus, the sensorimotor account can be taken as one way of elaborating upon Smith's realism about flavours; we access these objective flavours (i.e., the relevant 'sapid and odourous properties' of food or drink) through sensorimotor engagement with the world.

Todd (2018), like Gray and Tanesini, denies that flavour perception allows for the perception of objective, unified aspects of the world through sensory change. He argues that the temporal structure of olfactory and flavour experiences shows there cannot be a unified overarching flavour/smell.[10] He believes tasting only allows for ephemeral experiences, and denies there is any flavour beyond this to be found:

> Whether we conceive of it as a perception-like unified impression of all the elements we've encountered while tasting, or rather as a judgement we make on reflection, it is unclear how we are to tell in advance that the temporal part we are tasting is a temporal part of the overall (future) flavour of X. Indeed, I suggest that for the case of complex objects like wine, or a meal, this question is in fact unanswerable, because there is no identifiable, unified overall flavour or flavour profile; or at least none that can be described nondemonstratively. (Todd, 2018, p. 288)

These issues relating to the temporal nature of flavour perception and olfaction will be discussed towards the end of Section 4.2. For now, it suffices to note that both Todd (2018) and Gray and Tanesini (2009) argue there is no constant flavour amid sensory change. Gray and Tanesini explicitly take sensorimotor enactivism to be false in the case of flavour on these grounds. With their construal of the sensorimotor approach (pp. 2–7), an experiential duality is what evidences perceptual experience being *constituted* by an attunement to the way one's movement induces sensory changes. In the flavour case, they deny such a duality. This leads

[10] Todd (2018) also argues that the *affective* nature of flavour perception and olfaction shows objectivism about flavours and smells to be false. Here I shall not respond to these claims but see Smith (2007) for the other side of the debate.

them to conclude that, while sensorimotor skill is *causally* important for perception, it is false that it *constitutes* perceptual experience. Sensory changes induced by movement are not the building blocks of flavour perception, because they are all there is to flavour perception.

Burge (2010), like Gray and Tanesini (2009), and Todd (2018), presents arguments that call into question whether sensorimotor enactivism can be extended to flavour and smell. Burge's focus is perceptual constancies, which he defines as the 'representation of distal attributes, as distinguished from registration of proximal stimulation' (p. 422). Although he does not specifically target the sensorimotor approach, he argues that neither flavour nor smell relies upon these perceptual constancies in its operation. If successful, these arguments would demonstrate that a key tenet of the sensorimotor approach fails in the case of the chemical senses. He groups the chemical senses with other sensory systems such as capacities to sense heat and pain, and various interoceptive sensory systems such as those affecting heart regulation and vascular constriction (p. 421). He states: 'There appear to be no perceptual constancies – no traction for perceptual as distinguished from sensory psychology'. Thus, there is no space for an experience of a distinction between changing perspectival properties and invariant, non-perspectival properties.

According to Burge, constancies are central to perceptual experience and for this reason taste and smell are largely *non-perceptual*. The chemical senses do not allow for what he calls 'objectification' – an abstraction away from proximal stimulus, which is supposed to provide a distinction between perception and sensory discrimination. This objectification is achieved through the exercise of perceptual constancies. Where there are no constancies, Burge says (speaking of pain, but presumably intending this to extend to taste and smell) there is 'no explanatory need to invoke veridicality conditions or representational content' (2010, p. 421). With such an approach, taste and smell allow only proximal stimulation of sense receptors, without enabling the subject to (veridically or non-veridically) attribute these sensations to an invariant distal object/feature.[11]

The next two sub-sections will argue that Burge (2010), Gray and Tanesini (2009) and Todd (2018) are mistaken in claiming that the chemical senses do not involve constancies and/or the perception of invariance among sensory change. I begin by responding briefly to Burge's empirical arguments against constancies in the chemical senses, before moving on to more detailed phenomenological and empirical reasons for taking there to be perceptual constancies in flavour and smell, which can be manifested as a kind of duality in perceptual experience.

4.1 | An initial response to Burge

The reasons Burge cites for denying constancies in taste and smell are empirical. His main concerns are based upon the character of olfactory and gustatory stimuli. He notes that the chemical blends that the olfactory system detects are changing and amorphous (Burge, 2010, p. 415), lacking the permanence required for constancies. He argues that most animals simply rely upon proximal registration of intensities on one or other side of the body to locate food/prey, which

[11] Burge does concede that the chemical senses could be supplemented with conceptualisations, allowing for a degree of objectification. For example, we think of food as having a taste beyond the gustatory stimulation we experience. However, according to Burge's (2010) account, this is not down to the senses themselves, but rather is a product of conceptual association and memory (p. 415). The operation of the chemical senses themselves is to be explained entirely in terms of functional responses to proximal stimulation.

in his view does not involve perception. This kind of homing activity involves a kind of 'mimicking' of direction constancy, says Burge, but lacks true representation marked by veridicality conditions (p. 424). Similar remarks apply to taste: He takes it to involve mere proximal chemical stimulation. Taste profiles that go beyond the proximal stimulation in our mouths 'do not seem sufficiently important to animal well-being to have forced evolution of constancy capacities for determining such taste profiles in gustatory systems' (pp. 415–416).

I am unconvinced by Burge's claims regarding the 'mimicking' of constancies. It is not clear how an animal's behaviours 'mimicking' direction constancy differs from the behaviours manifested by *real* direction constancies. Why would an animal making use of proximal registration of intensities to uncover the direction of prey not count as an instance of perceptual constancy? Burge suggests the difference is that in cases of true directional constancy, distal sources of stimulation can be localised without 'serial sampling' (p. 427). It is not clear, however, that there really is a salient distinction between olfaction and vision with regards to whether serial sampling is involved. One with a particular view of perception might argue that visual experience is constructed of serial samples received through eye saccades. However, with the sensorimotor approach, this is not the basis of perceptual experience. As Hurley (1998) says of vision, '[a] frozen field of view provides only impoverished information, and normal vision is not compounded of *snapshot*-like units but is essentially dynamic' (p. 430). Although the dynamic patterns of interaction involved in olfaction differ from those in vision, with a sensorimotor approach, both emerge through an attunement to the sensory patterns that bodily movements can induce. Our perceptions of odours are not simply a matter of olfactory snapshots, but rather a grasp of invariances amid this sensory change.

4.2 | Constancies, duality and objectivity

Gray and Tanesini (2009), Burge (2010) and Todd (2018) all agree there are changing sensations when it comes to flavour perception but deny we also experience perspective-independent properties, with Burge and Todd also extending this diagnosis to olfaction.

When tasting things, different ways of moving the mouth and tongue will result in different patterns of sensory stimulation, allowing the perceiver to access different aspects of the flavour. Letting chocolate melt on the tongue will result in different types of sensory stimulation than from chewing it. Wine tasters use wide-ranging techniques to detect different aspects of a wine's flavour, such as drawing air through the wine, 'chewing' it, swirling it around their tongue and so on. Likewise, whether one sips, swishes or gurgles wine also will result in different patterns of sensation, and adjusting one's breathing techniques and patterns of swallowing further alter the tasting experience. There is no clear sense in which the varied techniques of a wine taster are superior or inferior to one another. They are all useful methods of engaging with the wine. Thus, I do not take these to be instances of 'perception in poor circumstances' versus 'perception in ideal ones' (contra Gray & Tanesini, 2009, p. 731), but simply instances of one's changing sensory relationship with the wine (i.e., *perspectival properties*, to use Noë's terminology). Importantly, though, as we shall see, there is phenomenological and empirical evidence that amid these sensory changes, we also experience invariant flavour properties.

First, we frequently think and talk as though we experience an invariant flavour, beyond the sensory changes induced by our engagement with the food and/or drink. For example, we often think of the same bar of chocolate as having the same flavour throughout each mouthful, despite the variations discussed earlier. If we ask someone what a particular type of chocolate

bar tastes like, it would be unusual for them to reply that, 'if I let it melt it tastes one way, and if I chew it, it tastes another way'. In one sense, we are aware that if we interact with the chocolate in different ways this alters our sensory relationship with the chocolate, but in another we think of *the flavour* of the chocolate bar as constant and as a property of *the chocolate bar itself*. Smith (2015b) highlights that wine tasting involves concentrating on ephemeral sensations but that: 'The whole can exhibit something untraceable to the parts, and in the case of great wines it is this holistic, elusive quality that we attend to most and that novice tasters can acknowledge through the rush of pleasure it causes'. Such comments are suggestive of a unified gestalt beyond the changing sensations.

Empirical and phenomenological evidence of constancies provides further grounds for believing we perceive invariant odours and flavours, alongside the sensory changes highlighted earlier. For example, both olfaction and flavour perception appear to exhibit constancies related to *intensity*. In olfaction, changes in sniff vigour do not alter the perceived intensity of an odour (Teghtsoonian & Teghtsoonian, 1982). Consonant with the sensorimotor approach, when the changes to airflow rate are not under the control of the subject but are instead controlled artificially by a special device, this constancy effect does not occur. Relatedly, the rate at which a subject moves their mouth while tasting impacts the quantity of stimuli released by food and/or drink. However, according to research by Theunissen and Kroeze (1996), changes in the rate of mouth movement do not cause a subject to perceive the food's flavour as more intense. They suggest this may be a product of a kind of constancy analogous to the olfactory case.[12]

Careful examination of the phenomenology of olfactory and flavour perceptions, indicates that such constancies are manifested in terms of a duality to experience. If I take a vigorous sniff of my coffee, there is a sense in which I *can* notice a difference in odour intensity from when I take a smaller sniff. That I am sampling *more* volatile particles is reflected in my perceptual awareness and the experience has a greater strength to it. However, I do not attribute this change to the coffee odour itself. It does not seem that the smell has become stronger; I perceive the odour itself as remaining of the same intensity between sniffs. Likewise, altering my savouring activities may induce stronger flavour sensations, but often I do not take this to be down to changes in the food's flavour itself. In both cases, there is an aspect of the experience which is perspectival in that it depends upon our current bodily engagement rather than on the flavour/odour itself. Bodily activity results in different sensory relationships with the same perceptual object, and with the sensorimotor approach, it is our attunement to these sensorimotor contingencies that allows for a stable experience of the invariant, overarching perceptual objects.

Another type of constancy exhibited in olfactory experience (and plausibly also flavour, though the empirical evidence in this area is sparser) is *amodal completion*. This phenomenon is also often talked about in the literature in terms of 'filling-in', although for the sensorimotor theorist, there is strictly speaking no need to 'complete' or 'fill-in' anything. The claim is that perception is constituted by an attunement to sensorimotor contingencies, rather than merely the immediate gappy sensory stimulation. When smelling an odour, we only usually detect

[12] Flavour involves very wide-ranging and complex bodily activities and involves an interplay of gustatory, retronasal olfactory, tactile and trigeminal components. Thus, even if there are constancies relating to mouth movements and intensity, there will be trickier cases where it is less clear whether only one's perspectival relationship with the flavour is changing, or whether the objective flavour itself is changing. For example, by chewing food, the texture is changed, and this thereby also alters the flavour, and temperature can also cause such changes. There is not space here for a full investigation of this issue, but fully parsing out the objective flavour from the changing perspectival properties will be a complex issue for the sensorimotor theorist. See also the discussion of temporally extended flavours and odours below. Thanks to an anonymous reviewer for prompting clarification here.

some of the molecules typical of that particular odour, and yet are still capable of recognising the odour for what it is, such as coffee, for example (see, for example, Barnes, Hofacer, Zaman, Rennaker & Wilson, 2008). This too is manifested at the level of conscious experience in terms of a duality of experience. When smelling coffee or wine, one can notice that different sniffing activity allows the detection of different aspects of the odour (perspectival properties), and yet still perceive that the odour is a wine/coffee odour. This is much like how when we see an object, although we are only in immediate contact with its facing side, our perception is as of a whole object.

Although the best evidence for this type of perceptual invariance amid change comes from the olfactory case, there is also suggestive evidence in relation to flavour. Manipulating expectations can induce flavour constancies. For example, food consumers expect rates of saltiness to remain the same across mouthfuls, and manipulating these expectations can result in a perceived constancy even if subsequent mouthfuls are less salty (Dijksterhuis, Boucon & Le Berre, 2014). Such findings are consonant with the sensorimotor approach, according to which it is our sensorimotor expectancies that enable these constancies. Implicit expectations about the kinds of salty sensations that will be induced through tasting give rise, on this view, to the overall constant perception of flavour.

Similar evidence is provided by Woods, Poliakoff, Lloyd, Dijksterhuis and Thomas (2010), who found that an expectation of homogenous taste caused subjects to perceive sips of different drinks to be more similar, up to a point where the differences between the drinks were too great. In several trials, it was made to appear that drinks were being poured from the same jug, creating an expectation of sameness. In these instances of homogenous taste expectation, tasters deemed these drinks to be more similar than when the drinks were shown to be from different jugs. Woods et al. claim that, '[t]hese results lend readily to the possibility of perceptual constancy in taste' (p. 179). It may be that subjects do not have enough time to fully explore a drink's flavour when briefly sipping it. With the sensorimotor approach set out, a subject's sensorimotor expectations ensure they do not experience gappy sensory stimulation. Instead, one's attunement to sensory changes, gives rise to a perception of homogeneity, in much the same way that visual experience presents itself as of a richly detailed scene, even though we have limited sensory information at any one time.

Sensorimotor theorists take the world itself to serve as an outside memory store, which, in vision, can be accessed through eye (and head and body) movements as and when required (O'Regan, 1992). This is said to give rise to the 'illusion' that we are perceiving a richly detailed world before us, despite only having immediate sensory access to certain aspects of it. This view is supported by studies on inattentional and change blindness, which suggest that the brain does not construct a detailed internal representation of the environment (e.g., see O'Regan & Noë, 2001 for discussion). Surprising changes can occur in the visual scene without the perceiver noticing, despite the impression of seeing the whole detailed scene. Relatedly, Noë (2004) invokes the idea that the world is 'virtually present' (pp. 49–52). When viewing the online version of the *New York Times*, your computer will only download one article at a time as required, rather than downloading the whole edition of the newspaper; yet the whole paper is *virtually* present, as the whole of it is accessible. Similarly, when we see the environment, we visually connect to parts of the world when needed rather than having to construct a detailed inner representation, and thus the world is *virtually* present due to our dynamic access to it.

The aforementioned cases of amodal completion in smell and flavour directly map onto these lines of support for the sensorimotor approach. According to sensorimotor enactivism, our understanding of how to bring other parts of the world into view allows for this apparently

detailed experience of the world. Extending this idea to the chemical senses, our understanding of how to access further aspects of a flavour or odour through additional savouring or smelling allows the experience as of a gestalt perceptual object. Plausibly, in cases where we do not already have clear flavour or smell expectations, or where our expectations are violated, it is only through a longer experience of a flavour or odour unfolding, whereby we develop new sensorimotor understanding, that we become aware of the invariant flavour/odour.

In the visual case, we often just see whole objects, and only notice our changing perspectives on the world if we adopt a particular 'painterly' attentional stance. With flavour and smell, this is likely also true. We generally simply experience the odours and flavours, and only notice our changing perspectives on these phenomena if we adopt a similar kind of attentional stance (perhaps the stance of the wine taster or the perfumer, rather than the painter). The wine taster seems to be especially adept at attending to their rapidly changing sensory relationship with the wine. For example, in describing the process and the difficulty of wine tasting, Smith (2015b) states:

> Wine tasting is exacting, requiring short but sustained feats of concentration. There is the quick, almost ephemeral, moment of sipping and swallowing a wine whose precise character may elude us at first ... We must concentrate on the sensations at each stage without impeding the normal progress of the liquid across the palate by which the wine has its effect on us.

It is also worth noting that a sensorimotor approach allows for a kind of objectivism about smells and flavours (see also Smith's body of work, for example, 2007, 2013, 2015b, for a related objective approach to flavour perception). According to this view, it is through an implicit grasp of how smelling and savouring induces sensory changes that we can perceive gestalt odours and flavours. Against Burge's claims (2010), we pick out genuine, salient patterns of invariance as we interact with the world via the chemical senses. For example, when we perceive an odour, we are perceiving real collections of volatile chemicals, and we experience it as exhibiting constancies because we pick out patterns of invariance through worldly exploration. The aforementioned constancies demonstrate that there is more to our olfactory engagement with the environment than a set of olfactory snapshots or serial samples, and similar remarks apply to flavour.

Finally, I would like to briefly address Todd's (2018) worry, mentioned in the previous section, that there cannot be an overarching, objective flavour or smell because flavours and smells themselves evolve over time. Todd is not explicitly targeting the sensorimotor approach, but rather an objectivism about flavour (e.g., Smith, 2015b). However, it should be clear that this worry also targets the sensorimotor approach to the chemical senses. A similar challenge has been posed against sensorimotor enactivism in relation to temporally extended *sounds* (Clark, 2006), and has been responded to by Noë (2006). Whether similar responses can be made in defence of a sensorimotor approach to the chemical senses has implications for the viability of extending the theory.

Recall that Todd argues that the temporal nature of flavour perception and olfaction presents a problem for there being an overarching flavour or smell. He argues odours are intrinsically temporal:

> not merely in that they change through time, but in that they can develop through time. They change, trivially, in coming into being (and into awareness) and fading away; but they can also develop in taking on new properties, dimensions, or aspects. (Todd, 2018, p. 287)

While I do not think this kind of description applies to all the odours we encounter, it captures the phenomenology of perceiving certain complex odours. Some scents do change significantly over time rather than merely fading away. A perfume may have a refreshing top note that is evident when the fragrance is first applied, before blending into an aromatic middle note, which eventually trails away into a sustained, heavier base note. These different aspects of a fragrance can be gradually revealed one by one.

Contra Todd (2018), however, the existence of complex scents and flavours that evolve over time is not at odds with there being an overarching flavour or smell. The overarching flavour and/or smell is temporally extended and may exhibit a particular objective trajectory, and this trajectory is something one's perceptual investigations can uncover. Noë (2006) discusses this issue in relation to perceiving sustained sound-streams: '[Y]ou hear them as having a certain trajectory or arc, as unfolding in accordance with a definite law or pattern' (p. 29). Our sensorimotor attunement can extend to such trajectories – through a grasp of such arcs, the changes to sound-streams can become perceptibly present, along with the more constant aspects of the sound-streams (such as, for example, the timbre or volume). Perceiving the structure of these auditory trajectories requires skilful engagement and a degree of familiarity. For example, Noë notes that we may struggle to perceive unfamiliar, experimental music as anything more than 'mere noise' (Noë, 2006, p. 31), but once we become familiar with a style of music, we are better able to perceive the acoustic trajectory's structure and complexities.

Some flavours and odours also follow these kinds of arcs. For example, Smith (2015b, 2016) argues that wines have a temporally extended, dynamic flavour profile, and 'the wine has that evolving flavor independently of each moment of tasting' (2015b). Likewise, the way an odour evolves to allow top notes to morph gradually into middle and then base notes is, importantly, not equivalent to fleeting sensory changes we experience by detecting different aspects of a flavour or smell. Such flavours and odours unfold in a definite manner (and in the case of perfumes and wines, this is carefully planned out by the designer of the fragrance/wine) rather than mapping onto nebulous sensory changes as we engage in tasting and smelling activities (involving different mouth movements, or rates and intensities of sniffing, for example). To perceive the overall profiles of evolving, complex flavours and smells, more temporally extended perceptual engagement will likely be a requirement. Simpler flavours and odours will be perceptible through less extended activity, in part because there is not the same degree of change over time to uncover. This is unsurprising given the phenomenology of our flavour and smell experiences: I can perceive the unified odour of lemon quickly (because of my pre-existing sensorimotor understanding, according to the view set out), whereas to perceptually make sense of the evolution of a complex perfume, I may need to engage in more temporally extended olfactory activity.

In Sections 4.1 and 4.2, I responded to the worries of Gray and Tanesini (2009), Burge (2010) and Todd (2018) by outlining the ways which the chemical senses allow for the perception of invariant, objective aspects of the world. Now we move on to some further challenges for the sensorimotor theorist. The idea we can perceive unified odours and flavours through a mastery of sensorimotor contingencies presents some puzzles when we consider how the chemical senses develop.

5 | DEVELOPING SENSORIMOTOR UNDERSTANDING AND THE CHEMICAL SENSES

Sensorimotor understanding is crucial to my responses to the argument about the chemical senses lacking constancies and the motionless perception argument. Motionless perception is

possible only where one has already developed the requisite sensorimotor understanding, and sensorimotor understanding allows for the perception of constancies amid sensory changes. In this section I discuss how the chemical senses are informative with regards sensorimotor understanding.

Recall that Section 1 suggested the sensorimotor theorist could side-step arguments about motionless perceiving by relying upon a kind of developmental argument. It can be argued that subjects have already acquired the relevant sensorimotor understanding to be able to perceive odours/tastes, even in the absence of the motoric elements of smelling/tasting. Once we have an implicit understanding of how bodily movements will induce sensory changes, we need not *actually* perform these movements. The sensorimotor approach must rely on *counterfactual* sensorimotor understanding. We experience the whole tomato as present, even without moving to look at the back of it. Similarly, placing salt on the tongue may allow for perceptual experience in the absence of movement because of expectancies about how, if one *were* to move their jaw or tongue, this would cause certain types of sensory changes. This counterfactual sensorimotor understanding is supposed to develop over time. This developmental notion of sensorimotor understanding also allows the sensorimotor theorist to draw on empirical evidence from cases such as Bach-y-Rita's tactile vision substitution systems (TVSS) and vision reversing goggles.[13]

Sensorimotor theorists often draw upon TVSS cases (e.g., Hurley & Noë, 2003; Noë, 2004; O'Regan & Noë, 2001). TVSS devices are composed of a head-mounted camera, which sends signals to a matrix of electrodes or vibrators attached to the subject's skin or tongue. The electrodes/vibrators produce patterns of stimulation corresponding to changes in the visual information received by the camera. Initially, users only experience tactile stimulation, but after an adaptation period they begin to have vision-like experiences. However, only subjects who could actively move around – and thus learn how their movements induced particular sensory effects – experienced this vision-like perception. They must reach a certain level of proficiency in using the device before they have such experiences. Again, this supports a developmental interpretation of the sensorimotor claim: Perception is something we learn to do over time. Cases of adaptation to vision inverting goggles, which distort the way the light enters the eyes, also suggest that we become attuned to sensorimotor contingencies over time (eg., Noë, 2004, pp. 8–10).

However, this developmental approach may seem to pose a problem for the sensorimotor theorist when applied to the chemical senses. Evidence suggests we are sensitive to olfactory qualities from an early stage in our development, leading to suspicion of the developmental interpretation of sensorimotor understanding. In particular, Young, arguing that olfaction is a problem for the sensorimotor approach, asserts:

> [T]he developmental line of reply will not help in this instance, as the olfactory system is on-line and allows us to perceive the olfactory qualities of odorants as neonates if not in utero. (Young, 2017, p. 106)

There is a possible inconsistency between the developmental version of the sensorimotor approach required to alleviate the motionless perception worry and the apparent olfactory abilities of neonates. Young's idea is that olfaction cannot be something we develop over time as a sensorimotor skill because even neonates can smell. He cites studies that relate to the fact that new-born infants turn their heads towards the smell of their mothers' breast milk (e.g., Stein,

[13] See Hurley, 1998, chapter 9 for detailed discussion of these cases of adaptation, along with other relevant developmental results.

Ottenberg & Roulet, 1958). The objection is implicitly premised on the notions that (a) neonates are able to smell, but (b) they have not engaged in the relevant sensorimotor activities required to develop perceptual skills according to the sensorimotor approach. There is reason, however, to question both premises, but doing so will place certain constraints upon the notion of sensorimotor understanding.

5.1 | The developmental line of argument

New-born babies have apparent olfactory abilities: They turn their heads towards the smell of their mothers' breast milk (e.g., Stein et al., 1958), and show specific responses to the smell of their own mother's breast milk in contrast to a control breast milk odour (Sullivan & Toubas, 1998). As noted earlier, Young (2017) thinks this shows the developmental version of the sensorimotor approach to be false, since (a) neonates can smell, but (b) they have not had the opportunity to develop sensorimotor understanding. There is scope to challenge either one of these premises. The sensorimotor theorist can: (a) Reject the first premise by denying that the neonate is actually perceiving, or (b) reject the second by taking sensorimotor understanding to be something that must be learned from experience, but take sensorimotor learning to have already begun in utero.[14]

Contra Young's first premise, there is reason to suspect the neonates' responses to breast milk odours are not truly perceptual. It has been suggested that lactating mothers' breast secretions may contain a particular stimulus, which is a candidate human pheromone. It is thought to be this specific stimulus to which neonates respond (see Wyatt, 2015, for review). All babies respond to areola secretions with suckling and nipple search behaviour, and it is doubtful whether such responses can truly be said to be based on olfactory perception.[15] If this is not a perceptual phenomenon, the sensorimotor approach is not threatened by apparent neonate olfaction, and it remains a possibility that smell (and, perhaps also flavour perception) is a skill developed over time after birth. Moreover, if neonates are unable to engage in olfactory perception, this would appear to further bolster the idea that perception is a skill developed over time, even in the case of the 'simple' chemical senses. However, it may perhaps still be the case that neonate responses to areola secretions are on a continuum with olfactory perception, even if they themselves are not perception-based responses.

If it turns out neonates are engaging in genuine olfactory perception, Young's second premise can instead be challenged. A degree of sensorimotor learning may occur in utero, allowing for some rudimentary perceptual abilities from birth. Numerous flavour and smell eliciting compounds are present in amniotic fluid, and after around 6 months of gestation, foetuses actively inhale this fluid as they mimic breathing motions (Schaal, Marlier & Soussignan, 1998). This allows them to obtain chemosensory information in a manner similar to orthonasal olfaction. Towards the end of gestation foetuses also swallow amniotic fluid, which mimics certain tasting behaviours. While foetuses do not seem to engage in genuine smelling (since their nostrils are full of fluid), they do engage in activity closely connected to our tasting and smelling behaviours. While this idea requires further empirical investigation, it is far from clear that neonate olfactory and gustatory abilities present an immediate problem for the sensorimotor approach.

[14] A further option not discussed here would be to take (a degree of) sensorimotor understanding to be innate, so (some) perception need not be learned from experience.

[15] Thanks to an anonymous reviewer for helpful comments on this issue.

Neonates' apparent olfactory responses therefore do not rule out sensorimotor enactivism's claim that perception is a skill. It is questionable whether they have truly perceptual olfactory abilities, but even if their responses do indicate a kind of rudimentary olfactory perception, this may be based upon prenatal learning. The work surveyed above suggests olfactory activity begins as a very minimal ability, perhaps not even classifiable as perception, while at the other end of the scale are highly trained perfumers and wine tasters.

5.2 | How should we understand sensorimotor understanding?

We have seen that flavour and smell do not present a problem for the sensorimotor enactivist, and in overcoming various challenges, I have outlined the beginnings of a sensorimotor approach towards the chemical senses. The preceding discussion also places certain constraints upon the notion of sensorimotor understanding. Sensorimotor understanding is supposed to be an implicit, practical understanding of how our movements will give us sensory access to different aspects of the world. It cannot require that the subject is making current, actual movements because of the motionless perception cases discussed above, so it must be counterfactual species of understanding.

Sensorimotor theorists deny that sensorimotor understanding is an intellectual or propositional kind of knowledge of the world; instead it is supposed to be a type of know-how – an understanding of how to act and access different aspects of the world. However, despite these proclamations, sensorimotor theorists have been criticised for being inconsistent in whether they flesh out this notion in a non-cognitivist, or a more cognitivist and intellectual, manner (e.g., Hutto, 2005). If it turns out pre-natal olfactory and gustatory learning occurs, this adds weight to the claims that sensorimotor knowledge should not be treated as an intellectual or propositional kind of knowledge. Even if one rejects neonate perception and prenatal sensorimotor learning, the chemical senses are often considered more primal and basic than the supposed 'higher senses' like vision. Extending the sensorimotor approach to the chemical senses thus bolsters the idea that sensorimotor understanding does not require propositional knowledge (it is hard even for human adults to describe their flavour and smell experiences in propositional form).

It may be puzzling that this kind of attunement, potentially even manifested by babies, could still be counterfactual in the sense required by the sensorimotor approach (e.g., see Silverman, 2018). However, many paradigmatic cases of practical understanding involve a sensitivity to counterfactual states of affairs. For example, one might know how to play the piano. This involves a kind of sensitivity to the different notes that will be produced by hitting each key. Likewise, knowing how to ride a bike involves a practical, and yet counterfactual, understanding of the effects of pedalling, changing the gears, and so on. Riding a bike or playing the piano are abilities to engage in an activity in a way that is sensitive to the impact that different types of movements would have. Similarly, knowing how to access different aspects of the environment involves a sensitivity to the sensory stimulation that will be induced by bodily movement.[16]

While there is still much work to be done in the provision of a fully fleshed out sensorimotor account of smell and flavour, we have seen throughout the preceding discussion how perceptual constancies in the chemical senses can be appealed to in service of developing a

[16] Here I concur with Silverman's (2018) interpretation of the sensorimotor approach. He argues that we ought to construe sensorimotor knowledge as an ability to act in a way that is sensitive to sensorimotor contingencies (p. 165).

sensorimotor account. An ability to act in a way that is sensitive to sensorimotor contingencies can allow for the perception of unified, gestalt odours and flavours, alongside more transient sensations. Moreover, there is something objective about these unified gestalts; we detect genuine patterns of invariance through our sensorimotor engagement. Constancies in the chemical senses, such as amodal completion, directly parallel the sensorimotor claims about the world serving as an external memory store, and the world being 'virtually present'. We only ever have limited immediate sensory contact with odours and flavours, but other aspects are present as accessible to the perceiver. Those who are convinced by such claims in the visual domain ought to recognise that analogous perceptual phenomena are occurring in the case of flavour and smell.

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