CHAPTER FOUR

ENACTIVISM'S LAST BREATHS

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Olfactory perception provides a promising test case for enactivism, since smelling involves actively sampling our surrounding environment by sniffing. Smelling deploys implicit skillful knowledge of how our movement and the airflow around us yield olfactory experiences. The hybrid nature of olfactory experience makes it an ideal test case for enactivism with its esteem for touch and theoretical roots in vision. Olfaction is like vision in facilitating the perception of distal objects, yet it requires us to breath in and physically contact the sensory object in a manner similar to touch. The paper offers an analysis of the central theoretical components of enactivism, whose soundness and empirical viability are tested using the empirical literature on sniffing. It will be shown that even if sniffing is an essential component of olfaction, the motoric component is not necessary for perceiving smells, which is contrary to the most crucial tenet of enactivism. Thus, the paper concludes that the theory cannot account for olfactory perception.

Introduction

The behavioral rhythm of breathing, which is under volitional control, modulates our inhalation and exhalation patterns in accordance with our internal states and surrounding environment. Even our breathing patterns are a form of interaction with our environment that facilitate olfactory perception and that can be utilized in testing enactivism. Enactivism argues that perception is constituted by the implicit deployment of skill based sensorimotor knowledge, which structures the nature of our perception of external objects in the environment (Noë [2001, 2002, 2005], O'Regan [1992]; O'Regan and Noë [2001, 2002]. Consequently, Alva Noë (2004, 2007, 2008, 2009), the most vocal proponent of enactivism, suggests that touch would serve as a better theoretical

launchpad for theorizing about the nature of perception than vision. Yet, he, like many others, concentrates upon vision with the promise that the theory should extrapolate to the other senses.

However, there are good reasons to doubt that the theory can accommodate the nature of taste (Gray and Tanesini [2010]), making its extrapolation to other modalities dubious, especially when compounded with the evidence that it is an inadequate account even for its designed domain of visual perception (Lycan [2006]; Prinz [2006]). Enactivism is unlikely to serve as a comprehensive theory of all forms of perception, yet our perception of smells might offer it a last bastion of hope. Rather than focus on all aspects of breathing the paper concentrates on the role of sniffing in olfactory perception. *Prima facie* olfactory perception provides a promising test case for enactivism, since smelling requires actively sampling our surroundings by sniffing. Olfactory perception depends upon the movement of chemical compounds through the nose.

The hybrid nature of the olfactory experience makes it an ideal test case for enactivism with its esteem for touch and theoretical roots in vision. Olfaction is similar to vision in enabling the distal perception of object. We perceive distal smells within the environment, yet physically contacting the sensory object in a manner similar to touch is required to transduce the smell stimuli. A survey of the empirical research on sniffing will be employed to both generate an analysis of the theoretical components of enactivism and test the soundness of the theory.

Airflow through the nose is required for normal cases of olfactory perception whether it be orthonasal, originating from the front of the nostrils, or retronasal, passing up from the throat through the back of the nose. However, for the purposes of this paper, only orthonasal perception will be considered, as the inhalation of odorant laced air as controlled by sniffing is the focus of this paper. Moreover, rodents, who serve as the primary animal models of olfactory perception related to sniffing, only have orthonasal olfactory perception. Thus, olfactory perception as initialized at the nostrils and flowing back to the olfactory epithelium will be the bases for sniff testing the enactive approach. It will be shown that though sniffing is at times an essential component of the olfactory percept, the motoric component is not necessary for perceiving smells. Since this is contrary to the crucial tenet of enactivism, the conclusion argued for is that the theory cannot account for olfactory perception.

1. Sniffing

The average sniff lasts 1.6 seconds. During the initial phase of sniffing we modulate the volume of airflow, pressure of airflow, and sampling rates. Additionally, towards the middle to end of a sniff we can detect the presence of an odor, as well as identify its olfactory quality (what it smells like) and valence (reviewed in Olofsson [2014]). The sniff sequence can be segmented into multiple stages. The initial sniff onset brings the stimulus into the nasal cavity and lasts 200 ms. Within 150-300 ms of stimulus presentation sniffing is modulated in accordance with the concentration, intensity, and valence of the odorant. Additionally, within 150 ms of sniff onset we modify our sniff response in accordance with the olfactory valence of the stimulus. Furthermore, encoding the olfactory properties of the odor occurs during a 500 ms period following the initial 200 ms of sniff onset. Only after 800 ms of sniff onset do we consciously detect the odorant. Identification of olfactory quality and odor valence follows at intervals of approximately 1000 ms and 1100-1200 respectively (reviewed in Olofsson [2014]).

What will be of interest in testing enactivism is that the behavioral modulation of our nostrils and breathing patterns, a paradigm of motoric action, occurs before we consciously report experiencing a smell. The behavioral modulation of each sniff serves not only to deliver the odorant to the olfactory epithelium, but it also plays a role in determining our perception of odor intensity and concentration. Our experience of smell is modulated by our sniffing behavior, which tracks the olfactory properties of the odorant below the level of conscious awareness.

Not only does sniffing facilitate our perception of a smell's valence, intensity, and concentration, it enables the localization of olfactory objects by actively exploring the external smellscape (Porter et al. [2007]). Having two nostrils serves a greater function than mere aesthetic symmetry, the two nostrils form distinct percepts of the olfactory environment and based on their differences in anatomical size and volume of airflow (Sobel et al. [2000]; Zhou and Chen [2009]) we are able to track olfactory objects across time and throughout an environment (Porter et al. [2007]).

The role of sniffing in generating the olfactory percept provides a promising line of evidence in favor of testing enactivism. But sniffing serves non-perceptual functions as well. Amongst rats, sniff rates are modulated based on social hierarchy. Males of lesser ranks will decrease their sniffing rates around those of a greater stature, because vigorous sniffing can be interpreted as a sign of aggression (Wesson [2013]). There is no evidence for the same social analogue in humans, but experimental

research demonstrates that we mimic the sniffing behavior of those around us. In these instances, sniffing might be a partial mechanism for directing shared attention towards olfactory objects (Arzi et al. [2014]). Sniffing plays a role in olfactory perception, but it might serve other purposes than just facilitating smelling (Galef [2013]). In what follows, the key target of this paper, actionism will be introduced, and its key tenets will be identified, clarified and tested, using what we know about the role of sniffing in olfactory perception.

2. Actionism

There is little doubt that sensorimotor contingencies play a role in our perception of the world, but enactivism endorses a non-trivial and strong constitutive relationship between them. Central to the theory is the claim that perceiving objects in the environment is only possible through the existence, knowledge and implicit deployment of sensorimotor contingencies. To perceive objects in the environment one must tacitly understand how one's movement would affect the sensory properties of external perceptible entities. The target of the paper is Noë's most recent incarnation of enactivism, actionism. His current theory is in keeping with the past versions, but with a more explicit formulation of the central claim that to perceive is a skillful act of knowing how movement affects the perception of an object's sensory properties. Actionism expands this idea into two separate conditions:

> (i) Movement-dependence: movements of the body manifestly control the character of the relation to the object or quality (ii) Object-dependence: movements or other changes in the object manifestly control the character of the relation to the object or quality. (Noë [2009], p. 476)

The first claim is consistent with previous theories (Noë [2001, 2002, 2005, 2004, 2007]; O'Regan and Noë [2001, 2002]), while the second is a fresh addition. The further addendum of object dependence seems like a banal augmentation that most perceptual scientists would agree on without much fuss. Surely, our ability to track perceptual object throughout their shifting mereology and changes in spatiotemporal properties depends on our knowledge of how objects move throughout an environment in a stable manner based on perceptual constancies. What remains the non-trivial and contentious claim is that of movement-dependence to which we now turn our attention.

Actionism has four foundational theoretical tenets. First, the theory tacitly endorses a model of direct perception. Second, actionism argues

that the transition from sensation to perception requires sensorimotor knowledge. Third, in keeping with its enactivist roots actionism maintains the constitutive claim that perception requires the possession of implicit knowledge and the skillful deployment of the aforementioned sensorimotor contingencies. Lastly, actionism attempts to explain the perceptual presence of three-dimensional objects using our knowledge of sensorimotor contingencies that determine perceptual constancies. To test the core tenets of actionism, the paper is split into four sections assessing its theoretical struts. Each of the central claims will be analyzed separately and tested using what we know about the role of sniffing in olfactory perception.

3. Direct Perception – Actionism as Theory of Access

Actionism is at its heart a theory of access – how we access the sensory properties present in the world. Though it is not clearly said, Noë endorses a version of direct perception according to which the sensory properties present in the world are directly perceived through the deployment of sensorimotor skill based knowledge. The knowledge and implicit deployment of sensorimotor contingencies allows for the transition from sensation to perception. However, the sensory qualities are directly sensed without any need for further encoding or representational mechanisms.

> My proposal is that what brings the world into focus for perceptual consciousness is our understanding of the ways movement alters sensory events. Mere sensation does not rise to the level of perceptual experience for perceptual experience we need sensation that we understand. (Noë [2008], p. 532).

The tacit assumption of a theory of direct perception helps situate the theory and highlights that perceptual access is the focus of actionism. It is unlikely that olfactory perception will cause much trouble for this assumption of direct perception, as it is arguably the case that what we smell is the molecular structure of chemical compounds within odor plumes (Young [2011]). The olfactory quality of an olfactory object is determined by these chemical properties as they engage with the olfactory epithelium. The olfactory qualities are objective properties of the external world that we sense through our inhalation of these objects in our surroundings. Hence, a direct theory of perception seems most fitting for the nature of olfactory perception and in keeping with actionism. However, the further claim regarding sensorimotor contingencies being necessary and sufficient without further encoding or representational mechanisms needs testing.

4. The Deployment of Sensorimotor Contingencies

The third claim that our perception of objects depends upon implicitly deploying sensorimotor contingencies faces little opposition from olfaction, but it requires clarification. The existence of law-like regularities between our movements and the way things appear is not enough. What needs to be established is that perception is only possible through the implicit deployment of this skillful knowledge. We need neither explicitly know these sensorimotor contingencies in a manner that is reportable in a propositional manner nor deploy them in an on-line routine like a set of rules or look up table. Rather the deployment of our sensorimotor knowledge is a skillful type of action performed in an automatic fashion. Noë's most explicit rendering of this implicit knowledge is:

> What matters for my purposes is that (i) perceivers are ***familiar*** with the way sensory motor stimulation varies as a function of movement; (ii) perceivers are generally unable to say what the relevant patterns are; (iii) being able to say what they are would not, in and of itself, be evidence of possession of the relevant perceptual capacities. (Noë [2006], p. 33 [emphasis added])

The last two claims are not problematic if olfactory perception is constituted by the sensorimotor contingencies, as these are mostly unattended and implicit. In general, we do not attend to our olfactory experiences, and are not conscious of most of the olfactory perceptible objects coming in contact with our sensory system. Based on the temporal processing time involved in sniffing it has been argued that olfaction is analogous to a constant state of change blindness (Sela and Sobel [2010]). The dearth of awareness to olfactory experience and our sniffing behavior is in keeping with the last two conditions, but the first is problematic.

I am dubious that we are *familiar* with how our movement affects our experience of smell. We might recognize that to locate a smell, we move around to gain access to the odorant's gradient. However, even this very limited form of movement dependent olfactory perception might escape peoples' grasp. Furthermore, we do not recognize that we modulate our sniff responses in a very robust and fine-grained manner to the valence of an olfactory object. Within 150 ms of the onset of a sniff the volume of air intake and strength of motoric inhalation are modulated in accordance with the pleasant or unpleasant nature of the stimulus (Johnson et al. [2003]). Odorants that are pleasing are inhaled more deeply and strongly, while those rated as unpleasant are sniffed less vigorously and we attempt not to inhale them (Bensafi et al. [2002, 2003]).

Doubtlessly the third tenet of actionism is applicable to olfactory perception based on the implicit role of sensorimotor contingencies in our perceiving the valence of an olfactory object. However, the extent to which (i) can be met depends upon the level of *familiarity* that is presupposed. Requiring too much olfactory familiarity will only breed contempt for actionism, due to humans' rarely attending to their active breathing patterns in relation to smelling. Furthermore, if too little familiarity is assumed then the theory is at best a theory of non-conscious sensory encoding and no longer perception. If (i) above requires some manner of conscious reportability of our olfactory experience and familiarity thereof then actionism will come up short; while if Noë allows for non-conscious processing this is in keeping with the experimental literature on the sniff sequence reviewed in section 2 except that the theory's target would be non-conscious states and not the phenomenological experience of perceptual states.

5. Perception Is Constituted by Motor-sensory Dependence

Actionism's most contentious claim is that the transition from sensation to perception is constituted by the subject's sensorimotor knowledge. The current section clarifies the role of sensorimotor knowledge in perception and explains why it is most likely not true of olfactory perception. According to actionism, we have direct access to objects in the environment, yet there needs to be an intermediate step that explains the transition from sensations to perception. The chief motivation of the project is an attempt to explain the perceptual presence of perceived objects in their entirety when we only sense surfaces or parts of objects. The transition from sensation to perception generates the necessity of sensorimotor contingency. "Sensory stimulation is intelligible only if its relation to us and to things around us is comprehensible" (Noë [2008], p. 535).

5.1. The Primacy of Motor-sensory Dependence

Intuitively our knowledge of how our interaction with our surroundings changes our sensations of the environment allows us to perceive objects in their entirety. However, the roles of the sensory and motor parts of sensory-motor knowledge within the theory need clarification. Are the sensory and motor components separable? If they

each perform independent functions, then which plays the primary role in generating perception?

Noë is explicit that the motoric component generates the changes in sensory stimulation. Even though it is often referred to as sensory-motor contingencies what is really meant is motor-sensory dependence. Carefully stated, the claim is that our knowledge of how our movements effect sensory stimulation allows us to experience the world as present and available for interaction.

> The detail shows up not as 'represented in my mind', but as available to me. It shows up as present – this is crucial – in that I understand, implicitly, practically, that by the merest movement of my eyes and head I can secure access to an element that now is obscured on the periphery of the visual field. It now shows up as present, but out of view, in so far as I understand that I am now related to it by familiar patterns of motor-sensory dependence. It is my basic understanding of the way my movements produce sensory change given my situation that makes it the case, now, even before I have moved an inch, that elements outside focus and attention can be perceptually present. (Noë [2009], p. 474)

The motoric component is not only primary in generating the transition from sensation to directly perceiving reality, it is necessary. "The obtaining of sensorimotor contingencies is necessary but not sufficient for perceptual consciousness" (2008, p.536-7). What fills out their further sufficiency is the implicit mastery of said contingencies. The implicit use of sensorimotor knowledge in olfactory perception is certainly within keeping of actionism, however, it will be argued that while sniffing is certainly sufficient for generating olfactory perception it is not necessary.

Moreover, actionism does not assert that the motor-sensory dependencies have a causal or determining relation in generating perception. Rather, Noë makes a stronger claim that perception is constituted by our knowledge and implicit deployment of motor-sensory contingencies. Logically this amounts to the conditional that if someone is undergoing a perceptual experience then they must have motor-sensory knowledge that is being masterfully deployed. Furthermore, the constitutive claim is equivalent to denying that one can have perception without motor-sensory dependence. Thus, what will be shown is that we can have olfactory perception in the absence of the motoric component of sniffing thereby yielding a contradiction between actionism's key claim and what is known about olfactory perception. To resolve the contradiction there are two possible conclusions; either the denial of perception being constituted by motor-sensory dependences, or that

olfactory experience is perceptual. The rest of this section will survey the literature on sniffing in favor of the first option, while section 6 will provide reasons to think that olfactory experiences should be considered perceptual.

5.2. The Motoric Component of Sniffing

Sniffing varies depending upon the concentration of the odorant plume, odorant intensity, and the presence or absence of an odorant. Nevertheless experiencing stimuli with olfactory qualities (i.e. what it smells like) does not require sniffing. The somatosensory experience of airflow and stimulating the olfactory epithelium are sufficient for the perception of smells, but sniffing and the motor component in particular are not necessary.

The necessity of airflow itself might be questioned based on a number of experiments whereby subjects had their nasal cavity flooded with an odorant-laced liquid to see if it elicited a sensation of olfactory quality. However, the reported results of these experiments vary from some claiming elicit olfactory experiences (Veress [1903]), to others who do not (Proetz [1941]; Weber [1847]) or do but with varying degrees (for a full discussion see Moncrieff [1946]). Furthermore, it might be questioned if these experiences might be attributed to olfactory perception, trigeminal stimulation, or somatosensory stimulation. To control for such issues Bocca (1965) delivered odorants to the olfactory epithelium by injecting them into blood circulation thereby delivering olfactory stimuli to the sensory transducers without sniffing or airflow. His results indicated that without active sniffing subjects do not report perceiving any olfactory qualities. So while odorant laced airflow might not be necessary, something about sniffing seems to be required.

One explanation of Bocca's results is that the delivery of odorants to the olfactory epithelium is not sufficient, as the mechanical stimulation of the epithelium is also required for producing the experience of smell. However, two other explanations are possible: the somatosensory experience of a medium flowing through the nostrils is required for the perception of smell; or, alternatively, the motoric action of sniffing and behaviorally modulating our nostrils is the necessary component in producing the smell experience.

Regarding the first option, in one of a series of experiments Sobel et al. (1998) demonstrated that subjects could perceive olfactory qualities even if the somatosensory experience of airflow was inhibited by topical anesthetic. Even in the absence of experiencing air flowing through our

nostrils, we nonetheless perceive olfactory qualities. However, this merely demonstrates the absence of the somatosensory stimulation does not affect our capacity to perceive olfactory qualities. To generate the contradiction with actionism it needs to be shown that perception occurs in the absence of the motoric component. To demonstrate this we must turn to the other set of experiments conducted by Sobel et al. (1998).

Aside from the aforementioned experiment using topical anesthetic, Sobel et al. (1998) conducted three experiments that fully clarify the role of the motoric component in sniffing. By fully occluding the nostrils, such that no air could flow through the nasal cavity when sniffing they showed that the motoric component alone does not generate the perception of smells. What is more interesting though is that by passively blowing air at the nostrils the somatosensory experience of airflow elicited activation in the relevant olfactory areas of the piriform cortex. Furthermore, even odorless air passively presented to the nostrils without sniffing elicits an experience of olfactory perception. To summarize, sniffing is not necessary for us to perceive smells and even when sniffing is used to gain access to the olfactory realm of stimuli the motoric component is inessential. Moreover, the somatosensory experience of airflow can be a sufficient condition of undergoing olfactory experiences – even passively.

> What would undercut it [the enactive approach] would be the existence of perception in the absence of bodily skills and sensorimotor knowledge which, on the enactive view, are constitutive of the ability to perceive. Could there be an entirely inactive, an inert perceiver? (Noë [2006], p. 9)

In answer to Noë's question, yes. In the case of olfactory experience we can have the perception of olfactory qualities completely passively. Thus, the central tenet of the theory that perception is constituted by the knowledge and mastery of motor-sensory dependences seems to be falsified when we consider active sniffing.

The experimental evidence demonstrates that the motoric component of sniffing is inessential for olfactory perception. Yet, the determinate role of the sensation of airflow in olfactory perception might provide some refuge for actionism. Being charitable it could be replied that the reason the airflow elicits the piriform activation is because usually our motor action of sniffing is what brings in and creates the airflow through the nostrils, thus we are implicitly deploying our knowledge of motor-sensory dependence.

Developmentally we slowly acquire mastery of this dependence, thus even in the absence of motoric action we deploy our implicit knowledge of how this sensation is generated in normal circumstances. In his earlier

work on enactivism, Noë emphasizes the importance of the developmental acquisition of sensorimotor knowledge. Yet, the developmental line of reply will not help in this instance, as the olfactory system is on-line and allows us to perceive the olfactory qualities of odorants as neonates if not *in utero* (Stein et al. [1958]; Steiner [1977]; Schmidt and Beauchamp [1988]; Schmidt [1992]).

Assuming by this point that the contradiction has been proven that we can have olfactory perception without the motoric component of motor-sensory dependence, Noë could retreat to the claim that olfaction is not a perceptual modality. But before we go down that road it might be wondered what role sniffing plays if, as is argued above, we can perceive smells without sniffing. Why do we sniff if not to perceive olfactory objects in the environment?

6. Perceiving Olfactory Objects – Perceptual Presence

The fourth tenet of actionism, which also serves as its *explanandum* is the phenomenal experience of perceptual presence. Though we do not receive sensory stimulation from the entirety of a three-dimensional object, we nonetheless perceive the object as a complete entity. According to actionism, the *explanans* of this phenomenon depends upon knowledge of perceptual object constancies. Our knowledge of motor-sensory dependencies facilitates filling in the sensory information, thereby generating the experiential percept of punctate entities external to us. Since Noë's theory is constructed to account for our phenomenological reports of consciously attended perceptual objects, the alternative conclusion provided by the previous section that olfaction is not perceptual might not seem so drastic.

We are not continually conscious of our olfactory experiences and rarely attend to them (Sela and Sobel [2010]). Furthermore, when we do attend to smells they seemingly appear within our nose in an almost unexpected manner (Peacocke [2008]). Moreover smells do not seem to present themselves to us as olfactory objects in the same manner as visual objects. Smells are not spatially or temporally punctate - they have vague boundaries that are difficult to individuate. Our experience of smells does not seem to present us with distal olfactory objects with a locatedness, rather we experience them as being somewhere in our surroundings (Batty [2010]).

6.1. Perceiving Olfactory Objects

As it is a chemosense what we olfactory perceive is the molecular structure of chemical compounds within odor plumes, thereby making our olfactory experiences of olfactory quality (i.e. what something smells like) a perception of mind independent of qualitative objects within the environment. However, the nature of smells relative to the external object of perception need not go any further about how we claim to experience odors *as* olfactory objects. The experience *as* is the operative issue, since the matter at hand is how we conceive of the object of olfactory perception when we consciously attend to olfactory experiences.

Most can attest to their ability to recognize and identify the smell of freshly brewed coffee. Furthermore, we can identify this reoccurring smell against the background of other breakfast odors, such as the doughy smell of pancakes or the intoxicating smell of sizzling bacon. We do not smell a smudge, rather our experience presents us with a multitude of olfactory objects within an olfactory array, such that one might be so inclined to think these odors compose scenes (i.e. smellscapes).

Our olfactory experience of breakfast attests to our psychological ability to track the objects of olfactory experience through their temporal changes in features, as well as their combination and mixture with other olfactory objects. When attention is paid to this aspect of our olfactory experience it becomes apparent that these are objective experiences of mereologically complex entities. Considered in this light the objective status of the entities experienced using olfaction is supported by ecological theories of olfactory perception (Wilson and Stevenson [2006]; Gottfried [2010]). The methodological assumption of these theories is that the olfactory object is identified with the complex set of molecular compounds that we psychologically group together in tracking, locating, and securing objects that are of value to us in maintaining our homeostatic needs.

Wilson and Stevenson (2006) develop the most exhaustive scientific account of the object of olfactory perception in keeping with the criterion of a perceptual object as a mereologically-structured entity. To explain our psychological ability to parse the chemical sea in which we are immersed into temporally persisting recognizable objects, they provide a host of evidence that olfactory object perception partially depends upon synthetic processing. Their ecological theory supports the claim that we experience olfactory objects in a mereologically complex fashion, thereby establishing that olfactory experience and perception are object directed.

Additionally, our experience of odors satisfies the criterion of figure-ground segregation, which is instrumental in ascertaining the objective nature of perceptual entities that do not fulfill the rigid requirements of

spatial locatedness. Empirical evidence for olfactory figure-ground segregation may be garnered from the overshadowing effect in odor mixture qualities. When combining odorants in a mixture, if the constituents smell similar on their own it is often difficult to recognize these constituents within the mixture; conversely, if they smell dissimilar on their own it is often quite easy to distinguish them within a mixture. However, in every variation of similar and dissimilar pairings of odorants there is "evidence of overshadowing of one component by another, depending upon the concentration level" (Kay et al. [2005], p. 727). Furthermore, if the concentration level of the overshadowed item is increased it is possible to switch the overshadowing effect. Indeed, whether one smells an odor *a* against a background of odor *b* (or vice-versa) can be manipulated by altering the concentration levels of the components of the mixture.

6.2. The Role of Sniffing in Olfactory Object Perception

Given that we do perceive smells as perceptual olfactory objects external to us and that we can have the experience of a smell independent of sniffing, why do we sniff? It is arguably the case that what determines the experience of olfactory quality is our perception of the molecular structure of chemical compounds within odor plumes. Such that the qualitative character of the olfactory experience is generated by the molecular structure of the chemical compound coming into contact and being transduced at the olfactory epithelium. However, a sufficient concentration level of odorants is required both for the experience of the olfactory quality and our capacity to perceive the smell as an objective entity external to us. What this suggests is that the olfactory plume plays a role in our ability to perceive smells as olfactory objects. So why then do we sniff?

Sniffing facilitates the actively exploration of a chemical smellscape in a manner that enables tracking the concentration and intensity of odors across a landscape. Sniffing enables the encoding of the intensity and concentration of an odorant (Sobel et al [1998]; Mainland and Sobel [2006]), thus it might help determine the spatiotemporal nature of olfactory objects. Odor plumes contain gradients of odorant concentration, yet we can recognize smells through changes in their intensity.

Shifts in concentration levels of an odorant generate variation in olfactory qualities. So how is it that we are able to have the perception of object constancies, such as our ability to recognize the smell of coffee across multiple exposures of varying concentrations? Recent experimental

research has shown that naïve mice treat odor plumes of varying concentration and ratios of the same kinds of chemical components as being of different qualities (Cleland et al. [2012]). Future developmental research on naïve humans is required to corroborate that odor plumes composed of the same chemical compounds at varying concentration levels are perceived as having different qualities. But, assuming this effect is not species specific, these results indicate that some properties of the odor plume partially determine olfactory quality.

Our ability to recognize an odor as having the same smell across presentations of varying concentrations is an acquired capacity determined by concentration invariance, which depends upon learnt odor categorization. Concentration invariance extends beyond the perceptible properties presented by the external object of olfactory perception including its property of olfactory quality. Further research needs to be done on Humans' olfactory perceptual constancy of concentration invariance. Speculatively, it is determined in accordance with the ratio of the chemical compounds within a given odor mixture, since the compositional ratio of components should stay constant despite a shift in concentration levels (Uchida et al. [2007]). Acquiring the capacity of concentration invariance depends upon multiple exposures to the same chemical compounds across varying concentrations, which is in keeping with the suggestion that active sniffing facilitates tracking the variations in concentration and intensity across exposures thereby enabling perceived object constancies of distal odor stimuli.

Doubtlessly our ability to parse the chemical sea of smells on a daily basis requires sampling across time and movement, as well as acquired knowledge of concentration invariance based on the ratios of constituents composing an odor. However, our perception of mereologically complex smells across time need not depend upon our knowledge (implicit or otherwise) of olfactory motor-sensory contingencies, as it might depend upon tracking the somatosensory experience of airflow through the nostrils.

We can parse our chemical environment into individual odors within an unfolding smellscape, which speaks to olfaction being a perceptual modality. If sniffing produces our capacity to demarcate the boundaries of smells thereby individuating and identifying them, then sniffing is required for olfactory object perception and not mere sensations of olfactory quality. Having established that olfactory experiences are perceptual, we can now turn to testing the fourth tenet of actionism, that we perceive objects as complete within an external environment.

6.3. Locating Smells and Individuation of the Olfactory Modality

We locate smells using differences in concentration, however, this requires active exploration either through movement of the entire body or at the very least our head (Richardson [2011]). The difference between the odorant properties presented to each nostril enables our ability to track an olfactory stimulus through an environment over time (Porter et al. [2007]). However, if we consider our olfactory experiences as individuated just in terms of olfactory stimulation as transduced only at the olfactory epithelium then smells are not localizable at a given time.

Despite evidence that each nostril creates a different olfactory percept as demonstrated by binaural rivalry between the nostrils (Zhou and Chen [2009]), it has been shown that we cannot tell at a given instant if an odorant is present in the left or right nostril (Radil and Wysocki [1998]; Frasnelli et al. [2008]). Moreover, actively sniffing a pure olfactory odorant (i.e. a stimulus that does not stimulate the trigeminal nerve endings within the nose) does not allow us to localize the odorant (Frasnelli et al. [2009]). Olfactory perception can, across time (diachronically), have spatial structure, yet at any particular time (synchronically), olfactory experience has no spatial structure even when active sniffing is taken into account.

Instances of perception that present us synchronically with a localizable smell or an olfactory object with a distal location are mediated by trigeminal stimulation within the nostrils. Trigeminal stimulation allows subjects to distinguish the onsets of stimulation between nostrils (Kleeman et al. [2009]), as well as to localize odorants within 7-10 degrees of their location (von Bekesy [1964]). Furthermore, if an odorant contains chemicals that elicit trigeminal activation then active sniffing further enables us to localize the distal extent of the olfactory object (Franselli et al. [2009]), thus leaving us with a conundrum that might help clarify actionism, as well as an issue concerning how to individuate the senses. Olfactory quality (what something smells like) is determined based on transduction of odorants at the olfactory epithelium independent of trigeminal stimulation. Trigeminal stimulation allows us to localize gaseous clouds that constitute odors, but it does not generate the perception of olfactory qualities independent of stimulation of the olfactory epithelium, thus creating a dilemma for actionism regarding how to individuate the olfactory modality.

The first option is to individuate olfaction as a perceptual modality including trigeminal stimulation. Considering olfaction as everything going on inside the nostrils gives us instances of perceived olfactory

objects with spatiotemporal properties within our surroundings. Furthermore, this allows for an active role of sniffing in olfactory perception of odor objects as being locatable and perceptually present to us. However, this option then falsifies actionism because the motoric component is neither necessary nor constitutive of olfactory perception. Moreover, the somatosensory component is necessary for our olfactory perception in a manner that allows for inert olfactory perception.

The second option is to individuate olfaction based on olfactory qualities, such that the only time we should say we perceive olfactorily is when we are presented with the experience of a smell. Excluding the other sensations from within the nostrils from the olfactory modality provides a retreat for actionism. It could be replied on their behalf that the experience of smelling without active sniffing do not yield synchronically perceived olfactory objects within the environment. Therefore, given the fourth tenet of actionism we can never make the transition from mere sensations to perceptions.

Olfactory experience considered synchronically might allow for the alternative conclusion in section 5 that the olfactory sensory modality never rises to the level of being perceptual. Yet, we can fill in the spatial aspects of an olfactory object even under this construal of the olfactory modality using diachronic active exploration making the restriction of its fourth tenet to synchronic perception the only bastion of hope for actionism.

A possible and overly charitable reply on their behalf could be that when considering our ability to perceive objects using perceptual constancies one of the necessary components is the felt presence of the object as having a locatedness in three dimensional space relative to us. Perceived locatedness is a stronger requirement whereby at a given instant we perceive the object as being at a given place within a spatial array. Immediately upon opening our eyes we are seemingly presented with a spatial array of visual objects located before us. Phenomenologically this experience is unmediated by our movement in a way that highlights what might be the key difference between olfaction and visual. Vision presents us with object locatedness at an instance, but olfaction does not, thus synchronic olfactory experiences are not object directed and perceptual in the proper sense specified by the theory. Our perceptual experience considered from a fully conscious introspectively reportable state seems to bear out this claimed difference, and provides a possible retreat, but there are two possible replies. The first questions the veracity of claimed lack of movement in the visual experience, and the second relies on a thought

experiment to account for the difference in size between perceptible punctate visual objects and diffused gaseous olfactory objects.

6.4. Diachronic Olfactory Perception

The assumption that olfaction automatically presents us, synchronically, with spatially located objects can be challenged on the grounds that similar diachronic processes occur in vision. To see things, one's eyes must be in constant motion either through volitional control or through saccadic and micro-saccadic movements. If one's eyes were to stop moving the visual field would shrink and eventually turn a uniform grey.[1] Saccadic eye movement presents a *prima facie* analogy to the role of active diachronic exploration through movement or sniffing in olfaction. If saccadic eye movement is not excluded either as a part of the perceptual experience or as an enabling condition of the visual percept, then there seems to be no reason to exclude exploratory olfactory movements.

Anticipating this reply, it could be argued that olfactory active exploration is not equivalent to saccadic eye movements. While the latter is not under volitional control, the former is always required when locating and moving towards a smell. However, some forms of saccadic eye movement required for visual perception are under our control in an analogous way. Thus, a more charitably interpretation of actionism is that it concerns the phenomenal awareness of movement such that one is not usually aware of saccadic eye movements, but always aware of movements used in attempting to locate a smell; raising the question of how our phenomenological awareness presents smell's temporal aspect in a manner unlike the spatiotemporal bound entities of vision.

Given the motivation of actionism as a departure from employing vision as our theoretical launchpad there would be a perverse irony in holding olfaction accountable to the phenomenology of visually presented objects. Undoubtedly there are phenomenological differences between the perceptual modalities, but further argumentation is needed before we can adjudicate the dominance of perceptual objecthood criteria between the modalities. As such I ask the reader to consider the following thought experiment using olfaction as our starting point.

[1] For an at home demonstration of this phenomena simply immobilize your eyeballs by holding them firmly against the side of the eye socket.

6.5. Perspectival Shrinkage

Assuming that the olfactory object of perception is chemical structures within gaseous odor plumes, then these are large diffuse entities that cannot be fully perceived in a single olfactory scene. Demarcating the edges of an odor requires either multiple samples of the stimulus to determine its concentration gradient or movement relative to the edges of the object. Now consider visual objects: these are experienced as three-dimensional punctate entities presented to use with a determinable location. But what if we were to shrink down to the size that we could move within these visual objects. Presumably we could still perceive them visually – they would still have refractory properties that our visual system is sensitive to. But in order to perceive their surfaces and edges we would need to move about.

In this situation my intuition is that we would still see visual objects, but that they would be without their phenomenological locatedness synchronically perceived. Holding the proper sensible constant, while shifting our perceptual perspective through shrinkage allows one of two possibilities: we conclude that vision is not perceptual in this scenario; or vision is still perceptual, but with further diachronic exploratory movements built in to allow for objectual perception.

Unsurprisingly, it is my contention that actionism must allow for diachronic exploration as part of the perceptual process, thus even on the second manner of individuating the olfactory modality we can perceive objects. Though this yields an unpleasant conclusion for the theory, it is in keeping with its overarching claim that perception is generated by both our knowledge of sensorimotor contingencies and our deployment of them. The down side of this conclusion for actionism is that even without sniffing and trigeminal stimulation we could undergo olfactory perception by tracking the somatosensory component of airflow through the nostrils independent of the motoric component of movement. Nevertheless it could be replied that even in these instances some manner of implicit knowledge is being deployed based on past movements, which calls for future experimental studies that argue olfaction is best suited for in isolating the motoric and sensory components necessary for our perception of smells.

7. Conclusion

Sniffing plays an important role in our experience of smells, but it does not substantiate actionism's claims regarding the necessity of our knowledge and implicit masterful deployment of motor-sensory dependencies. While

the theory is fitting given its foundations as a theory of direct perception, as well as the claim that our experience of smell is implicitly generated by our use of actively sampling and modulating our sniffing behavior, the further claim that motor-sensory dependencies constitute the transition from sensation to perception is not supported by the experimental literature surveyed. By clarifying the exact nature of actionism's claim regarding sensorimotor contingencies it was noted that the motoric component was the decisive factory in determining perception, and that sniffing served as a fitting test case since the motoric and somatosensory components could be isolated.

Not only can we have olfactory perception passively, but even when sniffing is employed in generating an olfactory percept the motoric component is inessential. Perhaps the motor stimulation is sometimes causally required, but the stronger constitutive claim is in no way substantiated. To handle the possible conclusion that olfaction is not perceptual, it was further shown that our olfactory experience is of olfactory objects in the environment in a manner that satisfies even the fourth tenant of actionism. We perceive olfactory objects in the environment in a manner that allows us to recognize and track them through spatiotemporal changes, as well as shifts in concentration and intensity. Olfaction is not only an applicable test case, but also a good fit for testing the key tenets of actionism. Nonetheless it seems as if this form of enactivism has taken its last breath, yet smelling endures.

References

Arzi, A., Shedlesky, L., Secundo, L. & Sobel, N. (2014), Mirror sniffing: humans mimic olfactory sampling behavior. Chemical senses 39 (4): pp. 277-281.

Batty, C. E. (2010), What the nose doesn't know, J. Conscious, Stud. 17, pp. 10–17.

Bensafi, M., Rouby, C., Farget, V., Bertrand, B., Vigouroux, M. & Holley, A. (2002), Autonomic nervous system responses to odours: the role of pleasantness and arousal, Chem. Senses 27, pp. 703–709. DOI: 10.1093/chemse/27.8.703.

Bensafi, M., Rouby, C., Farget, V., Bertrand, B., Vigouroux, M. & Holley, A. (2003), Perceptual, affective, and cognitive judgements of odors, Brain Cogn. 31, pp. 270–275. DOI: 10.1016/S0278-2626(03)00019-8.

Bocca, E., Antonelli, A. R. & Mosciaro, O. (1965), Mechanical co-factors in olfactory stimulation, Acta Oto-laryngol., 59, pp. 243–247.

Cleland, TA, Chen, ST, Hozer, KW, Ukatu, HN, Wong, K. J. & Zheng, F. (2012), Sequential mechanisms underlying concentration invariance in biological olfaction. Front. Neuroeng. **4**:21. DOI: 10.3389/fneng.2011.00021.

Galef, B. B. (2013), Animal Communication: Sniffing Is About More Than Just Smell, Current Biology, Volume 23, Issue 7, 8 April 2013, Pages R272-R273.

Gottfried, J. A. (2010), Central mechanisms of odour object perception, Nature Reviews Neuroscience 11, pp. 628–641.

Gray, R. & Tanesini, A. (2010), Perception and Action: the taste test, Philosophical Quarterly, 60:241, pp. 718–73.

Frasnelli, J., Charbonneau, G., Collignon, O. & Lepore, F. (2008), Odor localization and sniffing, Chem. Senses 34, pp. 139–144. DOI: 10.1093/chemse/bjn068.

Kay, L. M., Crk, T. & Thorngate, J. (2005), A Redefinition of Odor Mixture Quality, Behavioral Neuroscience, 119(3): pp. 726-733.

Kleemann, A. M., Albrecht, J., Schöpf, V., Haegler, K., Kopietz, R., Hempel, J. M., et al. (2009), Trigeminal perception is necessary to localize odors, Physiol. Behav. 97, pp. 401–405. DOI: 10.1016/j.physbeh.2009. 03.013.

Mainland, J.D. & Sobel, N. (2006), The sniff is part of the olfactory percept. Chemical Senses 31 (2): pp. 181-196.

Moncrieff, R. (1946), The Chemical Senses, New York: John Wiley & Sons.

Noë, A. (2001), Experience and the active mind, Synthese 29, pp. 41-60.
Noë, A. (2001b), Experience and experiment in art, Journal of Consciousness Studies, 7.

—. (2002), On what we see, Pacific Philosophical Quarterly, 83: 1: pp. 57-80.

—. (2004), *Action in Perception*, Cambridge, MA: MIT Press.

—. (2005), Real presence. Philosophical Topics, 33(1), pp. 235–264.

—. (2006), Précis of action in perception**,** Psyche, 12:1.

—. (2007), Understanding Action in Perception: Replies to Hickerson and Keijzer, Philosophical Psychology, 20:4, pp. 531-538.

—. (2009), Conscious Reference, Philosophical Quarterly, 59:236, pp. 470-482.

O'Regan, J.K. (1992), Solving the "real" mysteries of visual perception: the world as "outside memory", Canadian Journal of Philosophy 46, no. 3: pp. 461-488.

O'Regan, J.K. & Noë A. (2001a), A sensorimotor approach to vision and visual consciousness, Behavioral and Brain Sciences 24, 5: XXX.

O'Regan, J. K. & Noë A. (2002), What it is like to see: a sensorimotor theory of perceptual experience, Synthese: 29: pp. 79-103.

Olofsson, J. K. (2014), Time to smell: a cascade model of human olfactory perception based on response-time (RT) measurement, Front. Psychol., 5:33. doi: 10.3389/fpsyg.2014.00033.

Lycan, W. G. (2006), Enactive Intentionality, Psyche, 12:3.

Peacocke, C. (2008), Sensational properties: theses to accept and theses to reject, Rev. Int. Philos. 62, pp.7–24.

Porter, J., Craven, B., Khan, R. M., Chang, S. J., Kang, I., Judkewitz, B., et al. (2007), Mechanisms of scent-tracking in humans, Nat. Neurosci, 10, pp. 27–29. DOI: 10.1038/nn1819.

Prinz, J. (2006), Putting the brakes on enactive perception, Psyche, 12:3.

Proetz, A.W. (1941), *Applied Physiology of the Nose*, St Louis, MO: Annals Publishing Co.

Radil, T. & Wysocki, C. J. (1998), Spatiotemporal masking in pure olfaction, Ann. N. Y. Acad. Sci. 855, pp. 641–644. DOI: 10.1111/j.1749-6632.1998.tb 10638.x.

Richardson, L. (2011), Sniffing and smelling, Phil. Stud. 162, pp. 401–419. DOI: 10.1007/s11098-011-9774-6.

Sela, L. & Sobel, N. (2010), Human olfaction: a constant state of change-blindness, Experimental Brain Research 205(1): pp. 13-29.

Sobel, N., Prabhakaran, V., Desmond, J. E., Glover, G. H., Sullivan, E. V., Goode, R.L. & Gabrieli, J. D. E. (1998), Sniffing and smelling: separate subsystems in the human olfactory cortex. Nature 392 (6673): pp. 282-286.

Sobel, N., Khan, R. M., Sullivan, E. V. & Gabrieli, J. D. E. (2000), The world smells different to each nostril. Nature 402 (6757): 35.

Schmidt, H. J. (1992), Olfactory hedonics in infants and young children, in Fragrance: The Psychology and Biology of Perfume, eds. S. Van Toller and G. H. Dodd, London: Elsevier, pp. 195–219.

Schmidt H. J. & Beauchamp G. K. (1988), Adult-like odor preferences and aversion in three-year-old children. Child Dev. 59, pp. 1136–1143. DOI: 10.2307/1130280.

Stein, M., Ottenberg, P. & Roulet, N. (1958), A study of the development of olfactory preferences, AMA Arch. Neurol. Psychiatry 80, pp. 264–266. DOI: 10.1001/archneurpsyc.1958.02340080134028.

Steiner, J. E. (1977), Facial expressions of the neonate infant indicating the hedonics of food-related stimuli, in Taste and Development. The Genesis of Sweet Preference, ed. J. M. Weiffenbach (Bethesda, MD: NIH-DHEW), pp. 173–188.

Uchida N. & Mainen Z. F. (2007), Odor concentration invariance by chemical ratio coding, Front. Syst. Neurosci. 1:3. DOI: 10.3389/neuro.06.003.2007.

Veress, E. (1903), The irritation of the olfactory organs through the direct impact of odorous liquids, Pflugers Arch Gesamte Physiol Menschen Tiere, 95, pp. 365–408.

von Bekesy, G. (1964), Olfactory analogue to directional hearing, J. Appl. Physiol. 19, pp. 369–373.

Weber, E. H. (1847), Ueber den Einfluss der Erwärmung und Erkältung der Nerven auf ihr Leistungsvermögen, Arch. Anat. Physiol wiss Med Berlin, pp. 342–356.

Wesson, D. W. (2013), Sniffing behavior communicates social hierarchy, Curr. Biol., 23 (2013), pp. 575–580.

Wilson, D. A. & Stevenson, R. J. (2006), *Learning to Smell*, Baltimore, MD: The Johns Hopkins University Press.

Young, B. D. (2011), *Olfaction: Smelling the Content of Consciousness*, Doctoral Dissertation, City University of New York, The Graduate Center.

Zhou, W. & Chen, D. (2009), Binaural rivalry between the nostrils and in the cortex, Curr. Biol. 19, pp. 1561–1565. doi: 10.1016/j.cub.2009.07.052.