

4 Smelling Molecular Structure

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1. Introduction

Smells are mysterious entities.¹ They seemingly arise inside our nose, providing a private phenomenological experience, yet at the same time we acknowledge that smells are external entities carried upon the wind. We talk about smells as objective entities of shared attention but are not sure of their ontological status. While the chemoreceptive sciences are still researching the mechanisms of sensory transduction in olfaction, minimally there is consensus that we perceive chemical compounds. The exact property of these compounds is still under investigation, as well as how these yield our sensory experience of what things smell like. Nonetheless few would disagree with the statement that using olfaction we perceive chemical compounds composing gaseous clouds—that is, few except philosophers.

In the last decade, there has been a rapid development of philosophical theories regarding the nature of smell.² This chapter assesses the current philosophical debate about smells. The theories to be covered are: Naïve Realism, Odor Theories, Stuff Theories, Non-Objectivist Theories, Process Theory and Molecular Structure Theory.³ The theories will be evaluated based on their explanations of (a) the olfactory quality of a smell, (b) smells as distal entities and (c) our experience of smells as intentional objects,⁴ which are arguably the three central issues in answering what are smells.⁵ The chapter concludes with a defense of Molecular Structure Theory that demonstrates its strengths in accounting for each of these three aspects of smell.

2. Naïve Realism

Our pretheoretic conception of smells, predicated upon ordinary language descriptions of olfactory experience, is that smells are the emanations of ordinary objects. According to Naïve Realism, what we smell is the distal ordinary object by means of its effluvia becoming lodged in our nostrils. What we represent as the intentional object of olfactory experience is the ordinary object from which the gaseous odor plume

emanates. The olfactory quality of the effluvia is determined by the source object. Lastly, smells can be distal entities that become lodged in our nose. Despite its intuitive nature, the theory does not provide a viable explanation of olfactory quality and the intentional object of olfactory experience.

The Naïve Realists' account of the intentional object of olfaction has been criticized based on the different persistence conditions between ordinary objects and their smells⁶ and issues concerning illusory content and misrepresentations.⁷ Additionally, the theory's explanation of olfactory quality has been criticized based on the naïvety of assuming that all of the chemicals composing the ordinary object are necessary components for generating the olfactory quality of smells.⁸ Lastly, Naïve Realism faces difficulty in assessing the identity of the distal source of a smell given its dispersal rates and persistence conditions, as well as the ability of the olfactory quality of a smell to inhere in objects other than the ordinary objects from which it emanated.⁹ Thus, despite its intuitive appeal, the Naïve view is inadequate.

3. Odor Theories

A large number of philosophers who discuss olfaction argue that smells are odors.¹⁰ Contemporary Odor Theories are an outgrowth of Plato's Vapor theory (Timaeus 66d-67). Odor Theories assert the weaker claim that smells are the odorous subset of the gaseous effluvia of ordinary objects. The external objects of olfactory perception are the chemical odor clouds given off by ordinary objects. Odors identified as gaseous chemical clouds are curious perceptual objects. The clouds' spatiotemporal boundaries are less truncated than those of ordinary objects identified by vision and touch. Since only diffused subparts of the object are required to elicit a smell, Odor Theory has the resources to explain veridical olfactory perception when the ordinary object is not present in the immediate surroundings as well as the possibility of olfactory misrepresentation.

The three most developed positions within Odor Theory have been proposed by Batty, Lycan and Richardson. Each theory endorses the central tenet that the intentional object of olfactory experience are odors. However, they differ in their account of the external object of olfactory perception and the spatiotemporal nature of odors. Odor Theory is enticing, but it faces difficulties both in generating individuation conditions of odors and in giving an account of what determines olfactory quality, thus for brevity these inadequacies will be left aside in the discussion of each theory.¹¹

3.1 *The Abstract Theory of Odors*

The Abstract Theory is defended by Batty over the course of multiple arguments concerning the veridicality of odor perception,¹² the

individuation of multiple odors within an array,¹³ and the multiple properties problem.¹⁴ The object of olfactory experience is not of an odor which is a non-spatial non-objective property of environment. Thus, the intentional object of olfactory experience is not as of a particular entity composed by a gaseous cloud. Rather, an odor is a property of the environment. To correctly describe the representational nature of our olfactory experiences we must make use of an existential quantification that there exists some smell hereabouts in our environment.¹⁵

The Abstract Theory is primarily constructed to handle the intentional object of olfactory experience using our synchronic phenomenological experience of the distal nature of smells. However, Batty's focus on the phenomenology of synchronic experiences of smells generates the overarching claim that olfaction does not present locatable entities with fixed spatial locations. While the theory concedes that olfactory experiences have spatial aspects to them, the olfactory object does not have spatial properties. However, there are good reasons to doubt that we do not perceive objects with properties in olfaction and moreover that these do not have spatial properties.¹⁶ The theory provides a strong explanation of the intentional object of olfactory experience synchronically conceived but does not provide an explanation of the olfactory quality of smells or an account of our distal perception of smells across time.

3.2 Odor Objects and Representational Layering

The original odor theory proposed by Lycan claims that odors are not experienced as having spatial properties, such that they are not presented as being at a fixed spatial location.¹⁷ But he disagrees that they are properties of the environment. For Lycan, the intentional objects of olfactory experience are odors, which are objective entities composed by a gaseous chemical cloud. The primary object that is represented in intentional olfactory experiences is a non-spatial objective entity. More recently, Lycan has further distanced himself from other forms of Odor Theory by arguing for a layering account of olfactory experience according to which we experience odors, but there can be multiple layers of intentional object representation.¹⁸ For example, though we experience odors, we also might attribute the odor's smell to an ordinary object somewhere in the vicinity.

Despite endorsing an objectivist perspective on the olfactory object as external to the perceiver, Lycan's view has difficulties generating an adequate explanation of olfactory quality and the distal nature of diachronic olfactory experience. Moreover, Lycan denies that the olfactory object as a gaseous cloud presents us with spatial properties of the smell.¹⁹ His argument depends upon our agreeing with his account of the synchronic experience of the odorous cloud's vague boundaries not presenting us phenomenologically with spatial locatedness. However, even if his claims

regarding synchronic experiences are granted, the theory will not do justice to our diachronic experience of mereologically complex olfactory objects within an overlapping smellscape. For these situations, Lycan's layering approach might be of help, since our background knowledge and conceptual olfactory resources might enhance the meager nature of synchronic olfactory experience. Nevertheless, without a fuller account of the olfactory quality of an odor and some manner of how we determine the spatial extent of these distal entities across time, Lycan's theory only provides us with a partial explanation of the distal nature of smells and the intentional object of olfactory experience.

3.3 Exteroceptive Odorous Objects

The Exteroceptive approach straddles the boundary between Naïve Realism and Odor Theory. Richardson argues in defense of the common-sense view that smells are objective entities with spatial properties.²⁰ Her driving claim is that olfaction is an exteroceptive sense used to perceive spatial entities. Smells present us with spatial entities located in exteroceptive space, but the objective and spatial nature of smells depends on the active movement of airflow in the nostrils.

The Exteroceptive theory of smell is crafted to account for the intentional object of olfaction as determined by our olfactory phenomenology. Her theory is that we perceive odors as distal entities. Despite being distal external entities, odors are not synchronically presented at a specific distance or direction from the subject. Rather, the olfactory object is experienced as qualitatively being pulled in through the nostril. Enlarging the range of olfactory qualities inherent in the olfactory experience to include the somatosensory sensation of airflow in the nostrils requires expanding the olfactory modality to include everything that goes on inside the nostrils. However, it has been argued elsewhere that if we begin by assuming that smells must have an olfactory quality, then there is good reason for excluding these subsystems as part of the olfactory experience, because they are not necessary for generating olfactory quality.²¹

Even if we expand the olfactory modality to include motorsensory and trigeminal sensations, it is still far from clear how the olfactory quality of an odor is derived. Moreover, the addition of trigeminal and somatosensory stimulation facilitates the localization of smells synchronically either intranasally²² or within external space.²³ Thus, Richardson's claim that synchronically the olfactory object does not present us with a spatial entity at a distance or direction from us, becomes empirically questionable. The Exteroceptive theory progresses the debate by arguing that the intentional object of experience (diachronically considered) is of a particular entity with qualities including spatial properties, but its explanation of synchronic distal olfactory perception is debatable.

4. Smell as the Property of Stuff

The Stuff Theory of smell proposed by Mizrahi maintains the naïve realist position that smells inhere in the ordinary objects and their effluvia.²⁴ Smells are both identifiable with properties of the ordinary objects from which they emanate and properties of the gaseous plume. To account for the duality of smells, Mizrahi requires that we recognize a new category of stuff within our ontological framework. While particulars are objective individual entities, stuff is considered to be the constituent matter. According to Mizrahi's account of our phenomenology, we smell both the ordinary object and the gaseous odor, but the only way to capture the dual existential nature of our pretheoretic descriptions of smells is to embrace an ontology of stuff.

While it would seem that stuff is identified by our use of mass noun terms and commonsense phenomenology, a closer reading of Mizrahi's argument is that stuff has an inner structure which explains its dispositional properties. Stuff is the ontological categorical basis required for us to understand the chemical nature of smells. She does not fully elaborate on the ontological nature of stuff, but a closer look at the theorists cited reveals that they are primarily concerned with generating an ontological category that is proprietary to chemistry.²⁵²⁶ Properly understood, Stuff Theory's account of the duality of smells amounts to the following two claims. First, we can identify that the smell is within the ordinary object, because the ordinary object has a given chemical composition. Second, we experience a gaseous cloud as having a given olfactory quality, because it is composed of a given set of chemicals.

Further issues arise when considering that stuff has the property of homeomerosity. However, each sample of the odorous cloud will not necessarily have the same olfactory quality, given that it might have the same concentration levels. Not only does positing stuff not generate any explanatory gains but it also makes matters worse with its claimed mereological simplicity. For example, chemical compounds often have identifiable functional groups that provide a predictable olfactory quality such that the entire stuff-like entity is not mereologically simple.²⁷ A further problem is that in demarcating the edge of a given odor plume one must track the concentration gradient within the stuff. Yet if stuff is wholly present in each one of its component parts, then it seems odd to think that we would have a diffused gradient instead of something being fully present at each instance of the smelly stuff.

Mizrahi's account is structured around the motivation to account for our phenomenological experience of smells both in the air and at the source, yet olfactory quality is not dealt with. The theory does not explain why one kind of stuff has a given smell as opposed to another kind of stuff. However, the theory allows that the distal nature of smells is of properties of objects that are mind-independent and external to the

perceiver. Additionally, Mizrahi is able to justify our naïve intuitions that smells are both located in the air and ordinary objects. Moreover, the new ontological category allows us to track the stuff dispersed in the air back to their original sources. Given its own posits, the theory does capture the duality of smell by adverting to some more basic category of chemical composition. But identifying stuff requires evoking chemical structures; the nature of stuff does not seem to be at bottom a common-sense phenomenological category but something more readily identifiable and individuated by chemists. Stuff Theory does not supersede explaining the nature of smell using the molecular structure of chemical compounds, hence the proposed new ontology generates no further epistemic purchase.

5. Non-Objective Theories of the Olfactory Object

In contrast to the previous theories that primarily engaged with naïve realism, an interesting alternative is to jettison the object centric approach. The three theories in this section share the view that the intentional object of olfactory experience should not be conceived of as representing chemical stimuli as objects within the environment. However, each theory offers its own innovative research program concerning the function of olfactory perception and the ontological commitments required to fully account for the nature of smells.

5.1 *Smells as Affective Categories*

The non-objectivist theory proposed by Castro and Seeley claims that the olfactory object is generated by affective categorizations. Olfactory experiences are not about a particular set of stimuli in the environment.²⁸ Rather, olfactory objects are tracked by the olfactory system in accordance with their affective categories for generating ecologically significant behaviors. What we represent as the intentional object of olfactory experience are affective categories of ecological valuable kinds. The affective categories coarsely specify the dimensions of the olfactory stimulants relative to their biological value for the organism. Despite the label, the affective categories do not correspond merely to hedonics or perceived pleasantness, as they are a multidimensional set of categories meant to explain the mind-dependent realization of the olfactory object. Castro's research on the categorical dimensions of human odor description space using affective responses serves as a major piece of evidence in favor of the theory.²⁹ However, more parsimonious theories for demarcating olfactory quality spaces have been proposed using judgments of just noticeable difference.³⁰

Starting with our consciously reported phenomenology of smells, Castro and Seeley correctly note that we do not report our olfactory experiences as being of chemical structures, yet it is not clear that any

objectivist theory endorses such a claim. Additionally, they employ evidence for coarse coding of molecular features in the olfactory system in support of the claim that we do not wholly perceive the molecular structure of chemical compounds. While it was commonly thought that odorants are coded in a coarse manner at the receptor and olfactory bulb, Vincis et al. recorded robust fine-grained representations of odorants within the glomeruli of the olfactory bulb under more natural conditions using ordinary odorants at varying levels of concentration.³¹ Moreover, it is unclear how the encoding evidence is meant to bear upon the conscious experience of the intentional object.

They offer further support for the theory based on the claim that the primary determinant of odor identity is its property of valence. Drawing on a series of studies, Yeshurun and Sobel claim that valence is the perceptible property that determinates odor identity instead of olfactory quality.³² For instance, there is greater cross-cultural agreement on the categorization and identification of odors in respect of judged properties of pleasantness than olfactory quality.³³ Moreover, a computational model of the olfactory object can predict olfactory valence from chemical structure alone.³⁴ However, a recent set of studies indicates that the object of olfactory perception is more likely identified by humans in terms of its olfactory quality.³⁵ Additionally, Kumar created an alternative computation model using descriptors of qualities and not judgments of valence, as well as measures of psychochemical structures to predict olfactory quality.³⁶

The theory attempts to account for the olfactory quality of smells at the conscious level of experience. Olfactory quality is determined by the affective categories that the organism generates in encoding odor stimuli that are instrumental in the guidance of ecological behavior. Given their theoretical starting point of accounting for conscious reports of olfactory experience, they exclude nonconscious perception of olfactory qualities. But this is a highly dubious assumption given that most olfactory experiences occur in the absence of awareness.³⁷ Also, it is arguably the case that conscious awareness is not required for our perception of olfactory quality.³⁸ Additionally, olfactory experiences generate behavior even in the absence of conscious awareness.³⁹ Castro and Seeley do not account for distal nature of smells, as they are primarily concerned with the representational nature of the intentional content of olfactory experience. The intentional objects of olfactory experiences are mind-dependent entities generated from higher-level processing. Their theory is an interesting account of the intentional object of olfactory experience if one is only interested in accounting for conscious phenomenology.

5.2 Quality Space and Olfaction's Role in Guiding Behavior

Keller offers the most comprehensive treatment of the philosophy of olfaction centering around the claim that olfaction is designed for the

determination of behavioral output.⁴⁰ Olfactory perception should not be conceived of as generating accurate representations of external chemical stimuli, because the purpose of olfactory function is the detection of salient entities for behavioral output. His theory is similar to Castro and Seeley's, yet it differs in its determination of olfactory quality, which is ascertained using a triadic relation of just noticeable difference judgments of olfactory stimuli. Thus, the qualitative character of an odor is generated by its holistic placement in the mental quality space of each subject.

Regarding the distal nature of smells, Keller argues that olfactory qualities do not have spatial properties, because we do not have spatial properties presented to us as part of the olfactory quality. In those instances where it seems that olfaction provides us with spatial information, he rightly notes that these might be attributed to chemesthesis. His arguments derive from a review of experimental evidence on olfactory spatial abilities and tracking. However, there are some empirical studies that arguably show that olfactory experience might be spatial. The binaural rivalry between nostrils yields a slightly different smell percept for each nostril,⁴¹ yet this does not yield odor localization. The host of chemoreceptive research indicates that humans cannot use intranasal onset to determine olfactory distal perception.⁴² However, Negoias et al. demonstrated that individuals can be trained to localized odorants' onset within a nostril synchronically.⁴³ Their study provides a strong reason to think that we do have the capacity for synchronic odor localization, but it requires attention and training. Additionally, in open field environments subjects can localize a distal object using just the olfactory system without trigeminal stimulation. The use of both nostrils did not make a difference for locating the stimulus at two meters or less from the subject, but beyond two meters the use of both nostrils to demarcate the concentration of the plume seems to be of importance in the localization of the smell.⁴⁴

Keller entertains the claim that the intention object of olfactory experience could be determined in terms of the objects that are phenomenally present in the experience.⁴⁵ What is phenomenally presented to us in olfactory perception depends upon background knowledge, including our tracking the placement of odorous ordinary objects in the environment, which he finds problematic because the olfactory object will differ between perceivers. Moreover, based on the olfactory system's overall anatomical connectivity, he argues that tabled possibility of conceiving of the intentional object of olfactory experience as what is phenomenally present in experience misunderstands the function of olfaction, which is designed for detecting chemical stimuli for the guidance of behavior.

His quality space theory generates an account of olfactory quality based on triadic subjective judgments of just noticeable differences between stimuli. Olfactory quality is determined in accordance with its placement within the holistic mental quality space. Chemical stimuli do not have a smell on their own independent of the quality space. Additionally, based

upon experimental evidence, he carefully argues that smells do not have spatial properties even though we can use them for navigation. As such, smells are not distal entities on his theory—they inhabit spaces as a property of the environment. Olfaction is not meant to represent the environment, nor is it meant to generate intentional representational objects of experience. Rather, olfactory perception is meant to influence behavior based on the hedonic properties of an odor.

5.3 Process Theory of Olfaction

The process theory of olfactory perception proposed by Barwich challenges traditional philosophical conceptions of the olfactory object.⁴⁶ She argues that traditional approaches incorrectly assume that we can explain the nature of olfactory perception in terms of distal entities in the environment that drive perceptual processes within the individual. Rather, the intentional object of olfactory perception requires an entirely different metaphysical framework of processes. By jettisoning the stimulus-driven approach with its emphasis on the independence of perceptual object and the perceiver, the process ontology provides greater explanatory power in accounting for the nuanced nature of olfactory processing.

From an epistemic standpoint, the process view is rather appealing. The theory's strength derives from acknowledging that the stimuli transduction and neural encoding of odor stimuli within the olfactory system require both top-down and bottom-up processing.⁴⁷ While most philosophical views propose that we smell things in the environment, which we represent as the objects of olfaction, the process view focuses on how anticipatory effects and background knowledge conditions play a role in the determination of olfactory experience.⁴⁸ Olfactory processing is not a simple feedforward sensory system whereby the stimulus determines the complete nature of its perceived qualities. Ongoing dynamic processing across multiple sensory and cortical levels of the olfactory system play a role in generating how the sensory stimulus is perceived.

Background conditions and top-down processing within the olfactory system mold how an odor is constituted from a host of odorants. For instance, naïve animals treat the same chemical stimulus at varying concentration levels as having different olfactory qualities.⁴⁹ However, organisms learn concentration invariance (i.e., the shift in concentration of the overall odor does not change its identity) by tracking the concentration of the components⁵⁰ or by learning that the ratio between components remains constant.⁵¹

The process view is well argued for and on firm empirical footing, but jettisoning our traditional ontological framework of particulars, objects, states and properties together with their interrelationships in favor of a process ontology is unmotivated. Not only is the notion of what

determines a process vague, but it is unclear that a process ontology generates an explanatory purchase beyond that of our current models. The greatest problem is that the notion of a process as derived from the neuroscientific literature is conflated with the notion of a perceptual process phenomenologically individuated. Moreover, the very concept of a process is never adequately defined in a manner that lets us determine how this contrastive notion is meant to enhance our understanding of olfactory perception beyond that of our current ontological commitments.

We can reconstruct our current theories in a critical manner to account for processes, yet what needs to be shown is that the new process ontology constructively generates explanatory purchase over and above that of the original model or system.⁵² Embracing a process ontology requires that we consider processes to be non-reductive dynamic entities that are both productive and that sustain continuity.⁵³ Given this theoretical starting point, it seems fair to ask how the same olfactory processes realize similar if not the same perceptions of olfactory quality. One specific advantage of the objectivist ontology is that by considering reality to be constructed of discrete entities allows for symbolization and quantification, which thereby generate interpersonal predictions and generalizations. Without a clear delineation of what an olfactory process is across individuals, the processes account will not yield generalizability for the stability of interpersonal and intrapersonal judgments of olfactory quality, intensity or hedonic of smells. Not only does this place the theory at a disadvantage but it does not imbue the approach with any explanatory purchase beyond that of the current scholastic accounts.

Process theory's account of olfactory quality, smell's distal nature and the intentional object of experience show promise. A smell's olfactory quality is determined by an interactive process between the stimulus and top-down cognitive and perceptual processes within the olfactory system. How these processes determine olfactory quality will require future clarification based on empirical investigation, which is a strength of any empirically informed theory in philosophy. The process account clearly holds that olfactory quality is not within the stimulus-driven object. The chemical structures do not have a smell, since olfactory qualities are determined by perceiver-relative processes. In contrast with previous theories that the olfactory objects are distal entities, Barwich argues that the olfactory system is not designed to accurately represent external particulars. The olfactory system tracks information that is instrumental in the guidance of ecological behavior. Lastly, the intentional objects of experience, are generated through an interactive process between the perceiver and the chemical stimulus. There is a blurring of the boundaries between the perceived and the perceiver, which should allow for the intentional object of experience to be a process between top-down anticipatory effects and chemical stimuli encoding.

6. Molecular Structure Theory

According to Molecular Structure Theory (MST), the chemical nature of the stimuli is responsible for our experience of smells. Our experiences represent smells as distal environmental entities with spatial properties such that what determines the olfactory quality and the spatial temporal nature of smells is some property of the chemical structures within the gaseous plumes. Carvalho proposes a precursor of molecular structure theory according to which olfactory objects are chemical structures.⁵⁴ These chemical structures determine the type of odor that we perceive and generate the token representation of the odor that is the olfactory object of intentional experience. He argues that the existential quantification posited by Batty to explain our experience that there is a smell hereabouts as a property of the environment does not adequately capture our experience of smells. The nuanced temporal development of our experience of smell requires the existence of a spatiotemporally extended object to which properties may be predicated. Additionally, he demonstrates, contrary to Burge⁵⁵ that there are constancy effects in olfactory perception such that a change in the proximal stimulus does not necessarily yield a change in the olfactory quality of the distal stimulus. The ramifications of his view are that earlier odor theories are incorrect both in their denial of olfactory objects as particulars and their withholding spatial properties from olfactory experiences.⁵⁶

MST improves upon chemical structure theory by focusing upon the spatial nature of the olfactory plume. The olfactory quality of a given smell, the spatial and temporal boundaries of the distal object of smell and the intentional object of olfactory experience are determined by the molecular structure of chemical compounds within odor plumes.⁵⁷ According to MST, olfactory quality is determined by the molecular structure of chemical compounds. However, the plume plays a role in the determination of olfactory quality and the spatial extent of the olfactory object. The chemical compounds determine the distal nature of token odor plumes, given their concentration gradients. Additionally, the interaction effects between the different kinds of molecular structures within the plume also play a determinate role in generating olfactory quality.

The initial statement of the theory was primarily constructed to account for simple odor mixtures and monomolecular odorants,⁵⁸ but when considering natural environments, we must consider olfactory mixtures composed of multiple types of chemical compounds. Determining the spatial and distal nature of the olfactory object requires accounting for the plume structure of a given odor within a turbulent sea of overlapping chemical currents. The olfactory system binds together odorants of different molecular structures to compose an overall odor object. What was missing from the initial statement of MST was a specification of the

intentional object of olfactory experience. What we experience as the objects of olfactory experience are odors within a smellscape.⁵⁹

We experience a smellscape of complex olfactory objects that can change and shift their properties across time as against a background of other odors. To do so we employ background knowledge to generate the composition of olfactory mixtures in terms of their groupings. One of the strengths of MST is that it can advert to the olfactory system's capacity to encode the molar ratios between the components of a given olfactory mixture, the concentration rates and ratios between odorants and overall concentration rates of the key components of complex mixtures. As such, MST can account for the persistence conditions, the mereological identity conditions and individuation conditions of an odor in terms of the molecular structure of chemical compounds that compose the complex mixture.

According to MST, it is not possible for humans to have veridical perception of olfactory quality in the absence of stimulation, using chemical odorants. Empirically, MST's claim is supported by experimental manipulation of the olfactory system using electrical stimulation. In some mammals, it has been shown that stimulating the olfactory epithelium electronically yields stimulation of the olfactory bulb and cortex, though it is unclear if this yields perceptible olfactory qualities.⁶⁰ Additionally, one recent study generated the experience of olfactory quality in epileptic patients using cortical stimulation induced by subdural electrodes, which they equated with olfactory hallucinations.⁶¹ However, to the best of my knowledge no study has yet shown that electronic stimulation of the olfactory sensory system in humans generates experience of olfactory quality.⁶² ⁶³ These findings might not constitute definitive evidence for MST, as they are predicated upon the absence of results, but they are predicted by it.

Molecular structure is superior to the alternative approaches, because it comprehensively explains the nature of olfactory quality, the distal nature of smells and the intentional content of olfactory experience in a coherent and systematic fashion. To reiterate, according to MST, the quality of a given odor is determined by the molecular structure of chemical compounds in interactions with the olfactory receptor, as well as in composing the gaseous plume. Additionally, we can individuate the distal nature of olfactory objects in a principled manner that allows for their vague boundary conditions.

The overlapping plumes of odors that generate the sea of chemical currents enveloping us generates the environmental smellscape that is the intentional object of olfactory experience. Smellscapes are rather odd things to think about given our visiocentric default mode of thinking about our experience of reality. However, when thinking about smells it becomes natural to consider large-scale environments with overlapping

currents that inform us of distal entities of ecological and navigation value to us as organisms.

7. Conclusion

In less than a decade, the Philosophy of Smell has blossomed and expanded from just a couple of views to a host of different approaches, all aiming at explaining the nature of our olfactory experiences. I have sought to offer an overview of the debate within philosophy regarding the nature of smell by surveying Naïve Realism, Odor Theories, Stuff Theory, Non-Objectivist Theories including Process Theory and Molecular Structure Theory. To properly assess the merits of each theory, three separate issues were used as a means of comparison. The three central questions that any theory of smells must handle concern the distal nature of smells, what generates olfactory quality of smells and what is the intentional object of olfactory experience.

Naïve Realism was shown to be inadequate on all aspects of the nature of smell. Odor Theories strengths are built upon their criticisms of Naïve Realism and their explanation of the representational structure of the intentional object of olfactory experience. However, they fare poorly with their narrow synchronic distal object of smell and lack of engagement with the nature of the olfactory quality. Accounting for the olfactory quality of smells is also not handled by Stuff Theory. Mizrahi attempted to maintain our naïve realist conception of smells as inhering within the ordinary object and at the same time existing within the effluvia that reaches our nostrils. She offers an alternative ontological category of stuff to better explain the nature of smells experiences. In elucidating the nature of stuff, it was noted that the ontological shift is not required because stuff is equivalent to the chemical structures and posits of chemistry. The explanatory purchase provided by Stuff Theory can be supplanted by MST without abandoning the traditional ontological framework.

The non-objectivist theories offer a compelling alternative. Castro and Seeley's theory that olfactory quality is determined by affective categories did not set out to comprehensively deal with the intentional object of olfactory experience, nor the distal nature of smells. Hence, Barwich's Process Theory and Keller's theory offer more comprehensive non-objectivist models of the nature of smell. Barwich's theory presents a promising alternative to considering the nature of olfactory perception to be object oriented and stimulus driven. However, despite the explanatory value in including top-down processing within the determinants of the olfactory experience, the ontological purchase of abandoning our object-oriented approach in favor of an ontology of processes requires further motivation. Keller offered by far the most comprehensive theory of the nature of smell, centering upon the claim that the olfactory system is

designed not to accurately represent distal stimuli in the environment but rather to track the ecological affordances of chemical stimuli in the guidance of behavior. Overall, his theory is well crafted and empirically well supported. However, it has been argued that the olfactory system implements an alternative representational format of non-concatenative compositional representations that do not obey the strictures assumed of a representational format assumed by Keller.⁶⁴ Moreover, the alternative explanation of the olfactory systems' representational format might challenge his use of cortical connectivity in support of the claim that the olfactory system does not have a representational format that accurately depicts entities in the environment.

MST offers the most comprehensive explanation of the olfactory quality of smells, the distal nature of smells and intentional experience of smells, while at the same time being the most parsimonious in terms of its ontological commitments. The olfactory object should not be conceived as merely determined by the chemical structure of odorants. Instead, it is the molecular structure of chemical compounds within odor plumes that determines the olfactory object. MST does not require the abandonment of our ontological commitments to objects with properties. Furthermore, MST is in keeping with the object-centric stimulus-driven research program of the chemosciences. According to the theory, we smell particulars in external space that are not mind-dependent. The quality of these objects is determined in accordance with the molecular structure of the chemical compounds at the micro-level in their interactions with the olfactory receptors together with their macro-chemical properties in composing the odor plume. The distal nature of the olfactory entity can be determined by the chemical structures composing the overall plume. Lastly, the intentional objects of olfactory experiences are smellscape composed of a multitude of plumes within the turbulent sea of chemicals we inhabit.

Notes

1. The sole focus of the chapter will be upon orthonasal olfaction.
2. The chapter will not offer historical coverage of the philosophy of smell. Brief introductions to earlier accounts of smell can be found in Perkins, *Sensing the World*; Young, *Olfaction*; Richardson "Sniffing and smelling" and Batty "Olfactory Objects." Also, Johansen, "Aristotle on the Sense of Smell" provides a detailed assessment of the differences between Aristotle's theory in *De Anima* and *De Sensu*. Additionally, for an introduction to the commentators' debate over Plato and Aristotle's theories of olfaction, see Kemp, "A Medieval Controversy about Odor." Additionally, McHugh's *Sandalwood and Carrion* offers a historical overview of Indian Philosophy of Smell. Lastly, Wilson and Stevenson's *Learning to Smell* and Barwich's "Bending Molecules or Bending the Rules?" provide nice introductions to the history of olfactory science.
3. Subjectivism about the olfactory object, i.e., the claim that smells are unstructured sensation of odor qualities that are not representational and merely

properties of experience internal to subject, will not be considered. For a more detailed discussion and criticisms, see Carvalho “Olfactory Objects.”

4. The Intentional Object question is similar to giving an account of what Pylyshyn in the first chapter of *Seeing and Visualizing* refers to as the “phenomenal” content of perception.
5. Cf. Young, 2016.
6. Cf. Batty, 2010c.
7. Cf. Lycan, 1996.
8. Cf. Young, 2011, 2016.
9. Cf. Keller, 2017.
10. Cf. Batty, 2007, 2010a, 2010b; Lycan, 1996, 2000, 2014; Matthen, 2007; Smith, 2002; Tye, 2000, 2002; Richardson, 2013.
11. Cf. Young, 2016.
12. Cf. Batty, 2010.
13. Batty, 2010a, 2010b, 2011.
14. Batty, 2010a, 2010b, 2014.
15. Carvalho (2014) offers detailed criticisms that the existential quantification must also include an olfactory object to account for the diachronic nature of olfactory perception of mereologically complex smells to which we predicate temporal properties.
16. Cf. Richardson, 2013; Carvalho, 2014; Mizrahi, 2014; Young, 2016.
17. Cf. Lycan, 1996, 2000, 2014.
18. Cf. Lycan, 2014.
19. For criticisms see Carvalho, 2014; Young, 2016.
20. Cf. Richardson, 2013.
21. Cf. Young, 2017.
22. Cf. Frasnelli et al., 2009, 2010.
23. Cf. von Bekesy, 1964.
24. Cf. Mizrahi, 2014.
25. Soentgen (2008) claims that the phenomenological experience of reality allows us to categorize things not necessarily as particulars, but as groups of stuff. Yet, ideally the notion is supposed to correspond with our ontological posits in chemistry. The general problem with this account is that it is meant to be a commonsense account given our semantic and linguistic usages, yet all the examples that theoretically motivate positing stuff as an ontological category are derived from chemistry.
26. Lewowicz and Lombardi (2013) offer further reasons for why we must recognize the ontology of stuff based on the linguistic structures of our ordinary language, whereby we identify groups of categories as being of a given kind of stuff. However, the primary reason for positing stuff is to account for the nature of chemical reality. According to Lewowicz and Lombardi, we must have a macro-chemical ontology of stuff together with a micro-structural identification of reality at the level of physics.
27. Cf. Klopping, 1971.
28. Cf. Castro and Seeley, 2014.
29. Cf. Castro et al., 2013.
30. Cf. Young et al., 2014; Keller, 2017.
31. Cf. Vincis et al., 2012.
32. Cf. Yeshurun and Sobel, 2010.
33. Cf. Haddad R. Weiss et al., 2008, 2010.
34. Cf. Snitz et al., 2013.
35. Cf. Olofsson et al., 2012;
36. Cf. Kumar et al., 2015.

37. Cf. Sela and Sobel, 2010.
38. Cf. Young et al., 2014; Keller, 2017.
39. For a short review, see Young, 2014b.
40. Cf. Keller, 2017.
41. Cf. Zhou and Chen, 2009.
42. Cf. Kobal and Hummel, 1998; Radil and Wysocki, 1988; Frasnelli et al., 2009, 2010; Kleemann et al., 2009.
43. Cf. Negoias et al., 2013.
44. Cf. Welge-Lussen et al., 2014.
45. Cf. Budek and Farkas, 2014.
46. Cf. Barwich, 2014, 2016, 2018.
47. Cf. Barwich, 2014.
48. Cf. Barwich, 2018.
49. Cf. Cleland et al., 2012.
50. Cf. Le Barre et al., 2008; Sinding et al., 2013, 2014.
51. Cf. Cleland et al., 2012; Uchida and Mainen, 2009.
52. Cf. Seibt, 2005.
53. Cf. Seibt, 2005; Simons, 2000.
54. Cf. Carvalho, 2014.
55. Cf. Burge, 2010.
56. A further aspect of Carvalho's approach that runs counter to previous theories is that the olfactory objects have distal and temporal constancies such that we have an olfactory psychological ability figure-ground segregation.
57. Cf. Young, 2016.
58. Ibid.
59. The idea of smellscape is certainly not new, as distal olfactory perception has a long history of debate going back to Plato and Aristotle through to their Medieval Commentators. Additionally, Indian Philosophy contains a rich treatment of olfactory navigation and discussions of garden design to elicit a smellscape (for an overview, see McHugh, *Sandalwood and Carrion*). More recent discussions can be found in Papi, *Animal Homing*. Papi poetically writes about smells occurring within a distal array as a mosaic of odor patches. Gatty in *Finding Your Way on Land or Sea* uses similar terminology when discussing seabirds who use a sensory array of olfactory objects for navigating both at sea and on land. However, the contemporary coinage of smellscape must be attributed to Porteous, who introduces the term to capture our ability to navigate and remember olfactory environments. Porteous's research shows that smells are not randomly distributed; determining the location of smells requires accounting for the odor's current position given the smells' odorous concentration gradient and the wind patterns in the environment. Similarly, Roadaway in *Sensuous Geographies* examines how olfaction allows interactive navigation through an environment of sensory geographies. Moreover, there are long-standing and ongoing research projects devoted to demonstrating that olfactory perception provides navigational accuracy in using odor gradients within a coordinate space to navigate an environment (Wallraff, "Avian olfactory navigation," "Avian navigation," "Ratios among atmospheric trace gases together with winds imply exploitable information for bird navigation" and "Do olfactory stimuli provide positional information for home-oriented avian navigation?")
60. Cf. Ishimaru et al., 1997; Xu et al., 1999; Wei et al., 2003.
61. Cf. Kumar et al., 2012.
62. Cf. Uziel, 1973; Straschill et al., 1983; Sato et al., 1996; Ishimaru et al., 1997; Li et al., 2014; Weis et al., 2016.

63. A possible explanation of these negative findings might be that the electronic stimulation is not sufficiently dynamic and distributed, so it might not stimulate the olfactory epithelium and bulb with the same transduction pattern as chemical stimuli. Moreover, there is reason to be hopeful that, with modern technological advances in computational technology, we might be able to build electronic sensors that mimic the computational patterns at the OB (Persaud et al., “Neuromorphic Olfaction”). However, as of now our optimism in future technology does not threaten the claim that olfactory quality is inherent to the molecular structure of chemical compounds.
64. Young, 2015.

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