Making Sense of Smell

Ann-Sophie Barwich on why philosophers should pay attention to olfactory perception

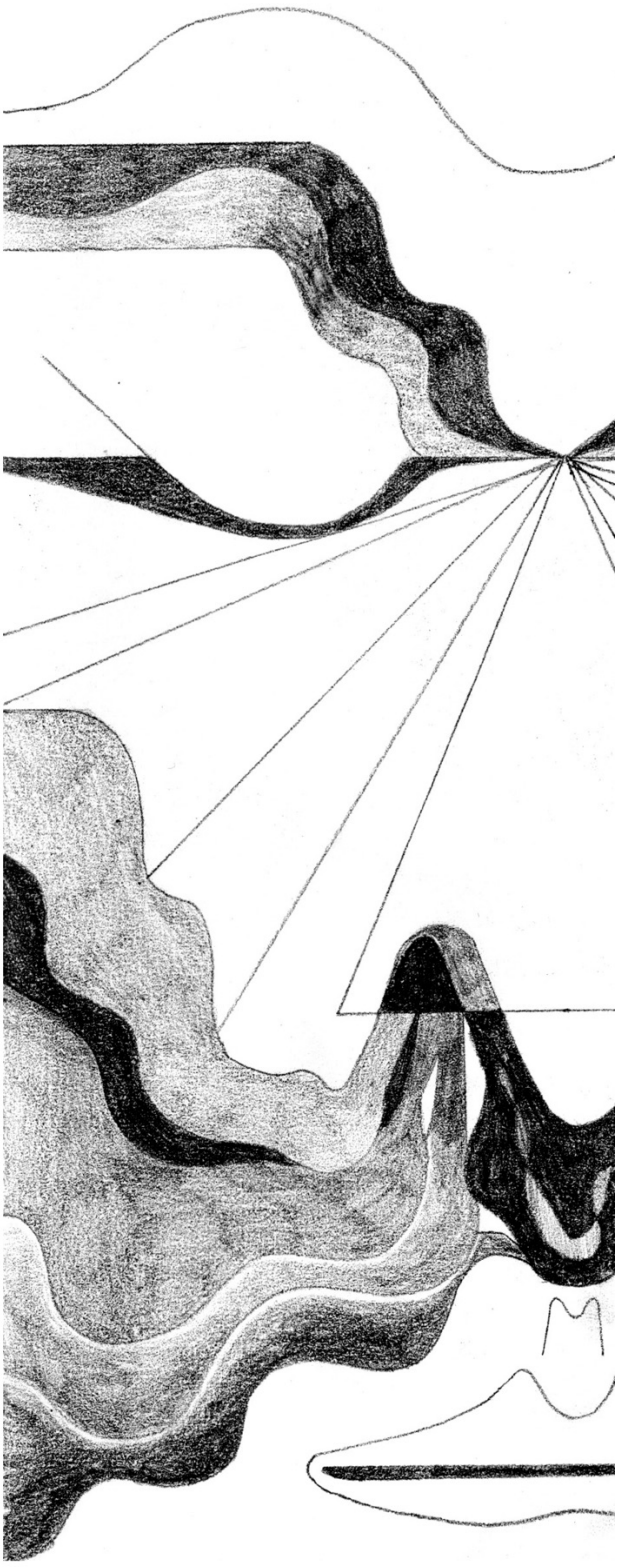
Half a decade ago a puzzling observation got me interested in olfaction: while we have sent a man to the moon, we still don't really know how we smell. How is that possible? And does it even matter? There are many popular opinions you hear about our sense of smell, most of them are markedly negative: the human sense of smell is losing evolutionary significance and it is declining, we are much worse than dogs in sniffing out scents, and we don't seem to have a good vocabulary for describing odours. These statements could not be further from the truth. You actually are awesome at smelling. Let me debunk some of these myths about your sense of smell before I show you why olfaction is key to understanding the brain and how this argues for renewed philosophical attention to questions of perception.

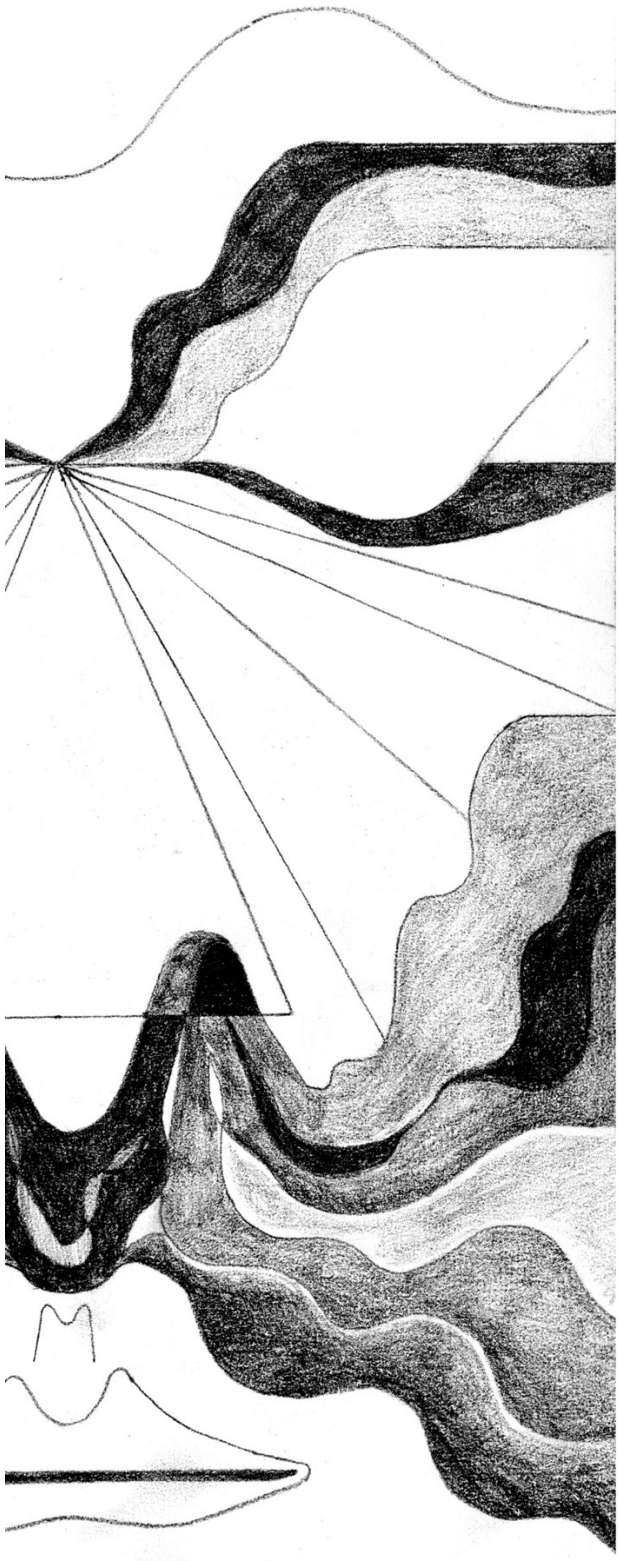
"The human sense of smell is impoverished and other animals such as dogs are much better at it than we are." This is possibly the most persistent myth about our sense of smell. If you are a former Berkeley undergrad you may already know otherwise. In 2006 Noam Sobel conducted a test with 32 students where he showed that humans track smells in the same fashion as dogs and even outperformed them. Of course, it makes sense that dogs are more responsive to their odorous environment than we are in our day-to-day lives, as their noses are placed constantly where the smells are: the ground.

"The human sense of smell is evolutionary insignificant and in decline." Olfaction in humans often is considered rudimentary based on a lower number of odour receptor genes. While mice have over 1000 olfactory receptor genes, in humans the number currently is just over 400 as most of the olfactory genes in the human genome are non-functional (i.e., they are not producing receptor proteins). But counting genes does not lead us to a neat hierarchy of smell performance in animals. Dogs, the prime example for an animal with a good sense of smell, have 850 functional receptor genes. This, for instance, is less in comparison to other animals with lower behavioural sensibility to odours such as cows. Some researchers such as Gordon Shepherd at Yale, one of the founding fathers of modern olfactory neuroscience, further suggest that the decrease in human olfactory receptors is not an indicator of the decline of smell in humans but must be seen in parallel with their enlarged brain capacity for odour processing, particularly in the cortex. Why would humans need enlarged cerebral capacities for odour processing? Because we invented cooking! Which brings us to the next myth.

"Modern humans rarely have any use for the sense of smell." You will quickly notice that most of your flavour experiences are bound to smell perception, especially when you have a blocked nose during a cold and everything starts tasting bland. And there is another and more fun way to demonstrate this: get yourself some fruity Schnapps (or a good whiskey if you prefer). Hold your nostrils closed when you take a sip. You will notice the alcohol and a bit of its taste. Now take another sip, gently exhale through your nose and swallow – the intense flavour, especially the lighter and fruity notes, will hit you. This is retro-nasal, mouth-breathing, smell perception (indeed, the philosopher Barry Smith beat me to living the dream of studying the phenomenology of flavour by having a project on wine tasting at University College London). And whoever doubts the importance of flavour perception for understanding human nature and society might simply recall the incredible impact of the spice trade on our socio-economic as well as ecological landscape throughout history. Men of strong volition may have been able to resist the visual enticement of beautiful women, but less often so the allure of fried bacon.

"We do not have a good vocabulary for odours" You may sometimes read that olfactory performance in humans has decreased as a result of increased language processing. Olfaction and language processing share some cortical resources in neural coding, and the apparent weakening of olfaction in favour of language is seen as an economic evolutionary trade-off. Our difficulty in naming and describ-





ing smells is often considered as further evidence for this trade-off hypothesis.

However, as anthropological studies have shown, the cultural and mainly Western neglect of olfaction is not a biological fact of being human. Other cultures possess and rely on a precise analytic classification of smells with incredibly rich and complex vocabularies. The Desana Indians of the Amazon, for instance, base their entire social life (group hierarchy, marriage and gender, cooking, tribal kinship, hunting) on a very strict olfactory value system. Numerous more examples can be found in Constance Classen, David Howes and Anthony Synnott's by now classic book *Aroma: The Cultural History of Smell.* Likewise, Asifa Majid at the Max Planck Institute for Psycholinguistics in Nijmegen has undertaken wide-ranging studies of different odour vocabularies across the globe. Her most prominent study being on the extensive lexicon for odour coding in the hunter-gatherer society of Maniq in Southern Thailand. You may not even need to go that far to look at other cultures. A longer conversation with any fragrance chemist or perfumer will have you convinced that you met a talking labrador. It's all a matter of attention and training. Smelling in humans suffers from neglect, not inability.

While the humanities have been slow in picking up this scented trail, research in neuroscience has begun shifting its attention to olfactory processing. Smell, it became clear over the past twenty-five years (after Linda Buck and Richard Axel discovered the olfactory receptors in 1991),

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may hold the key to several fundamental questions in biology. One of them is how the brain works. What is so significant about smell, what does it tell us about the brain, and why should philosophers of perception care about it?

Olfaction is one of our two chemical senses, the other being taste. The olfactory pathway consists of three basic processing steps. First, you recognise smelly molecules through a number of protein receptors that are situated on the sensory neurons in your nasal epithelium. In fact, these protein receptors are part of the largest gene family in the mammalian genome. Second, the receptor signal is transmitted and collected at spherical neural structures (called glomeruli) in the olfactory bulb (a bulb-like looking domain at the frontal lobe of your brain). Each olfactory sensory neuron in your epithelium expresses one receptor type, and all sensory neurons expressing one specific receptor type are collected in one glomerulus. Thanks to this characteristic, you can nicely trace which receptors are activated and how they form activation patterns in the bulb. The bulb then presents you with a neat map, meaning that the patterns are specific to the molecules causing them. Your bulb will come up with a different map for musk than for orange. Third, these signals are further projected to the olfactory cortex.

And this is where things start getting really interesting. It was long thought that olfaction should work just like the visual pathway, suggesting that the map of the olfactory bulb must be maintained further in the cortex. This may not be the case. Instead of a neat topographic synaptic pattern, we are suddenly confronted with mere signal noise in the piriform cortex (this area is the largest domain of the olfactory cortex and is shaped like a pear). It is as if you are coming from an orderly organised English garden and stepping into the savanna where everything is distributed randomly. Different questions revolve around this mystery of "the lost map".

Perhaps we got the idea of mapping wrong? Solving the mystery of the missing map, some olfactory scientists like 2004 Nobel Prize laureate Richard Axel at Columbia University are looking for a "relay station" such as the amygdala as mediating pattern distributions from bulb to cortex (based on aversive behaviour and conditioning).

Other olfactory neuroscientists like Stuart Firestein, also at Columbia, reverse the problem and trace whether there is any information flow from higher cortical areas back to the piriform cortex. The latter strategy suggests that we may want to look at what the signal is for (tracing efferent projections), rather than from where the signal comes (tracing afferent projections).

While the scientific implications of this yet unresolved issue are not entirely clear, they invite us to rethink our understanding of percept formation, and they carry a lot of philosophical potential. One assumed function of the piriform cortex was that it is the centre of odour object formation, meaning that it is the place where sensory signals from the bulb, amygdala, etc., are synthesised into the olfactory percept. Having no obvious domain of such perceptual synthesis raises some interesting questions about odour object formation. How are odour percepts formed instead, and what may this processing difference imply for philosophical enquiry into perception?

First of all, the expression of odour object formation is misleading. The scientific notion of odour object does not correspond to what philosophers refer to as perceptual objects. When philosophers speak about perceptual objects, they tend to discuss the (un)reality and truthfulness of our perceptions. In the case of olfaction this would lead to questions such as whether odour objects as the object of perception stand in any representational relation to the objects associated with their perceptual quality (say, freshly cut green grass) or to the chemicals carrying them (cis-3-Hexen-1-ol). The philosophers William Lycan, Clare Batty, and Ben Young undertake this kind of scholastic exercise. I see such discussions as putting the cart before the horse. Taking the naturalistic turn to perceptual analysis, a closer look at the neural basis of olfaction in general and the erratic organisation of the piriform cortex in particular urges us to ask different questions to understand smell. It further presents a chance to catapult philosophical ideas about perception from occasionally disembodied analytical obscurity back to empirical relevance.

Our understanding of the brain and its organisation is advancing as we speak. Advancing does not mean we necessarily have a good understanding of the brain but, rather, that we are pursuing questions that were not considered possible a few years ago. The uncertain organisation of the piriform cortex now may lead us to renew philosophical ideas about the nature of percepts. The piriform cortex does not seem to form stable input maps like the bulb. However, the piriform has been shown to respond to a different sort of mapping. Axel's strategy of looking at the amygdala led to findings where the piriform cortex seems to get trained into forming more or less temporally stable patterns through innate as well as learned behaviour (associated with smells). In comparison, Firestein's idea of looking at projections from higher cortical areas back to the piriform cortex found two distinct neural populations having a topographic organisation. To what extent these two strategies will converge into a consistent model of olfactory cortex processing is an exciting outlook for the next couple of years. What both approach-

es have in common thus far is a focus on behaviour and learning as fundamental to tracing the formation of odour percepts. Stimulus analysis alone will not provide a clear idea of what odour percept formation entails. What are the implications here for philosophical interest in odour perception?

These studies of the piriform cortex suggest that we ought to take a closer look at how our responses to perceptions are key to understanding what percepts are. Instead of taking a stimulus-centred approach and looking at smells as stable percepts, computationally linked to objects, we trade better if we adopt a more processual and context-bound perspective. That means that we need to abandon the orthodox view where we look for stable and intrinsic links between chemicals or input sources and their odour quality. Instead, we must consider contextual handles to understand what it is that we perceive through our sense of smell. To be sure, this is not an argumentative exercise about the (un)reality of perception but the more fundamental enquiry of understanding what odour percepts are.

The question we need to ask first is: What are you doing when you are sensing smells? Smells are not so much perceptions of objects but of changes in context. You are constantly surrounded by hundreds of molecules, but you rarely are aware of their smell all the time. If you sit long enough next to a chalkboard you continue to see it while you will lose awareness of its smell, but you'll immediately detect chemical concentration changes caused by your neighbour's gaseous expression of bowel activity. Thinking of odour perceptions as referring to processes and not objects sounds like an eccentric philosophical idea at first: nice in theory, but does it work in practice?

Imagine you want to model a machine that measures the presence of small changes in your chemical environment. That is precisely what your nose is doing in tandem with your brain. Your nose detects what is out there, your brain measures what the present ratio and changes in ratios of chemicals means. Reengineering this biological principle is also the idea behind research on the electronic nose, or the nanonose. The team of Andreas Mershin at the Center for Bits and Atoms at MIT, for instance, works on such a machine for olfactory pattern detection. Instead of looking for a detection mechanism that recognises a list of particular singular chemicals, they work on a device that notices changes in (variable) chemical patterns associated with certain events (for instance, changes in odour profiles of human skin that are indicative of cancer).

The implicit difference in the perceptual principle involved in this model is fundamental. Not only at the cerebral processing stage, where complex processing mechanisms like learning, memory, and behaviour play into percept formation, but even at the chemical detection level olfaction is not simply about perceiving single molecules but the changing relations in the chemical environment. For this task, your nose is an incredibly precise instrument.

You actually are awesome at smelling

It will be interesting to see how all these ongoing enquiries, ranging from cortex mapping to nanonose models, will lead to a more comprehensive and consistent model of olfaction. What does the present state of affairs tell us about odour perception in a philosophical setting so far? First and foremost, it suggests that focus on finding an intrinsic or analytic link between the structural nature of stimuli and our perceptual experience to argue for some sort of representational realism of veridical object perception is misguided. Especially when the actual pathway of how our sensory apparatus works becomes blackboxed. Such an approach ignores the evolutionary history of organisms that formed what our senses evolved to perceive, and it further neglects the individual experiences that provide the clues as to how these sensory perceptions are implemented.

If you are interested in perception, I want to motivate you to start asking different questions. For the case of olfaction, how can we model and analyse the perceptual nature of changing relations in the chemical environment? How can we understand percepts as dynamic sensory experiences? What may this tell us about the other senses and cross-modal perceptions?

A lot of philosophically interesting questions are waiting to be asked, but we need to look at them in tandem with the empirical sciences. Introspection and philosophical intuition alone can be misleading. (Mind you, although he must have had colds, even the great mind of Immanuel Kant considered the sense of smell as subordinate to the sense of taste, a clear violation of the causal principle if you think of it.) Unravelling the current progression of sensory science, identifying and analysing the open questions it produces, contributes more to philosophical studies of perception than just traditional arguments on physicalism and reductionism. Instead of merely trying to bring our (sometimes hopelessly old-fashioned) philosophical intuitions in agreement with the state of current science, we must further also pursue new philosophical questions about the nature of perception that arise from current science.

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