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Affectively Mixed Olfactory Experiences

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Abstract
One of the central debates in the contemporary science of affectivity concerns the structure of affective valence. Recent discussion has focused on the possibility of affectively mixed experiences–experiences that are pleasant and unpleasant at the same time. Yet this debate has almost exclusively centered on one class of such experiences: mixed emotions. In this paper, we argue that affective perceptual experiences provide a promising avenue for advancing our understanding of affectively mixed experience. Focusing on the neglected case of olfaction, we first argue that phenomenological evidence supports the existence of affectively mixed olfactory experiences. We then show that, owing to the distinctive temporal dynamics of olfactory processing, these experiences resist a reductive explanation in terms of the vacillation hypothesis, the leading reductive account of affectively mixed phenomenology. Finally, we assess the existing empirical evidence for affectively mixed olfactory experiences and propose experimental paradigms to guide future research.

Keywords Affective valence · Affectively mixed experiences · Mixed emotions · Olfaction · Smell · Vacillation hypothesis

Olfactory experience is often affectively unambiguous: smells strike us as either pleasant or unpleasant. The honeyed aroma of a sun-ripened strawberry exemplifies a typically pleasant olfactory experience; the acrid, oily funk of spoiled mackerel an unpleasant one. Yet, not all olfactory experiences fit neatly into this dichotomy. Imagine an apple pie that has been left in the oven too long and has partially burned. Smelling it, one may be simultaneously aware of the unpleasant harsh, charcoal-like odor of the burnt crust and the pleasant sweet, caramelised aroma of apples and cinnamon from the intact filling. Cases of this kind suggest the possibility of what we will call *affectively mixed olfactory experiences*: olfactory experiences that feel simultaneously pleasant and unpleasant.

In this paper, we use the term 'affective experiences' to denote the experiences that have a felt positive or negative character.[1] The term 'valence' refers to the pleasant or unpleasant phenomenological character of such experiences.[2] In other words, affective experiences are such because they have a certain valence (i.e., they are valenced). With the expression 'olfactory valence', we thus indicate the pleasant or unpleasant character of an olfactory experience. Affectively mixed olfactory experiences – such as the one of the partially burnt apple pie – belong to the broader family of affectively mixed experiences, experiences that have both a positive and negative valence. The latter experiences have recently received much attention in the debate on the structure of affective valence (Larsen et al. 2001, 2017; Larsen and McGraw 2011, 2014; Larsen and Stastny 2011; Russell and Carroll 1999).

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[1] In the debate on affective perception, the same style of definition has been adopted by Fulkerson (2020) and De Vignemont (2021). In the literature, the term 'affective experiences' is sometimes used interchangeably with 'affectively-laden experiences'. To avoid confusions throughout the text, we will stick to the first one.

[2] With the term 'valence' we therefore do not refer to any characteristic of stimuli themselves, but to a phenomenological property of the experience. To avoid confusions, it is important to acknowledge that the term 'valence' has been employed differently in the empirical literature (for instance, in Gottfried 2010 'olfactory valence' denotes 'the appetitive or aversive nature of an olfactory stimulus'). For a useful discussion of the terms in the literature on olfaction, see Skrzypulec 2023a.

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Crucially, the two leading theories of valence (the bipolar and bivariate theory) make opposing predictions about the possibility of affectively mixed experiences. According to bipolar theories, pleasantness and unpleasantness lie at opposite ends of a single dimension and therefore cannot be instantiated simultaneously. By contrast, bivariate theories hold that pleasantness and unpleasantness are independent dimensions, allowing for genuinely mixed affective experiences. Affectively mixed experiences have thus become a central testing ground for these competing views.

Thus far, however, this debate has focused almost exclusively on a single kind of affectively mixed experience: mixed emotions. Proponents of the bivariate view have sought to provide evidence that people can feel, for example, happy and sad at the same time; on the contrary, proponents of the bipolar view have developed alternative explanations designed to accommodate this evidence within their preferred paradigm. In this paper, we argue that affectively mixed olfactory experiences constitute a promising avenue for advancing the debate on the possibility of affectively mixed experiences. In particular, we will argue that the unique architecture of olfaction makes affectively mixed olfactory experiences especially challenging to accommodate within a bipolar framework and thus theoretically significant for understanding affective valence.

The paper will be divided into three sections. In Section 1, we first introduce the debate between bipolar and bivariate theories of valence. Then, we reconstruct a tacit assumption that has shaped the debate in question: namely, that core affect is the sole kind of mental state that can be valenced. This assumption – we argue – has led theorists to overlook affective olfactory experiences. Drawing on cumulative evidence from phenomenology, behavioral psychology, and neuroscience, we contend that olfactory experiences themselves should also be regarded as potentially valenced.

In Section 2, we argue that reflection on the phenomenology of certain olfactory experiences provides prima facie support for their being affectively mixed. We then introduce the so-called *vacillation hypothesis*, the most influential strategy deployed by proponents of the bipolar view to accommodate affectively mixed phenomenology. According to this hypothesis, experiences that seem simultaneously pleasant and unpleasant are better understood as involving rapid, introspectively unnoticeable oscillations between positively and negatively valenced experiences (Condon and Feldman Barrett 2013; Kahneman 1992; Larsen 2017; Russell 2017). We conclude by arguing that, unlike with mixed emotions, certain distinctive architectural features of olfaction undermine the plausibility of applying this hypothesis to affectively mixed olfactory experiences.

Lastly, in Section 3, we discuss whether phenomenological considerations for the existence of affectively mixed olfactory experiences can be further supported by the existing empirical literature. We argue that, at this stage, the evidence remains underdetermined, largely because affectively mixed olfactory experiences have received very limited empirical attention. We conclude this section by outlining promising directions for future research, including experimental paradigms that could test whether olfactory experiences can, in fact, be affectively mixed.

1 The Debate on the Structure of Affective Valence and its Neglect of Affective Perception

One of the central debates in the contemporary science of affectivity concerns the structure of valence. Two families of views have dominated the debate. According to bipolar accounts (Barrett and Bliss-Moreau 2009; Condon and Feldman Barrett 2013; Russell 1980, 2003, 2017; Russell and Barrett 1999), valence is constituted of a single dimension which ranges from extreme pleasantness through a neutral point to extreme unpleasantness. Proponents of this account maintain that the valence of a subject's affective state at any point in time should be represented by a single point along this dimension. On the contrary, according to bivariate accounts (Cacioppo and Berntson 1994; Larsen et al. 2004; Larsen 2017; Watson and Tellegen 1985), valence is constituted of two independent dimensions, both ranging from a neutral point to extreme pleasantness or unpleasantness, respectively.

One of the crucial testing grounds for these competing models has been the possibility of affectively mixed experiences: affective experiences that have both a positive and a negative valence simultaneously. Proponents of bipolar accounts deny that affectively mixed experiences are a real possibility. Since, in their view, a subject's overall affective experience can at any point in time occupy only one position on the dimension of valence, it is not possible for that experience to feel simultaneously pleasant and unpleasant. Conversely, proponents of bivariate accounts can readily admit that affectively mixed experiences are possible. In their view, these will be affective experiences that, at some point in time, have a value other than zero on both the dimensions of valence.

The main focus of the dispute between bipolar and bivariate accounts of valence has been the possibility of a specific kind of affectively mixed experience: mixed emotions. The claim that mixed emotions are a real possibility seems phenomenologically plausible (think about bittersweet nostalgia) and has been corroborated by recent empirical work by proponents of the bivariate account (Larsen et al. 2001; Larsen and Green 2013). Although these findings

may seem to pose a serious threat to the bipolar account, defenders of the latter have devised ingenious strategies to accommodate them within their preferred paradigm (we will provide a detailed discussion of one of those strategies, the so-called vacillation hypothesis, in section 2). For this reason, Jeff Larsen, one of the main advocates of the bivariate view, expressed concern that the debate between bipolar and bivariate theories may have reached an impasse (Larsen 2017).

In this work, we suggest that we can make progress on the question of the structure of affective valence by broadening our inquiry to a class of affective experiences that has thus far received very little attention in the debate: *affective perceptual experiences*.

Affective perceptual experiences have recently been the focus of a small but growing literature in the philosophy of perception (see e.g., De Vignemont 2023; Fulkerson 2020; Jacobson 2024). They are usually characterized as perceptual experiences (i.e., visual, auditory, tactile, gustatory, and olfactory experiences) that have a felt positive or negative character (are pleasant or unpleasant). Consider, for instance, the perceptual experiences of catching sight of blood or hearing a terrifying scream: the idea is that these perceptual experiences are not mere triggers of subsequent affective states (in this case, emotions like fear), but can themselves be valenced. For example, Fulkerson (2020, p. 4) argues that there are instances of perception that involve "a component with some features more typical of emotion – strong positive or negative affect," but that, differently from emotions, they "seem stimulus-driven and fused to the perceptual object".[3]

The reason why affective perceptual experiences have been set aside in the debate between bipolar and bivariate accounts of valence is connected to a foundational assumption shared by proponents of both these views: namely, that the only kind of mental state that can be valenced is core affect. Core affect is a simple, introspectively accessible affective state out of which all other kinds of affective states are allegedly constructed (Larsen 2017; Russell and Barrett 1999; Russell 2017). In this view, perceptual states cannot themselves be valenced. At best, they can be causally associated with certain systematic variation in the valence of core affect. Accordingly, James Russell – one of the most influential defenders of the bipolar account – explicitly states that "perception of an affective quality per se is a cold perceptual process that fixes a belief about the affective consequences of something [i.e., the causal impact that thing can have on core affect]" without being valenced themselves (Russell 2003, p.157).

However, the view that perceptual experiences can be valenced is well motivated both introspectively and by empirical research, or so we will argue in the remaining part of this section. Our focus will be on a specific kind of affective perceptual experiences: affective *olfactory* experiences. These are the kind of olfactory experiences that we typically have when we smell the pleasant smell of freshly baked bread, or the unpleasant smell of rotten fish. Our focus on olfaction is motivated by two kinds of considerations. For starters, the view that perceptual experience is affective is more plausible for olfaction than it is for almost any other sense modality (see Martínez 2015; Skrzypulec 2023a, b).[4] Secondly, as we will see in the next section, certain architectural features of olfactory perception make affective olfactory experiences particularly interesting for the debate between bipolar and bivariate views.

A good starting point to discuss affective olfactory experience is phenomenology. Consider the experience of smelling a piece of rancid anchovies. This experience does not merely present the smell as having specific olfactory sensory qualities, e.g., as being fishy. It also presents the smell as unpleasant. Here, Fulkerson's (2020) description of the unpleasant experience of a durian's smell undergone by a Western person is illustrative. When smelling the durian, Fulkerson argues, it can immediately strike the subject as unpleasant.[5] Fulkerson is careful to distinguish this phenomenon from a full-blown emotional reaction to durian. To see the difference, we can contrast the case in which we perceive a foul smell of durian with the case in which thinking about such a smell, or imagining it, induces a certain emotional reaction (say, disgust). There is a phenomenological difference between these cases, for in the former, but not in the latter, the unpleasantness of the durian is presented to us as inextricably bound to our olfactory experience of it. From this observation, Fulkerson concludes that the olfactory

[3] In this paper, will not take a stance on a variety of questions which have been discussed in detail in the literature on affective perception. For starters, we will remain neutral on the question of whether the affective character of a perceptual experience should be understood as a distinctive attitude that one might hold towards some perceptual contents (Martínez 2015), or as part of perceptual content, e.g. as properties perceived along with the sensory ones (Skrzypulec 2023a, b). We will consequently also not take a stance on the question of whether the affective character of perceptual experience should be taken to track any properties of perceptual stimuli, be they intrinsic or relational properties.

[4] Other perceptual experiences that plausibly count as valenced include those associated with taste and affective touch.

[5] Fulkerson also insists that these kinds of olfactory encounters can display distinct motivational drive. For the sake of this paper, we will not analyse the presence of such a motivational force, limiting ourselves to stating that olfactory experiences can be valenced.

experience itself possesses an unpleasant phenomenological character.[6]

These phenomenological observations have been further substantiated by empirical research in the psychology and neuroscience of olfaction. In fact, it is nowadays common practice, among both scientists (Castro and Seeley 2014; Wilson and Stevenson 2006; Yeshurun and Sobel 2010) and philosophers (Martínez 2015; Skrzypulec 2023a, b) working on olfactory perception, to consider olfactory experiences as valenced.[7]

Surely, these considerations are not a novelty in philosophy. In the *Timaeus*, Plato already noted that smells are primarily categorized based on their valence (Plato 2000, *Tim.* 66d–67a). Plato's insight aligns with a position in contemporary olfactory science known as the valence-first account of olfactory perception (Castro and Seeley 2014; Yeshurun and Sobel 2010). According to this view, valence is the primary dimension of olfactory experience, and, accordingly, smells are mainly characterised in terms of their valence (Yeshurun and Sobel 2010).

Of course, not everyone agrees that valence is the *primary* dimension of olfactory experience. For example, proponents of the so-called object-first account of olfactory experience argue that smells are perceived and classified primarily along their sensory qualitative dimension (e.g., Olofsson et al. 2012; Gottfried 2010). Even proponents of this latter view, however, tend to agree that valence is *a* dimension of olfactory experience, though not the primary one. For example, Donald A. Wilson and Richard J. Stevenson – key theoretical references for the object-first approach – describe the phenomenology of olfaction as tripartite. Conscious olfactory experiences, they write, are constituted by three dimensions: intensity, quality, and hedonics (what we refer to as valence).[8]

In fact, an object-first view is not necessarily incompatible with the idea that an olfactory object is partly constituted by its degree of valence (as noted by Gottfried 2010).[9] In any case, in this paper, we will remain agnostic on whether valence is the primary dimension of olfactory experience. We reckon that, while the valence-first view would straightforwardly entail the claim that olfactory experiences can be valenced, such a claim is also widely endorsed by proponents of the object-first view.

The idea that valence is a dimension of olfactory experiences (if not the primary one) is supported by a variety of sources. Some support comes from behavioral evidence on the categorization of smells. It is sometimes argued that humans can make valence judgments significantly faster and more accurately than they can identify the odor's specific identity (Yeshurun and Sobel 2010; but see Olofsson et al. 2012; Olofsson 2014 for a dissenting view). Furthermore, Zarzo's (2008) comprehensive review of the dimensions of odor perception, synthesizing data from decades of multivariate analyses, demonstrated that the dimension of pleasantness or unpleasantness consistently emerges as the single most dominant factor organizing the human olfactory space. Regardless of the specific qualitative descriptors used by subjects across the studies analyzed (such as 'fruity,' 'spicy,' or 'putrid'), the component that explains the largest proportion of the statistical variance in human responses to olfactory stimuli is invariably the pleasantness-unpleasantness dimension (for consistently similar results, see also Bierling et al. 2021; Khan et al. 2007).

Another line of support for the claim that valence constitutes a dimension of olfactory experience comes from evolutionary considerations. From an evolutionary perspective, it has been argued that olfaction's ability to provide rapid affect-based classification is fundamental for survival, as it allows organisms to approach or avoid environmental

[6] In our view, the sensory dimension and valence dimension constitute two fundamentally distinct dimensions of olfactory experience. This position aligns, we believe, with their treatment in the empirical literature. That said, there are systematic correlations between these dimensions: smells that have certain olfactory sensory qualities tend to be experienced as pleasant or unpleasant. But given that we take the two dimension of smells to be independent, it seems plausible to us that two smells with the same olfactory sensory qualities could be experienced as either pleasant or unpleasant by different people in different contexts (as illustrated by the case of the durian smell, which is generally found unpleasant by Western people and pleasant by people in Southeast Asia). We thank an anonymous reviewer for inviting us to clarify our stance on this issue.

[7] Again, we acknowledge that the term 'valence' is not used homogeneously in the literature. However, it seems uncontroversial to state that the majority of theories of olfaction concede that the experience of a smell can be pleasant or unpleasant.

[8] Wilson and Stevenson (2006, 136) state that "all olfactory experience, irrespective of orthonasal or retronasal origin, still seems to be characterized by three dimensions: intensity, hedonics, and quality". They support their claim by reference to findings from multidimensional scaling analysis, which measured how similar different pairs of smells were perceived to be (for instance, they mention Schiffman 1974; Schiffman, Robinson, and Erickson 1977; Carrasco and Ridout 1993).

[9] Gottfried, one of the main supporters of the object-first view, writes: "A purely hedonic definition of odour objects has also been proposed. According to this alternative definition, the complexity of odour space reduces to a single continuum of pleasantness, along which each odour has a unique pleasantness score. It is this hedonic score that constitutes the odour object. Insofar as synthesis, segregation, categorization, discrimination and selection are equally pertinent for guiding behavioural distinctions among smells of different valence, this alternative hypothesis is not incompatible with the definition adopted in this Review" (Gottfried 2010, p. 637).

stimuli before fully processing their identity (see a discussion of olfaction's functions in Keller 2016; or in Stevenson 2010). Indeed, the affective classification of odours is crucial for smell to play its role in the identification of edible sources, of potential sexual mates, and of environmental hazards. In this sense, Keller (2016) argues that the evolutionary function of olfactory perception is not to collect accurate information about the environment, but to guide adaptive behaviour. If this is the case, then the ability of olfaction to rapidly differentiate an olfactory source as pleasant or unpleasant becomes crucial: the olfactory system might be evolutionarily tuned to categorize the world, among other things, in terms of pleasant and unpleasant stimuli (of something either being 'good' or 'bad' for the organism).[10]

The final pieces of evidence for the idea that the detection of valence is an intrinsic dimension of olfactory experience come from neuroscientific research. That there are bidirectional connections between olfactory and affective neural centres has been widely recognized in the empirical literature. However, recent data supports the even more radical claim that olfactory areas themselves might encode valence from the earliest stages of processing. Let us start with the classical literature on the connection between olfactory and affective centres. In an influential study, Zald and Pardo (1997, p. 4123) write that "the human amygdala plays a fundamental role in olfaction. Olfactory perception robustly engages emotional processes". Indeed, it is well-known that olfactory areas enjoy bidirectional connections with affective neural centres. The amygdala, for instance, has been found to systematically activate in the presence of pleasant and unpleasant smells (Soudry et al. 2011; Yang et al. 2025; Zald and Pardo 1997). Furthermore, olfaction is the only sensory system that reaches the amygdala directly, bypassing the thalamus, suggesting tight, fast connections between olfactory and affective areas.

This classic evidence might not convince theorists who maintain that olfactory experiences are not inherently affective. The skeptic might suggest that, since the perception of pleasant and unpleasant smells engages the amygdala, which is usually classified as one of the neural centres of our affective life, the underlying processes are not truly perceptual, but rather involve the combination of perceptual and post-perceptual affective states. However, the neural elaboration of the pleasantness and unpleasantness of smells does not begin with the activation of the amygdala. More recent studies (Iravani et al. 2021; Nordén et al. 2024) have demonstrated that the olfactory bulb is also organised around the dimension of valence. In fact, the activation of the human olfactory epithelium *itself*, the specialized layer of epithelial tissue located in the roof of the nasal cavity that contains the sensory neurons responsible for detecting odor molecules, reflects valence categorization (Lapid et al. 2011). More specifically, evidence suggests that, from the very early stages of sensory transduction, the olfactory epithelium encodes olfactory stimuli along the dimension of valence. The main takeaway from these findings is that the categorization of olfactory stimuli along the dimension of valence is not confined to brain regions traditionally associated with affectivity (such as the amygdala), but is instead already performed by uncontroversially olfactory areas. In other words, the olfactory pathway is hardwired in such a way that valence is a dimension of stimulus transduction, rather than a subsequent, distinct emotional appraisal.

A final objection against our view contends that it is salience, rather than valence, which constitutes the fundamental dimension of olfactory experience, and that valence is ultimately reducible to salience.[11] An initial clarification that needs to be made to frame this objection is that there is no universal definition of salience in the olfactory literature. Sometimes, researchers treat salience as a property of olfactory stimuli, like the property of a stimulus of drawing the subject's attention. On other occasions, they treat salience as a dimension of our olfactory experience of the stimulus. Lerman (2022), for instance, offers a simple phenomenological notion of salience: an olfactory experience is salient if it stands out in the foreground of our awareness. Of course, the notion of salience that is germane to the present debate is the phenomenological one, since what we are discussing is whether the olfactory *experience* of valence can be reduced to that of salience.[12]

The challenge posed by this phenomenological characterization of salience is therefore that of distinguishing valence from salience, and of showing that in the phenomenology of olfactory experiences, the former cannot be reduced to the latter. A proponent of the challenge we are considering might suggest that the main difference between pleasant and unpleasant odor just consists in the fact that the

[10] While we do not position ourselves in the debate concerning which feature of the stimuli plays a role in determining the valence of an olfactory experience, we shall note how the idea that olfactory experiences are intrinsically valenced might find support in studies on the physicochemical structure of odorants. Such studies demonstrate that a molecule's pleasantness can be predicted from its chemical features, suggesting a hard-wired basis for this categorization (Khan et al. 2007) that might be already determined at the receptor level (Joussain et al., 2011). It should be noted how this finding is consistent with a certain variability in perceived pleasantness. While the chemical structure of the stimulus can have an impact on perceived pleasantness, individual and cultural factors play a role as well. On this latter point, see, for instance, Ferdenzi et al. (2013).

[11] We thank an anonymous reviewer for raising this point. For an introduction to the concept of salience, we refer the reader to Archer (2022) and the entire volume her contribution is a part of.

[12] Other – more complex – phenomenological definitions of salience can be found in Watzl (2002) and in Ratcliffe & Broome (2022).

former are generally less salient than the latter, something that is also corroborated by empirical research. For example, Zhang and colleagues (2021) found that experience of unpleasant odours often recruits more attentional resources, suggesting that unpleasant odors are more likely to stand in the foreground of our awareness. Nevertheless, while we acknowledge that there might exist interesting interactions between the valence and salience dimensions of an olfactory experience, we still believe that such dimensions are best kept separate.

To see why this is the case, notice that it seems possible to conceive two olfactory experiences that similarly stand in the foreground of our awareness, but have a different valence. Imagine, first, the experience of crossing paths with a reeking trash can while walking through the street on a sunny day. We saw that the empirical literature confirms that unpleasant olfactory experiences such as these are more likely to stand in the foreground of our experience. But now consider the experience of getting a delicious whiff of the smell of pizza when you are hungry. It seems that in this scenario, the smell of pizza will equally stand in the foreground of your awareness. Crucially, in this case, the smell in question will be experienced as pleasant, as the literature on the olfactory perception of food odors also confirms (Horio and Liberles 2021). Two observations should be made here. The first one is that the determination of pleasantness and unpleasantness cannot be reduced to a scale from less salient to more salient. It is not simply that unpleasant odours are more salient than pleasant ones (or vice versa): two smells can both stand in the foreground of our awareness and have opposed valence. The second one is that pleasant odors, in addition to possibly being just as salient as their unpleasant counterparts, can be experienced as simultaneously having a more pleasant valence and a higher salience depending on factors such as the hunger state of the perceiver. These considerations lead us to conclude that valence and salience should be treated as two dimensions of olfactory experience that can possibly interact and influence each other, but remain nonetheless independent.

In summary, phenomenology and empirical evidence from a variety of sources seem to converge on the idea that olfactory experience can be affective. Olfactory experiences should not be characterized as mere triggers for subsequent affective states: on certain occasion, they should be characterized as having valence themselves. In the next section, we will suggest that this conclusion has significant implications for the debate on the structure of affective valence.

2 Olfaction and the Vacillation Hypothesis

In the previous section, we argued that olfactory experiences should be considered potentially valenced. This, we suggest, has important implications for the debate between bipolar and bivariate accounts. As we saw, the debate between these accounts has mostly revolved around a specific kind of affectively mixed experience – namely, mixed emotions. The goal of this section will be to motivate the broadening of the scope of the discussion to include other kinds of affectively mixed experiences, such as affectively mixed olfactory experiences.

We will start by arguing, first, that phenomenological considerations provide prima facie support for the claim that affectively mixed olfactory experiences are real. After that, we will introduce the main strategy that proponents of the bipolar view have advanced to dismiss analogous phenomenological considerations in the case of mixed emotions. Lastly, we will argue that, unlike with mixed emotions, certain distinctive architectural features of olfaction undermine the plausibility of applying this strategy to affectively mixed olfactory experiences.

Now, in the previous section, we argued that olfactory experiences can be pleasant or unpleasant. While this is widely accepted in the philosophy of olfaction, when discussing the affective component of smell, philosophers usually linger on rather simple cases of affective olfactory experiences: usual candidates (as we mentioned earlier) are the unpleasantness of rotten fish or the pleasantness of freshly baked bread. However, the real-life experience of smells is much more complex than that. We began our discussion in this paper with an example of one such multifaceted experience, the experience of the partially charred apple pie. The scent of the steaming pie, coming from the piping-hot oven, might include pleasant notes of apples spiced with cinnamon and ginger, and a sugary aroma of caramelized honey. But it could also carry unpleasant, pungent notes of burnt flour and carbonized crust. And it seems phenomenologically plausible that, when smelling the pie, one might be simultaneously aware of both the pleasant and the unpleasant notes that characterize its overall olfactory profile.

On many occasions, it is precisely the fact that certain olfactory experiences are affectively mixed that makes them interesting to us. Consider the experience of a ripe *Époisses* cheese. The olfactory hit might simultaneously involve the experience of organic decay along with a creamy, nutty, and profoundly savory density. Crucially, the turophile's appreciation of this distinctive aroma, and the reason why she might be drawn to these cheeses to begin with, seems to be dependent on the experience's being affectively mixed. That is, on the fact that the olfactory experience of these cheeses

is not straightforwardly pleasant, but incorporates *both* pleasant and unpleasant notes. Something analogous might occur in our appreciation of other kinds of complex food aromas, such as the distinctive smell of things like truffles, kimchi, and various kinds of seafood.[13]

The charm of affectively mixed experiences has not been overlooked by artistic perfumery. In fact, the juxtaposition between pleasant and unpleasant notes is at the core of an aesthetic technique widely deployed by master perfumers. One representative case of this is the famous État Libre d'Orange's perfume *Sécrétions Magnifique*s. The scent combines the cold, metallic accord of blood with a sour, milky note of bodily fluids. The unpleasant harshness of such notes, however, is also coupled with a pleasant powdery iris and creamy sandalwood base.[14] The simultaneous presence of pleasant and unpleasant notes explains how this perfume achieves its distinctive aesthetic effect, described as disturbing, even revolting – yet highly addictive.[15]

The idea that the ability to engender affectively mixed olfactory experiences is what makes *Époisses* cheese or avant-garde perfumes so interesting is supported by empirical research, such as a study by Grabenhorst et al. (2011). The study investigates the perception of an affectively mixed odour mixture, i.e., a mixture comprising both components that, when sniffed alone, are experienced as pleasant, and components that, when sniffed alone, are experienced as unpleasant. When subjects are exposed to the mixture, their neural activity spontaneously recruits cortical regions that mediate top-down selective attention. Crucially, this neural activation occurs in the absence of explicit attentional instructions, suggesting that it is the juxtaposition of opposing valences within a single stimulus that triggers an implicit mechanism of attentional capture, hence making the experience of the complex stimulus more salient. Furthermore, the magnitude of this neural response is correlated with the individual's perceived affective disparity between the pleasant and unpleasant components, indicating that the brain's attentional resources are engaged in direct proportion to the affective conflict in the stimulus. To put it simply: the very fact that these mixtures exhibit an increased ability to draw attention seems to be directly dependent on the fact that they comprise both pleasant and unpleasant notes.

While these phenomenological cases might offer at least a prima facie reason for believing in the existence of affectively mixed olfactory experiences, supporters of the bipolar hypothesis will be skeptical that these cases ought to be taken at face value. Indeed, this is exactly the kind of strategy they have pursued in the debate on the existence of mixed emotions. While proponents of the bivariate account of valence point at the phenomenological plausibility of mixed emotions, proponents of bipolar accounts have thus far been able to explain away this phenomenological evidence as a kind of introspective illusion. In particular, in order to explain away the phenomenology of mixed emotions, proponents of the bipolar view generally appeal to the so-called vacillation hypothesis.

The vacillation hypothesis was originally introduced in a seminal paper by Daniel Kahneman to capture the phenomenology of an individual experiencing an event that can be interpreted as either a gain or a loss, depending on the reference point from which it is valued (Kahneman 1992). Kahneman's preferred example is that of a man who was given a good reason to expect a $5,000 raise but received only a $3,000 raise instead. Kahneman suggests that the subject in this scenario will likely code this event simultaneously as a gain, insofar as he evaluates it relative to a scenario in which he gets no raise at all, and as a loss, insofar as he evaluates it relative to a scenario in which he gets the $5,000 he was expecting. Does this mean the subject will feel both good and bad about the same event at the same time? Kahneman explicitly denies that we should accept this conclusion.

To explicate what is going on in the subject's experience, he draws an analogy with cases of bistable figures like the 'Necker Cube' picture. In this picture, the same side of a cube can be seen as either its front or its back side. However, with images such as these, it is never possible to see that side as *both* the front *and* the back side simultaneously.[16] At best, our visual experience can vacillate between the two. Something similar occurs in the case of the man who just got the raise, or so Kahneman argues. Rather than simultaneously feeling good and bad about the raise, the subject will vacillate between feeling good and feeling bad.

[13] Far from being an idiosyncratic case of smell, this tension between positive and negative valence might also play a role in the so-called principle of *terrible eating* in cuisine (Korsmeyer 2002, p. 219), a phenomenon where disgust and pleasure seem to blend together in the complex appreciation of certain dishes.

[14] See, for instance, the following review: https://olfactics.net/2015/12/07/secretions-magnifiques-by-etat-libre-dorange-a-social-experiment/.

[15] This strategy is shared by other avant-garde creations. A famous one is *Sadonas*o by Nasomatto. Here, the olfactory tension operates on a similar register: the comforting, sugary warmth of musk and vanilla is intentionally corrupted by a humid, animalic accord evocative of latex and sweat. Similarly, Serge Lutens' *Kublai Khan* contains unpleasantly sweaty, animalic qualities mixed with pleasant olfactory qualities like rose, amber, and musk. Other perfumes, like Orto Parisi's *Stercu*s, combine pleasant woody and musky qualities with an unpleasant fecal undertone, from which the perfume derives its name. Yet other perfumes, like Filippo Sorcinelli's *But Not Today*, which is inspired by the character of Hannibal Lecter, contains a strong metallic note, reminiscent of blood, with pleasant aromatic notes of lavender, rosemary, sandalwood and musk.

[16] An analogous mechanism, in the case of smell perception, might be individuated in cases reported in Martina (2021), where a substance can smell alternatively woody and citrusy depending on what other odourants one has recently been exposed to.

Proponents of the bipolar account might suggest that similar reasoning applies to all cases of mixed affectivity, including both mixed emotions and affectively mixed olfactory experiences introduced in this section.

This proposal, however, faces an immediate challenge. When we experience a bistable figure, we are generally aware of vacillating between different interpretations of the figure. For example, when we introspect upon our experience of the 'Necker Cube' picture, it never seems to us that we are aware of both figures simultaneously. Kahneman himself suggests that the subject in the scenario he describes will be aware of vacillating between feeling good and bad about the raise. However, there are cases of mixed emotions and affectively mixed olfactory experiences where it does not phenomenologically seem that our experience is vacillating. Rather, it seems to us that our experience feels simultaneously pleasant and unpleasant. A proponent of the vacillation hypothesis who wants to treat the appearance of mixed affective experiences as illusory cannot, therefore, take the analogy with reversible figures to be perfect.

In fact, at this point, proponents of such a hypothesis usually reason as follows. The experience of reversible figures and mixed affective experiences should be taken to be analogous insofar as both involve the vacillation between two mutually exclusive experiences: the experiences of the two alternative interpretations of the same picture, in the former case, the positively and negatively valenced experiences in the latter. However, these cases are also importantly disanalogous. In the former, the subject can be introspectively aware that the vacillation is taking place, while in the latter, she cannot. Instead, when the subject introspects upon her vacillating affective states, it will seem to her that she is simultaneously undergoing a positively and negatively valenced experience.

The leading proposal as to why subjects who are vacillating between positively and negatively valenced affective experiences fail to notice vacillations appeals to the *speed* at which these vacillations occur. The proposal is that one can shift back and forth between positively and negatively valenced experiences at a speed of around 100–150 ms (Condon and Feldman Barrett 2013). Our introspective mechanisms are not accurate enough to detect these shifts, leading us to believe that the positively and negatively valenced experiences are occurring at the same time, while, in fact, there is no experience that feels simultaneously good and bad.

Although this strategy might appear promising for explaining away the phenomenology of mixed emotions, we argue that there are compelling reasons why it does not equally apply to affectively mixed olfactory experiences. The main reason for this is that there are some unique architectural features of olfactory perception that do not permit the rapid shifts of attention that would be needed to generate the introspective illusion of mixed affectivity. As such, the phenomenological case for the existence of affectively mixed olfactory experiences is much harder to explain away by appealing to the vacillation hypothesis than that for mixed emotion.

The empirical literature on attention shifts traditionally distinguishes between overt and covert switches of attention (Cohen et al. 2011; Kulke et al. 2016; LaBerge 1983; Posner 1980).[17] Overt attention shifts are those shifts driven by the movements of our sense organs. Covert attention shifts, on the contrary, do not involve movements of the sense organs; instead, they involve a shift in internal focus to a specific area of the subject's perceptual field without altering the external input. In vision, paradigmatic examples of overt attention shifts are cases in which one moves one's eyes to attend to different features of a given object, while paradigmatic examples of covert attention shifts are cases in which one focuses on an object somewhere in the visual field without actually moving one's eyes. In light of this, one might wonder whether attentional shifts between pleasant and unpleasant olfactory experiences are switches in overt or covert attention.

Consider first the case of overt attention shifts. Overt shifts in olfactory attention would be attention shifts that are driven by the movements of the sense organ of olfaction, our nose. These can be performed by moving our head and, most importantly, by sniffing. Sniffing is the active process of inhaling air, which plays a crucial role in olfactory perception (Laing 1983; Mainland and Sobel 2006). When one sniffs, one pulls air into the nasal cavity, which carries more odorant molecules to the olfactory epithelium and thereby allows a better sampling of their olfactory profile. Sniffing driven shifts in olfactory attention are clearly possible. Suppose someone was trying out a new fragrance. To better appreciate it, she will likely sniff it repeatedly and use every

[17] An anonymous reviewer asks whether one shouldn't be skeptical that the distinction between covert vs. overt attentional switches applies to olfaction given that the study of attention is rather limited for olfaction, and that most of olfaction occurs in the absence of attention (de Luca and Botelho, 2019; Sela and Sobel 2010; Young, 2024). It seems to us that here are different ways to be skeptical that the distinction between covert and overt attentional switches applies to olfaction. One is to be skeptical that there can be attentional switches in olfaction to begin with. If this were the case, the vacillation hypothesis wouldn't even be able to get off the ground in the olfactory case. Another would be to say that there is a sui-generis kind of olfactory attentional switches that is neither overt nor covert. However, it is not at all clear what this form of attentional switches would amount to. A third proposal would be to be skeptical of the existence of either overt, or covert switches in olfaction. In this section, we start by assuming that both forms of attentional switches are possible within olfaction to examine all the theoretical options available to the proponent of the vacillation hypothesis. However, as we will see, we are ourselves quite skeptical that covert attentional switches are possible in olfaction.

sniff to attend to different olfactory qualities among those that constitute the perfume's profile.[18]

Still, the active sampling of an odor by sniffing, and consequently the overt shift of attention it drives, are known to be remarkably slow, especially compared with the overt shifts in attention that occur within other sensory modalities. Consider the overt attention shifts that occur within vision. Saccades, the eye movements that drive overt attentional shifts within vision, are known to occur at a rate of around 2–5 saccades per second (Mahanama et al. 2020). The duration of a human sniff, on the contrary, is between one and three seconds, with a typical one lasting about 1.6 s (Wu et al. 2024). If to switch our attention from pleasant to unpleasant olfactory qualities we need to sniff, and one sniff requires an average of 1.6 s, then the vacillation between those experiences would occur within the timeframe that far exceeds that of around 100–150 ms, which is what would be required for it to go unnoticed by the subject when she introspects upon her olfactory experience.

Perhaps we should consider the possibility that the switches between pleasant and unpleasant olfactory experiences could be driven by covert, rather than overt switches in olfactory attention. The problem with this alternative proposal is even more radical. There are reasons to be skeptical of the claim that olfactory perception allows covert attentional shifts to begin with (Keller 2011). To understand why, notice that covert attention shifts are generally understood to operate by enhancing the processing of stimuli located at a certain spatial region in the subject's perceptual field (for example, the center or the periphery of the subject's visual field). However, it is a common conviction among philosophers of perception working on olfactory perception that the spatial content of olfactory experiences is far less developed in comparison to that of other sensory modalities, such as vision, audition, and touch (Skrzypulec 2024).

We can divide the main views of the spatial content of olfaction into two families. On one family of views, the spatial content of olfaction is always impoverished: olfactory experiences are either incapable of representing olfactory objects as spatially located (Lycan 2000), or they represent all olfactory objects as located at the same extremely generic location, like 'around' (Batty 2010, 2011; Keller 2016) or 'outside' (Chomanski 2022; Richardson 2013) the subject. Since covert attention shifts operate by enhancing the processing of stimuli at a location, covert attention vacillation in olfaction would require a rapid alternation between different locations in the olfactory field. However, if olfactory perception does not represent any spatial location whatsoever, or if it represents only one generic spatial location, no such alternation would be possible to begin with.

On the second family of views, ascribing impoverished spatial content to olfaction arises from a narrow focus on short and passive olfactory experiences. If we conceptualize olfaction as a temporally extended process, involving the gathering of olfactory information via activities like sniffing and bodily movement, then it becomes more plausible that olfaction could possess sophisticated spatial content (Aasen 2019; Millar 2019). Some have even suggested that through the diachronic exploration of our environment, we could experience odors as occupying different spatial locations relative to one another (Young 2016, 2019, 2020a). Still, if olfactory experiencing distinct locations requires bodily movement, then attentional switches at those locations will count as overt rather than covert. And we saw that the speed at which overt attentional switches occur within olfaction is not compatible with that speed required by the vacillation hypothesis.

These observations have been further supported in a recent review of the literature on bistable perception (the phenomenon involved in the aforementioned Necker's cube case) in olfaction and gustation (Di Stefano and Spence 2025). In the review, the authors note that there is a surprising lack of evidence for the existence of an olfactory and gustatory bistable perception, and partly impute this to these sense modalities' impoverished spatial content.[19] Even so,

[18] As pointed out by an anonymous reviewer, evidence suggests that, in certain cases, one can experience a change in the olfactory qualities of the stimuli to which one is exposed when the stimuli are provided by airflow without sniffing (Croy et al. 2015; Menzel et al. 2019). This is perfectly compatible with our main point in this section. For starters, what is relevant to our argument is the possibility of changes in olfactory qualities one experiences that are due to attentional switches. However, in neither of the experiments above, the change in the olfactory qualities the subjects experienced was due to an attentional switch. In both, subjects detected a change in olfactory qualities as a result of a difference in the kinds of olfactory stimuli to which they were exposed. Even setting these issues aside, these experiments confirm that human beings 'perform poorly and slowly in detecting changes of olfactory objects' (Croy et al. p. 78), and that they ' have a rather low capacity to detect odors presented short after each other' (Menzel et al. p. 354) In fact, the Croy et al. study showed that it takes almost two seconds for subjects to identify changes in the olfactory environment. And Menzel et al. confirmed that 'the time of less than 2.5 s seems to be the critical time interval from which on olfactory detection is compromised'. This speed is inconsistent with that necessary for the vacillation hypothesis to have force.

[19] Interestingly, in an opening of an influential review on the timing of olfactory processing, Olofsson (2014) argues that it is inconceivable (even for the most sophisticated nose) to imagine an 'olfactory trill' (a concept proposed my Cooke and Myin 2011). An olfactory trill would be an olfactory percept that swiftly alternates between two notes (for instance, a citrusy note and a floral one), something very close to an olfactory attentional switch we have been talking about in this section. The impossibility to imagine an olfactory trill might be taken to provide further, indirect evidence that rapid attentional switches in olfactory perception are not possible, especially in light of the structural similarities between olfactory perception and olfactory imagery (Young 2020b).

one might suggest that not all attentional switches need to be based on a representation of fine-grained spatial content. Instead, it might be possible to have attentional switches that are purely 'feature-based' (Sela and Sobel 2010; Keller 2011). These are attentional switches that are achieved not by targeting a specific location in the subject's perceptual field, but by directly targeting a specific quality within a stimulus's 'quality space', such as attending to the fruity versus woody notes in a perfume, and switching back and forth between those qualities.

Even this solution is problematic, however. Though there is evidence of 'feature-based' attention in vision and hearing, as in the case where one singles out a voice in the crowd based on its pitch, the extent to which this mechanism might depend on these senses' spatial capacities is unclear. Evidence suggests that, while in vision and hearing 'feature-based' attention leads to better detection and identification of the perceptual quality one is attending to, an effort to direct attention towards a specific aspect of stimulus' quality space does not improve performance in detection and identification tasks in olfaction (Laing and Francis 1989; Livermore and Laing 1996). Again, Sela and Sobel (2010) explicitly connect this to olfaction's impoverished spatial content. They suggest that, even if 'feature-based' attention does not directly target spatial locations, the ability to represent them is still critical for these attentional mechanisms to work effectively (Deouell et al. 2007).[20]

Furthermore, it should be noted that, for a 'feature-based' attentional switch between different qualities to occur within the timeframe compatible with the vacillation hypothesis, it should be a covert, rather than an overt attentional switch. That is, it should be an attentional switch between qualities that are detected within a single sniff, and not between qualities that are detected via different sniffs. This, however, overlooks a fundamental constraint of olfactory psychophysics: the temporal integration window. Unlike vision, human olfaction functions through discrete sampling 'snapshots', each roughly the duration of a sniff, within which the system exhibits a profound 'change blindness' to temporal dynamics (Sela and Sobel 2010). Different odorants within a single sniff are usually experienced as simultaneous and as part of a stable blend, rather than being temporally arranged in a way that could enable the subject to switch back and forth between them.[21]

At this stage, the proponent of the bipolar view might concede that the vacillation hypothesis cannot be appealed to explain away the phenomenology of affectively mixed olfactory experiences. However, she might still try to salvage her view by pointing to the fact that the content of perceptual experiences is usually complex.[22] Consider the olfactory experience of a charred apple pie that we discussed at the beginning of this paper. A proponent of the bipolar view might argue that this experience does not present us with one smell, i.e., the smell of the burnt apple pie, which feels both pleasant and unpleasant at the same time. Rather, it presents us with two wholly separate smells, the smell of apple and the charred smell, with each of these smells receiving a different evaluation on a bipolar scale. If this were the case, then we would have no individual stimulus that is experienced as both pleasant and unpleasant simultaneously. Though this explanation of the cases at hand might be appealing, it does not seem to us that the proponent of the bipolar account will be able to avail herself of it. The bipolar view, as it is formulated in the empirical literature, is not just the thesis that valence is codified along just one dimension, ranging from extreme pleasantness to extreme unpleasantness. It is also the view that valence is codified in such a way that only one position at a time along this dimension can be occupied. This is because proponents of the bipolar view generally uphold the claim that "a person's core affective state […] can be psychologically described and represented by *a single point* on the two-dimensional space" defined by

[20] An anonymous reviewer wonders whether this claim is not contradicted by a study by Stevenson and Mahmut (2013), showing that if the left nostril receives chemical stimulus A and simultaneously the right nostril receives stimulus B, the experience fluctuates between presenting A and B. In our view, this evidence cannot be interpreted as supporting the vacillation hypothesis. To see this, we need to examine the setup that was used to determine the presence of the fluctuations by researchers. In the experiment, subjects were exposed to odor mixtures of two components. Exposure to each mixture was composed of 20 trials, separated from one another by 5s breaks. In each trial, subjects were exposed to the mixture, and asked to rate whether they thought that smell was more similar to one of its components or the other. The most important piece of evidence for the presence of fluctuations was the fact that participants' ratings of similarity indicated switches from one component to the other across trials. Let us grant that the experiment demonstrates that the subjects' experience of the mixture fluctuates between presenting A and B across trials. This would still not be enough to vindicate the vacillation hypothesis. Each trial was saparated from the previous one by as long as 5s, and involved a novel sampling of the mixture. This shows that the fluctuations in the subject's experience were at best due to overt, rather than covert attentional switches, and were occurring too slowly to support the vacillation hypothesis.

[21] This point is important for answering a question raised by an anonymous reviewer. It has been shown that valenced smells modulate nasal airflow and inhalation volume within the first 150–350 ms of exposure, depending on their pleasantness or unpleasantness. It has also been shown that an individual sniff might be broken down into distinct temporal phases (Olofsson 2014). The reviewer worries that valence-dependent shifts in nasal airflow and inhalation volume across different temporal phases of the same sniff could provide an underpinning for the covert attentional switches required by the proponent of the vacillation hypothesis. However, the point discussed above showed that, even if such valence-dependent shifts were demonstrated, they would not lead to an experience of vacillation, but rather to pleasant and unpleasant odors being experienced simultaneously as parts of a stable blend.

[22] We thank an anonymous reviewer for inviting us to address this point.

valence and arousal (Barrett and Bliss-Moreau 2009 p. 8. See also Russell 1980; Russell and Barrett 1999). For this reason, even if one granted that the subject in the apple pie experience was aware of two separate olfactory objects, the proponent of the bipolar view would not be able to maintain that those objects simultaneously receive different evaluations on the bipolar scale. What she could say, at best, is that the subject rapidly oscillates between experiencing the apple smell as pleasant and experiencing the charred smell as unpleasant. Renouncing the claim that valence is codified in such a way that only one position at a time along its dimension can be occupied effectively means abandoning the bipolar account in favor of a different view.[23]

Summing up, the architecture of olfaction generally prevents rapid attention shifts from one olfactory quality to another from taking place. Consequently, no rapid vacillation between positively and negatively valenced olfactory qualities would be possible. This conclusion is significant for the debate between bivariate and bipolar theories of valence, as the introspective evidence for the existence of affectively mixed olfactory experiences cannot be explained away by appealing to the vacillation hypothesis. In the next section, we will look closely at the empirical literature on the perception of olfactory mixtures to see whether phenomenological considerations for the existence of affectively mixed olfactory experiences are also empirically supported. We will point out that, though current evidence is suggestive, it is far from decisive, especially due to a lack of empirical work specifically targeting affectively mixed olfactory mixtures. This makes the latter a promising avenue for future empirical research.

3 Empirical Evidence for Affectively Mixed Olfactory Experiences

In the previous section, we presented phenomenological considerations for the existence of affectively mixed olfactory experiences. Most of our examples of affectively mixed olfactory experiences involved experiences of a complex olfactory mixture, containing different components. In particular, we focused on cases in which subjects (i) are aware of the olfactory properties of different components in a mixture, (ii) are simultaneously aware of the properties of those components, and (iii) experience one of the components as pleasant and the other as unpleasant. In this section, we will examine whether the existence of experiences of the kind we discussed finds support in the empirical literature. We will proceed in three steps. First, we will examine whether empirical evidence supports the claim that we can olfactorily experience the properties of several components within the same olfactory mixture. Secondly, we will look at whether it supports the claim that those components can be experienced simultaneously. Lastly, we will look at whether it is possible to experience one of those components as pleasant and the other as unpleasant.

Let us begin by addressing point (i). It is widely accepted that humans can perceive a range of olfactory properties via olfaction – for instance, citrusy, woody, nutty, or floral (Batty 2010; Mizrahi 2014; Young 2016). But can we perceive olfactory properties of different components in the same olfactory mixture, in the same way in which we can distinguish Paul Simon's from Arthur Garfunkel's voice in *Scarborough Fair*? To answer this question, we need to briefly examine the empirical literature on olfactory mixtures and, in particular, the literature on whether the olfactory mixtures that we perceive should be understood as elemental or rather as configural (see Young et al. 2020 for discussion of this distinction). An elemental mixture is a mixture whose smell is the additive combination of that of its components, the individual olfactory properties of which are still discernible within the complex. A configural mixture is instead a mixture whose olfactory properties differ from those of the components, which are not discernible as constituents of the new smell.

Many olfactory mixtures that we perceive in our daily life are configural. Their smell is not a sum of the olfactory properties of their components (see Young 2019; 2024 for an explanation of this phenomenon in terms of the format of olfactory representation). However, this does not mean that there is no such thing as an elemental olfactory mixture. Classic studies in the literature on elemental versus configural mixtures show that it is possible to identify up to three or four components within a complex chemical mixture (Laing and Francis 1989; Laing and Glemarec 1992; Jinks and Laing 1999, 2001; Laing et al. 2002; Livermore and Laing 1996, 1998). In fact, the distinction between elemental and configural mixtures is not a binary distinction. The same mixture can be perceived as elemental or configural depending on a variety of factors, like the concentration levels (McNamara et al. 2007) or the ratio (Sinding et al. 2013) of individual components, with changes in these factors corresponding to predictable changes in how the mixture is perceived (Pellegrino et al. 2025).

[23] At this point, one might wonder whether it could be possible to defend a view *intermediate* between the bipolar and bivariate views, such as the view that valence is codified along only one dimension, but that multiple positions along that dimension could be occupied at the same time. This is an interesting and underexplored question, which unfortunately we will not have the space to address in depth in this paper. In any case, a hypothetical proponent of the view in question would have to make a compelling case that the difference between her proposal and the bivariate account is substantive rather than purely verbal.

The possibility of perceiving multiple olfactory qualities within the same mixture is also in line with the practice of professionals of olfactory experience (though evidence suggests that even experts cannot generally identify more than 3–4 components within the same mixture, see e.g. Livermore and Laing 1996 on perfume experts; Luckett et al. 2020 on wine experts). Indeed, the ability to sort out the different properties of complex olfactory mixtures is at the core of the practice of perfume or wine experts. For instance, a sommelier can describe the olfactory profile of a Müller Thurgau by noting a vibrant white-fruit opening, centered on crisp notes of green apple, underripe pear, and subtle hints of grapefruit. The same applies to the ability of perfumiers to describe or design the olfactory pyramid of an eau de parfum. The most straightforward explanation for such olfactory reports is that they reflect the phenomenological complexity of these experts' olfactory experience, which involves the awareness of multiple olfactory qualities of the same mixtures.

Our claim that olfactory experiences like that of the smell of a burnt apple pie might involve the awareness of two distinct olfactory properties, the harsh, charcoal-like olfactory quality of the burnt crust and the sweet, caramelized olfactory quality of apples, is therefore consistent with empirical evidence. In fact, it is especially plausible, that a case like the one we describe would be one where subjects experience the mixture in an elemental way: the components in the burnt apple pie mixture in question are components most of us would be familiar with, and evidence suggests that familiar components are those whose qualities are more likely to be experienced in an elemental way in an olfactory mixture (Thomas-Danguin et al. 2014).

It is therefore possible to perceive the olfactory properties of different olfactory components when exposed to an olfactory mixture. Still, this does not entail that those olfactory properties can be experienced simultaneously. And this leads us to our next point, (ii). One might argue that, in order to perceive the various properties in a mixture, a temporal dimension is necessary: the perception of the properties of the various components does not happen in a synchronic fashion, but it always develops diachronically. However, this is unlikely, especially given the evidence we discussed in the previous section. For starters, there is evidence that subjects are capable of identifying multiple components within a mixture, even if they are given the possibility of smelling it just once (Frank et al. 2010). This means that the multiple olfactory components reported are perceived within the same sniff.[24] Furthermore, subjects exposed to mixtures could identify the components correctly even in cases where they were unable to report their temporal order, suggesting that the different components were likely experienced in a synchronic fashion (Jinks and Laing 1999).

The empirical literature therefore also vindicates (ii), the idea that we can simultaneously experience the olfactory properties of multiple components when smelling a complex mixture. Does empirical evidence also support point (iii) – namely, that the simultaneously experienced properties can be both pleasant and unpleasant? The current evidence is suggestive, but not yet decisive. This is largely because affectively mixed olfactory experiences have received very limited empirical attention. Perhaps the most significant piece of evidence for the claim that we can simultaneously smell both pleasant and unpleasant properties within the same mixture comes from two fMRI studies (Grabenhorst et al. 2007; Rolls et al. 2010). In the experiments, researchers presented subjects with three odour conditions: a pleasant one, an unpleasant one, and a mixture of the two. Using fMRI, they then examined which brain regions were activated by these smells.[25] Researchers have found that the brain uses distinct neural pathways to encode pleasant and unpleasant smells. Crucially, they found that these pathways are activated simultaneously and independently from one another when subjects are exposed to the mixture.

Our brain's ability to simultaneously encode the pleasant and unpleasant components of the same mixture might provide the neural underpinning for affectively mixed olfactory experiences. Though this would provide at least partial empirical vindication of the phenomenological considerations we discussed in the previous section, it must be noted that the above interpretation of the study can be challenged. In fact, in the Grabenhorst et al. (2007) study, when subjects were asked to rate the mixture containing both pleasant and unpleasant components, they judged the overall stimulus

[24] This point might seem to be in tension with our argument concerning the impossibility of covert, feature-based attention shifts in olfaction. However, the findings mentioned above do not demonstrate that it is possible to switch attention between several olfactory qualities within the span of a single sniff. What they show, rather, is that such olfactory qualities are experienced *simultaneously* within one sniff. No attentional vacillations or shifts are necessarily involved.

[25] Neuroimaging reveals that the brain segregates the affective value of complex odour mixtures, with the medial orbitofrontal cortex emphasizing positive components to align with subjective pleasantness ratings. In contrast, regions processing unpleasantness, such as the dorsal anterior cingulate cortex, register negative constituents through intermediate activation patterns, demonstrating that the brain simultaneously and independently represents both opposing valences within a single stimulus. The authors thus conclude that "the brain can simultaneously and independently represent the positive and the negative hedonic value of an odor mixture that contains pleasant and unpleasant components" (Grabenhorst et al. 2007, p. 13538).

as pleasant.[26] Prima facie, this result might be taken to entail that the subjects' olfactory experience did not involve awareness of both pleasant and unpleasant components, but rather a synthesis in which one valence predominated over the other (while the registration of the opposite valence of the stimuli was encoded at a subconscious level).

However, this is not the only possible interpretation of the findings. Since subjects were instructed to rate the pleasantness of the mixture *as a whole* rather than its individual components, it is possible that they focused on the most prominent (pleasant) component, effectively ignoring the negatively valenced one in their ratings. This interpretation is consistent with independent findings showing that, when subjects are asked to rate the qualitative profile or intensity of a complex olfactory mixture, they generally focus on the quality and intensity of the dominant component, even when the mixture is not configural (Ma et al. 2020). Unfortunately, though protocols on olfactory mixtures' perception routinely require participants to identify distinct components within a mixture (Laing and Francis 1989; Livermore and Laing 1996) or to rate the intensity of its specific component (Laing and Willcox 1983), no experiment yet extends this familiar protocol to the case of affectively complex mixtures. Implementing a design that mandates separate valence ratings for the properties of the components that are perceived within the same mixture would be crucial to determine whether we can experience components of opposite valence within the olfactory experience of the same mixture.

For example, following a protocol that is standard in the kinds of experimental setup described above, subjects could be exposed to a binary mixture containing both a component that is generally experienced as pleasant on its own and a component that is generally experienced as unpleasant on its own (such as the one we find in Grabenhorst et al. 2007; Rolls et al. 2010). During their exposure to the mixture, subjects should ideally be allowed to sniff it just once to prevent overt attentional switches between the components of different valence (as in the experiment by Frank et al. 2010). They should then be asked to provide a separate rating for the pleasantness of the mixture as a whole and of its individual components, a procedure that is standard in experiments on smell discrimination like Laing and Francis (1989) or Livermore and Laing (1996). Ideally, one could try this with different mixtures, or with the same mixture, but varying the concentration and ratio of the components.

Two outcomes are conceivable from such an investigation. On the one hand, subjects might report experiencing both the pleasant and the unpleasant components in the mixtures. This finding, together with the neural findings described above, would further substantiate the phenomenological considerations for the existence of affectively mixed olfactory experiences, hence of a bivariate account of valence. Crucially, unlike the empirical findings that have been collected in support of the existence of mixed emotions (Larsen et al. 2001; Larsen and McGraw 2011, 2014; Larsen and Stastny 2011), evidence of this kind could not be explained away by appealing to the subject's rapid vacillations between their experience of pleasant and unpleasant olfactory components, for the reasons that we have discussed in the previous section. In light of this, this kind of setup would provide much stronger support for the bivariate view than the evidence collected in the literature on mixed emotions.

However, at the current stage, we should also be open to the possibility that this kind of setup might yield a result that is friendlier to the bipolar account. While subjects might be able to identify distinct components in a mixture (e.g., 'I smell rose and skunk'), the affective valence of the experience triggered by such stimuli might involve a synthesis in which one valence predominates over the other. That is, a component that is rated as pleasant on its own (like rose) might be judged as unpleasant or neutral when paired with an unpleasant component. This outcome would align with the 'law of contagion' described by Paul Rozin (Rozin et al. 1986; Rozin and Fallon 1987), who argued that neutral or positive stimuli tend to acquire negative properties upon contact with disgusting ones. Evidence of this kind would put pressure on the phenomenological considerations we raised in support of the existence of affectively mixed olfactory experiences. As such, it would support the bipolar account of valence, suggesting that, at a conscious level, olfaction always resolves affective conflict through a synthetic mechanism rather than sustaining a mixed affective experience. The outcome of such an experimental inquiry, we therefore argue, would be crucial for tipping the balance in favour either of the bivariate or the bipolar theory of valence.

4 Conclusions

In this paper, we have drawn attention to a kind of affective experience that has thus far been completely set aside in the debate on the structure of valence: affective olfactory experiences. As we have argued, attention to these experiences promises to yield progress on the issue of whether valence is bipolar or bivariate. This is because the phenomenological considerations that can be taken to support the existence of affectively mixed olfactory experiences cannot be easily accommodated by appealing to the vacillation hypothesis, given the unique temporal architecture of

[26] For a philosophical discussion of such neuroscientific findings, see Skrzypulec (2023a).

olfactory perception. We have also noted that neurophysiological evidence for the existence of affectively mixed olfactory experiences is suggestive, but that further research would be needed to rule out alternative explanations for the data. We concluded by suggesting experimental protocols to overcome the limitations of existing studies. All in all, we hope to have shown that a careful discussion of candidates for affectively mixed experiences beyond mixed emotions offers a promising path to advancing our understanding of mixed affect.

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Declarations

Conflicts of interest The authors have no conflicts to declare.

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