Olfaction:
Smelling the Content of Consciousness.

by

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Abstract:

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Scientific research on the sense of smell has blossomed over the past two decades, yet a comprehensive philosophical treatment of olfaction is nonexistent. My dissertation remedies this neglect by showing how the anatomical structure, functional circuitry, and sensory states of the olfactory system, call into question the reigning theories of cognition and consciousness. Specifically, olfaction provides new insight about the nature of object perception, the structure of our thoughts, consciousness, and the qualitative character of our experiences.

The object of our olfactory experience and what constitutes its olfactory quality, is the chemical structure of molecular compounds, which are unlike those of the other perceptual modalities. Additionally, the content of olfactory experience is represented in a format that is unlike the system of representations posited by Language of Thought Theorists, thus creating a new game in-town. The olfactory system's implementation of a functionally compositional system of representations allows for a new treatment of nonconceptual content as an issue of the representational format that a system employs. Formative nonconceptual content resuscitates the 'Richness of Experience' argument by showing that our experiential content outruns our conceptual repertoire, since the syntax of these states is not fully compatible. Furthermore, the unique anatomical structure and functional organization of the olfactory system helps clarify, and at times falsifies, the putative necessary conditions of consciousness posited by the leading neurobiological theories of consciousness.

The dissertation concludes by offering an alternative approach to explaining phenomenal consciousness, which builds upon the findings that the olfactory object is the chemical structure of molecular compounds, that olfactory experiences are partially nonconceptual, and the failure of contemporary neurobiological theories of consciousness. My theory is that olfactory phenomenal consciousness arises from sensory states, that these are necessary for awareness, and that our olfactory consciousness occurs in a nonconceptual format.

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"Every man takes the limits of his own field of vision for the limits of the world."

—Arthur Schopenhauer (1891, p. 69)

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Chapter 1

Introducing Olfaction

1.1 Why olfaction is important

What does your home smell like? Do you know? Have you ever even thought about sniffing your home? Though you might not be aware of this (perhaps only when it stinks), your home just like everything else has a smell. Moreover it is not a gross exaggeration to say that every biological organism smells. Olfaction, the sense of smell, is by far the most fundamental and elementary perceptual modality employed by creatures for navigating their environment. Smells envelope us continually, pervade every aspect of our lives, and guide our behavior in ways that we are not conscious of. However, it is shocking how little we are aware of our use of smell and its impact upon our daily life. Until recently we knew very little about our sense of smell and the olfactory system. Thus, its neglect by the philosophical community is understandable, but a tremendous mistake. Olfaction's basic nature provides a fecund body of research with interesting consequences for the traditional study of the human mind.

Scientific research on the sense of smell has blossomed over the past two decades, yet a comprehensive philosophical treatment of olfaction is nonexistent. My dissertation remedies this neglect by showing how the anatomical structure, functional circuitry, and sensory states of the olfactory system, call into question the reigning theories of cognition and consciousness. Olfaction provides new insights into the nature of object perception, the structure of our thoughts, consciousness, and the qualitative character of our experiences.

The anatomical structure, functional organization, and sensory states of the olfactory system provide a profoundly different starting point for theorizing about mental content and consciousness. Traditionally, the construction of neural models and philosophical theories of cognition and consciousness has derived from ?<a priori>? conceptual theorizing using our linguistic abilities, or from empirical evidence gleaned from studies of the visual system. Aside from rectifying philosophy's neglect of olfaction, it is important to generate an overarching theory of olfaction for two reasons. First, olfaction provides an external perspective from which to clarify the keys posits and assumptions of the current theories of mental content and consciousness. Second, olfaction's unique nature provides reason to doubt the traditional views of mental content and consciousness that arise from using the visual system and our linguistic capacities as a theoretical starting point. For instance, the differences between language and olfaction provide a new treatment of the structure of mental content and nonconceptual content based upon the functionally compositional mechanism of stimuli transduction and processing in the olfactory system. Furthermore, since thalamic relays or corticothalamic loops are not required for olfactory consciousness, the very existence of the anatomical differences of the olfactory system provides reason to doubt the current neurobiological theories of consciousness that are predicated on the visual systems thalamic relays. Lastly, the nature of both the olfactory object and our olfactory sensory states facilitate a novel way of thinking about the nature of perceptual objects as having an inherently qualitative character.

Our sense of smell is special, because of the olfactory system's unique anatomy, circuitry, and stimuli transduction. Anatomically, the olfactory system does not require an intervening relay in the thalamus. Information from the olfactory bulb projects directly to the cortex. Functionally, the lack of a thalamic connection makes the olfactory system's circuitry different from vision and audition's hierarchical structure.

While theorists as far back as Plato and Aristotle discussed olfaction, little has been learnt about our sense of smell over the past few thousand years and interest in this modality has been sparse. An explanation as to why olfaction has been so neglected, besides the general predisposition to study vision and language, may be its preconceptual linkage to taste (which is by far the most impoverished sensory modality). After all, Aristotle, who posited four different dimensions of taste, easily described the typology of basic tastes and though he got these wrong, his basic tastes approximate the current list of sweet, sour, bitter, and salty, with the exception of the recent addition of umami. Folk psychologically we might neglect olfaction based on our conflating the chemosenses, taste and smell, as they both perform the role of detecting chemical stimuli. Though conflated by folk psychology, these senses are served by different sensory modalities and neural systems. The vast majority of what we commonly think of as the flavor of food is actually its smell. While chewing food, air from the back of the throat is sent up into the nostrils and comes into contact with the olfactory epithelium. We correlate and falsely attribute this sensation to taste, when most of our gustatory experience should rightly be attributed to smell.

While the basic typology of taste has been easy to determine, little headway has been made with a typology of our sensation of smell. As recently as the 1960s it was thought that giving a typology of the basic sensations of smell and the transduction of sensory stimuli for the olfactory system was impossible. Traditional attempts to come up with a typology of smell were based on anosmia.[1] The working methodological assumption was that olfactory deficits in identifying odorants by anosmias would be a good basis for inferring what the most basic smells are. However, this methodology generated far too many basic odorants with no means of validating them independently of the disorders. Moreover, these typologies did not generate any confirmable predictions regarding the combinatorial nature of smells.[2]

The inability to come up with a typology of our sensation of smell has only recently shown promise based on the work of Buck & Axel (1991) for which they received the Nobel Prize in 2004. Using genetic sequencing they were able to identify basic smells by studying genetic protein synthesis. According to their

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[1] Anosmia is the condition of being unable to detect odors and might be caused by trauma, infection, or in some rare instances by psychopathologies.

[2] For a good introduction to the history of olfactory typology of the primary smells, Wilson & Stevenson (2006) provide a good scientific introduction, while Gilbert (2008) provides a nice introduction for those less comfortable with scientific terminology.

research mice have approximately 1,000 separate genes for encoding smells that allow for the discrimination of up to 10,000 separate basic odors. (For humans the number is estimated at roughly 600, which amounts to 3% of the entire human genome.) However, this number of basic odors is a historical misnomer due to vague estimates from the beginning of the last century, which have never been scientifically substantiated.[3] Currently, without any clear indication of the primary smells in olfaction, the nature of the olfactory object, and its combinatorial system of encoding stimuli, the actual number of basic odors could theoretically be unbounded. Furthermore, even if the estimate of 10,000 basic odors turns out to be accurate, the combinatorial structure of the olfactory system permits nearly an unbounded number of odor discriminations based on how basic odorants form complex smells.[4]

It is hard to provide an introduction to a sensory system that pervades our lives so much, when so little is known about it. Currently the field of olfactory studies is blossoming with new research continually changing the way we think about smell. Introducing olfaction is a tedious task, as so little is still known about this modality and new findings are constantly being generated. Nonetheless what is known about smell has a tremendous amount to teach us about our conscious experiences and the contents of our mind.

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[3] For a good discussion of the background to this figure consult Chapter 1, Gilbert (2008).
[4] See Chapter 3, Section 2.2 for a more detailed discussion of these claims.

1.2 Olfaction's foundational phylogenetic and ontogenetic status

A comprehensive philosophical treatment of our sense of smell is important because the olfactory system is phylogenetically and ontogenetically more basic than either vision or language. Ontogenetically the olfactory system is employed even by fetuses and influences such important aspects of daily life as the identification of kin, food preferences, social selection, and our choice of mates. Phylogenetically, olfaction predates all other modalities, thereby allowing both the validity and ease of extrapolation from animal models of olfaction to a human model. Since the olfactory system develops before our visual or linguistic abilities and predates them, its study provides a rich access point for studying our minds, while placing us on a continuum with other biological organisms.

Ontogenetically, olfaction develops well before the visual and auditory systems allowing conclusions to be drawn about the content and consciousness of human minds well before the other perceptual systems. The olfactory system is fully functional during gestation, which is not the case for audition or vision. Though newborns can orient themselves to sounds from birth and show a preference for their parent's voice, it takes between one and two weeks for the auditory system to develop (or at the very least for the fluid within the cochlea to dissipate), which is necessary for them to encode sounds. Indeed, the length of time that it takes the visual system to fully mature is quite well documented. A tremendous amount of research has been done on young children's ability for feature recognition showing how they begin by focusing upon broad features or distinctive characteristics with high contrasts.

Infants do not immediately recognize their parents or caregivers by sight or sound, but they do identify themusing olfaction from birth onwards. Anosomic rats do not survive, since the sense of smell is necessary for infants to identify their own mother and orient to her nipples. Young infants (mere minutes old) are able to recognize their mothers lactating nipples via the sense of smell and show preferential head movements in an attempt to orient themselves (Porter & Winberg, 1999).

Olfaction is a basic sense that shapes how we perceive and interact with our environment even from before birth. The sense of smell *in utero* is responsible for our future food choices: what one's mother ingests while pregnant has significant impact upon the tastes and smells of the objects that one is willing to consume for the rest of one's life. Olfaction is responsible for our food preferences (Rozin et al., 1986), allows us to recognize if food is fit for ingestion (Fallon & Rozin, 1983), and determines which new foods we are willing to try in adulthood based on flavor principles and ethnic culinary styles that are learnt in childhood (Rozin, 1978; Rozin et al., 1992).

Furthermore, olfaction is an important factor in our ability to determine kin relationship. Infants show a preference for their mother's breast pad, which can only be determined by smell (Russell, 1976). Mothers have the capacity to discriminate between the smell of their infant and the odor of other children

(Porter, Cernoch, & McLaughlin, 1983). Aside from infant mother kin detection, nuclear family members can also recognize the smell of their kin (Porter et al., 1986).

Phylogenetically, olfaction predates all other modalities. Olfaction's basic nature at times causes interesting conundrums. In humans the olfactory bulb projects directly to the cortex bypassing the thalamus, thus making it the only modality that necessarily requires the cortex for conscious awareness of stimuli. Yet, olfaction is the most basic form of sensing the environment having evolved in most species well before the rise of the cortex.

A further implication of olfaction's ontogenetic and phylogenetic primitive nature is its validity in deriving conclusions about human behavior or psychology from animal models. Mammalian olfaction is highly conserved (Ache & Young, 2005), such that similar structures and functional processing occur across species. Moreover the human olfactory system is not very different from that of goats and guinea pigs (Sela & Sobel, 2010). But, the place of olfaction in human behavior is largely diminished in comparison to most mammals (Stevenson, 2009). Humans mistakenly downplay and distrust their olfactory acuity. We might not be as gifted olfactory perceivers as bloodhounds or rats, but our olfactory capacities are excellent.

Animal models of human behavior and cognition are an important research tool in biology and psychology. Olfaction is shared across species from basic bugs to very robust systems found in mammals, thereby providing a tremendous body of research that can be validly used to make inferences from studies on other creatures about our olfactory states. The sheer amount of data that could be gathered for these purposes dwarfs that of audition or vision. The similar structure and functional organization of the olfactory system across species allows all sorts of inferences about how humans might encode scents.

Olfaction is responsible for our ability to navigate our environment, fulfilling our biological needs, and shaping social interactions. Aside from facilitating the selection of food, smell is responsible for ascertaining whether something is fit for consumption. Additionally, olfaction guides our choice of mates, our ability to identify our family, and our ascertaining parentage of ones offspring. Lastly, smell is responsible for our selection of social circles.[5] Whether due to bodily odors, diet, or general environmental odorants embedded in their clothes, we do not like people who smell different than us. Whether we are aware of it or not our sense of smell shapes major aspects of our lives: how we maintain homeostasis, our selection of mates, and even the company we keep.

1.3 Introducing the olfactory system

Olfaction is different from the other perceptual modalities in ways that have serious import for the study of cognition and consciousness. As an introduction to the olfactory system's unique architecture and stimulus processing, this section proceeds by discussing the olfactory system's anatomy

[5] For further details, see Chapter 5, Section 3.3 on the effects olfaction has on social acquaintance selection.

and its functional organization. What is offered is a cursory introduction to the olfactory system that should enable those without a background in the chemosciences to not get lost in the major discussions of anatomical structures and computational processing discussed throughout this dissertation.

The focus of the dissertation is merely that of the olfactory system. I will not discuss the other chemosenses; taste, the flavor system, or the other chemosensory subsystems within the nose, such as the Vomeronasal system (Halpern, 1987; Meredith, 1991; Keverne, 1999; Dulac, 2000), which is implicated in pheromone encoding in nonhumans, or the Trigeminal system (Doty, 1995; Hummel, 2000; Hummel & Livermore, 2002) that is responsible for the sensation of irritation and pain responses associated with olfactory stimuli. Aside from issues of scope, I have not considered these last two mammalian chemosensory systems because their existence and utilization by humans is unclear (Meredith, 2001; Witt & Hummel, 2006; Sela & Sobel, 2010).

Before introducing the olfactory system it is worth noting the range of molecules that the human olfactory system can be sensitive to. We can detect the smell of any volatile molecular species (molecular weight <294 daltons) with surface activity, low polarity, water solubility, high vapor pressure, and high lipophilicity (Ohloff, 1986). However, in order for an odorant to be smelled, it must first reach the olfactory epithelium by traversing the nasal passage and the Mucosa layer within our nostrils.

Odorants reach the olfactory epithelium and olfactory receptor neurons orthonasally or retronasally. Orthonasally (from the front of the nose via the nostrils) the odorant reaches the epithelium either through diffusion from high levels of concentration to lower levels or through actively sniffing the odorant. Alternatively, an odorant might arrive from the back of the throat via retronasal olfaction (Hornung & Enns, 1986). The retronasal system is highly involved in flavor and gustation and has its own functional organization, as well as rules of odorant transduction. While retronasal olfaction is fascinating, the dissertation is primarily focused on orthonasal olfaction.

1.3.1 The Nostrils – Shape and Number Matter

Ascending through the anatomy of the olfactory system, an odor enters the nose through the nostrils or via the back of the throat and becomes encased in the mucus surrounding the olfactory epithelium. It would be easy to skip ahead to the nature of receptor cells and transduction processes within the primary sensory area of the olfactory epithelium, yet this would grossly overlook the importance of the nostrils and muscosa layer. Both the shape and number of the nostrils is important. Having two nostrils allows us to determine the location of a smell in a similar fashion to sounds in auditions using two ears. There are small differences in time and intensity between a sound arriving at one ear versus the other, as well as between a smell arriving at one nostril versus the other (von Bekesy, 1964). Additionally, the shape of the nostrils is of importance because they are asymmetrical in airflow, which switches every couple of hours (Bojsen-Moller & Fahrenkrug, 1971), and change each nostril's sensitivity to odorants depending upon the rate of airflow at different sorption rates (Sobel, et al., 1999).

In general the rate of airflow is higher in one nostril than the other, which is caused by swelling of the nasal turbine that increases airflow resistance in one nostril as opposed to the other (Principato & Ozenberger, 1970; Bojsen-Moller & Fahrenkrug, 1971; Hasegawa & Kern, 1977). Also, the rate of increased airflow alternates between nostrils in accordance with an ultradin rhythm (Gilbert & Rosenwasser, 1987; Mirza, Kroger, & Doty, 1997). When the information regarding airflow compared by nostril is combined with the sorbency rates across nostrils in accordance with information about sniffing, this generates the result that each nostril is tuned to odorants that sorb to the mucus at the current flow rate in that nostril (Sobel et al., 1999; DePay & Hornug, 2002). Each nostril conveys a different olfactory percept to the brain, which depends upon airflow and sorbency rates. That each nostril creates a different olfactory percept is substantiated by Zhou & Chen (2009) who demonstrate that binaural rivalry exists between the nostrils. Their research shows that perceptual rivalry can occur within the olfactory system such that "alternating odor percepts [occur] when two different odorants are presented to the two nostrils" (Ibid., p. 1564).

1.3.2 Mucus Matters

Mucus plays an invaluable role within the olfactory system. Mucus coats the olfactory epithelium and is produced by cells of Bowman's gland. Mucus is responsible for immune function, enzymatic, stimuli transduction, and removal of olfactory stimuli (Lewis & Dahl, 1995). More importantly it contains odorant-binding proteins for transferring the odorants through the Mucosa layer (Pevsner et al., 1985; Pelosi, 2001). The sorbency of odorants for traversing the Mucosa to reach the cilia of olfactory receptor neurons plays a vital role in how the olfactory system computes olfactory stimuli.

The Mucosa layer in combination with the sorbency of odorants allows the olfactory system to not continually fire in accordance with every peripheral environmental shift, thereby allowing slower temporal processing speeds. Additionally, it enables the olfactory system to account for changes in concentration levels across a given stimuli. Lastly, mucus and sorbency rates are needed to calculate the olfactory stimuli. Especially with regard to sniffing odorants, the sorbency of chemical stimuli and rate of airflow needs to be accounted for in determining the quality of an olfactory stimulus. High airflows will optimize perception of higher sorption rate odorants and low airflows will optimize perception of lower sorption rate odorants, both of which are required to calculate the olfactory stimulus (Mozell, Kent, & Murphy, 1991; Keyhani, Scherer, & Mozell, 1997).

1.3.3 The Olfactory Epithelium and Olfactory Receptor Neurons

Having traversed the nasal cavity and Mucosa layer an odorant must come into contact with Olfactory Receptor Neurons (ORN) within the olfactory epithelium to be encoded. The olfactory epithelium consists of a sheet of receptor neurons (and Basal cells poised to become olfactory receptor neurons or support cells) composed of roughly one thousand different types of receptor cells as determined genetically according to their ability to produce proteins to which the odorant molecules bind (Buck & Axel, 1991). While roughly 3% of the mammalian genome is devoted to olfactory receptor formation, the vast majority of these genes are pseudogenes (roughly two- thirds) which do not generate ORNs (Rouquier, Blancher, & Giorgi, 2000). The number of pseudogenes is similar across mammals though a decrease in pseudogenes occurs in species with less acute color perception.

Olfactory receptor neurons are unique in two important ways. First, they regenerate over time with a lifecycle spanning a month to a year (Hinds, Hinds, & McNelly, 1984; Mackay-Sim & Kittel, 1991). Indeed, the olfactory system is the only system whose receptor neurons regenerate over time. The function of ORN neurogenesis is debatable, but the most traditional explanation is that regeneration is required to repair the damaged caused to ORNs by being exposed to the environment. However, receptor regeneration over time could play a functional role in stimuli transduction by allowing the olfactory system further plasticity for sensitivity to novel stimuli as the receptors become more prevalent within a constantly evolving environment (Cummings & Belluscio, 2008). Second, ORNs are special, because they are exposed to the external environment, thereby coming into direct contact with olfactory stimuli. An ORN sends its dendrite into the Mucosa layer terminating in the olfactory knob that contains between 3 and 50 nonmotile olfactory cilia (Morrison & Costanza, 1990, 1992)

Both epithelium contain roughly six million ORNs, each of which is capable of binding to many different types of odorants based on the protein structures of their receptor sites. Thus, a typical odorant activates many different classes of receptor neurons, but to different degrees. The olfactory system's functional organization for stimuli encoding further differentiates it from vision and audition. ORNs do not generate a sensory typology of chemotopic maps at the receptor level analogous to retinotopic maps and columnar organization in the visual system and sound wave transduction by the cochlea within the auditory system. A chemotopic map is also not available at the olfactory bulb's glomureli and mitral cells. While ORNs are selectively sensitive to different odors to different degrees, there is no clear chemotopic mapping within the olfactory epithelium, since each type of ORN is diffused in a random manner throughout the olfactory epithelium (Yaksi et al., 2009). Chemotopic organization begins with the glomureli that received input from only one type of ORN from across the olfactory epithelium.

1.3.4 The Olfactory Bulbs

The axons of the olfactory receptor neurons project through the bone of the nasal cavity to the glomeruli in the olfactory bulb. Just as the olfactory system operates using two distinct nostrils and epithelia, we have two distinct olfactory bulbs. Each olfactory bulb consists of six layers arranged in concentric rings similar to the structure of an onion (Shepherd, 1972; Greer et al., 1981) in the following order: (1) the olfactory nerve, (2) the glomerular layer, (3) the external plexiform layer, (4) the mitral cell layer, (5) the internal plexiform layer, and (6) the granule cell layer (Kratskin & Belluzi, 2003). For the purposes of the dissertation, I shall only discuss the Glomeruli and Mitrals layers and leave aside the other parts of the Olfactory Bulb (OB).

Glomeruli are spherical clusters of axons from the ORNs, dendrites from the mitral cells, and dendrites from local interneurons that modulate the connections between sensory neuron axon terminals and mitral cell dendrites. Aside from the spherically shaped glomureli, the olfactory bulb also contains mitral cells whose role is to act as excitatory connections with their axons traveling to the olfactory cortex.

Each glomerulus's selective sensitivity to a particular odor might form the beginning of a chemotopic map. However, they also have a different base-firing rate for a secondary set of odors involving mitral cells. Furthermore, as will be argued in greater depth in Chapter Three, the olfactory bulb encodes odorants by implementing a functionally compositional system of representation that does not obey classical concatenative compositionality. Within the olfactory bulb there is no strict odorant encoding and certainly no isomorphic mapping of odorant to receptor types as is the case with the cochlea and the cones within the retina. Rather, each stimuli is encoded piecemeal by the activation patterns of the glomeruli throughout regions of the olfactory bulb. The distributed encoding of olfactory stimuli, in combination with neurogenesis, allows for a theoretical capacity of smelling an infinite number of odorants.

The anatomical structures within the olfactory bulb play a more robust functional role in stimuli encoding, than the receptor sites in other sensory modalities, making comparisons between the structural hierarchy of the other perceptual systems and olfaction difficult. The olfactory bulb is not analogous to the Rods and Cones or Ganglion within the retina, subcortical relays like the LGN in the thalamus, or the Cortex like primary visual cortex (V1) in the occipital cortex. The olfactory bulb performs a greater computational role than the first two options and even though it is considered to be cortical (based on its location within the skull and proximity to the cortex) the OB is not as computationally sophisticated as the cortex.

1.3.5 The Olfactory Tract

Moving upwards in the olfactory system, axons from the olfactory bulb project via the olfactory tract to the primary olfactory cortex. The olfactory system's anatomy is unique in not requiring thalamic connections before projecting to the cortex. There are no direct thalamic connections between the olfactory receptor sites in the olfactory epithelium and bulb: rather the olfactory tract projects directly to the cortex.

The olfactory tract runs ipsilaterally from each OB directly to the primary olfactory cortex. The lack of contralateral projection or any form of crossover makes olfaction unique, since information from the right receptors goes to the right cortex and left receptors to left cortex (unlike the other sensory modalities that integrate incoming stimuli before projecting to the cortex). The olfactory tract's ipsilateral projections and lack of contralateral connections are still the traditional organization of olfactory anatomy, yet some have begun to question this dogma using fMRI findings that are suggestive of the existence of contralateral pathways (McBride & Slotnick, 1997; Wilson, 1997; Savic & Gulyas, 2000; Uva & de Curtis, 2004; Porter et al., 2005; Cross et al., 2006).

1.3.6 Primary Olfactory Cortex, Piriform Cortex, and Thalamic Relays

The olfactory bulb connects via the olfactory tract directly to the olfactory cortex, making it the only sensory modality without subcortical relays. The primary olfactory cortex consists of all brain regions that receive direct input from the mitral and tufted cell axons of the olfactory bulb (Allison, 1954; Price, 1973; 1987, 1990; de Olms, Hardy, & Heimer, 1978; Carmichael, Clugnet, & Price, 1994; Shipley, 1995; Haberly, 2001). The primary olfactory cortex includes the entorhinal cortex, periamygdaloid cortex, cortical amygdaloid nucleas, piriform cortex, olfactory tubercle, tenia tecta, and the anterior olfactory nucleas. The entorhinal cortex projects to the hippocampus, while the piriform cortex projects to the orbitofronal cortex, the insula, and the dorsalmedial nucleaus of the thalamus, which also gains incoming stimulation from the olfactory tubercle (Mackay-Sim & Royet, 2006). The Piriform cortex accounts for the largest portion of the primary olfactory cortex and lies at the junction of the temporal and frontal lobes, as well as fusing into the anterior cortical nucleus of the amygdala.[6] However, given the size and range of these cortical areas the definition of what constitutes the primary olfactory cortex is far from functional and there have been some who suggest abandoning the current definition (Haberly, 2001; Sobel et al., 2003).

The primary olfactory cortex encodes airflow, so as to allow for olfactory constancy (Teghtsoonian et al., 1978; Teghtsoonian & Teghtsoonian, 1982, 1984). Given that odorants are unevenly dispersed throughout the environment and airflow varies between the nostrils, cortical monitoring allows the system to account for these fluctuations within the olfactory object, by comparing the incoming stimuli against airflow and sniffing. For example, if a high concentration

[6] Limbic connections are direct and unmediated. Some argue on this basis that olfaction has a stronger effect on memory encoding than the other modalities. However, it is unclear whether olfactory stimuli create stronger emotional responses to their presence or cause stronger memory encodings, or whether remembering olfactory experiences is more vivid. Since nothing in the dissertation turns on this issue I will not deal with this topic, but leave it aside as something of interest for further research.

of odorant with high velocity is presented to one nostril and a low dose with a low velocity to the other, the system can surmise that it is the same olfactory entity.

Aside from encoding nasal airflow and sniff rate, the olfactory cortex has areas devoted to the categorization of odorants as well as their identification. Thus, odorant coding would seem to come to a head within the cortex. However, each layer plays a role in olfactory encoding. Since we can discriminate more odorants than we have receptor types, olfactory odor coding cannot occur at the ORNsthereby ruling out a one-to-one receptor to odorant mapping scheme. Current research suggests that odorant encoding is a combination of the activity summed across the ORNs and glomeruli in a manner that is both spatially and temporally distributed. Odorant coding is a combination of temporal and spatial encodings for a complete percept. Compared to vision and audition, olfactory temporal processing is slow at about 150 ms given the need to traverse the Mucosa layer (Firestein & Werblin, 1989). ORNs and Glomeruli need not constantly fire to keep up with peripheral transduction like receptor cells in vision and audition. Furthermore, the spatial map of the epithelium and glomeruli is maintained in the cortex.

1.4. Summary of Chapters

Chapter 2 – Smelling Matter

We smell the wet dog in the elevator, the cookies from the bakery down the block, and the smell of an imminent snowstorm. Since we admit of smelling things, the aim of the second chapter is to uncover the nature of the objects of our olfactory perceptions. I argue that we smell chemical objects i.e. we smell the chemical structure of molecular compounds or mixtures. We smell matter.

Although the spatiotemporal and structural properties of odors meet the criteria of being a perceptual object or spatial temporal entity as posited by the visual model (Scholl & Pylyshyn, 1999; Matthen, 2005) and the criteria of being a mereologically complex entity as posited by the auditory model(O'Callaghan, 2008, 2009), neither of these models adequately capture the nature of smells. Nevertheless, it demonstrates that the object of our olfactory perceptions is external, not subjective or mind-dependent, thereby falsifying sensationalist theories of smell (Reid, 1764; Peacocke, 1983, 2008; Perkins, 1983). Furthermore, we should not identify smells with ordinary objects, as these are usually thought of as medium size objects in our immediate vicinity. Clearly smells are not such objects, since they pervade vast distances at varying levels of concentration. The variegated nature of smells seems to favor Plato’s view that the objects of olfaction are odors (detached parts of the object), as opposed to Aristotelian vapors. However, identifying the olfactory object with gaseous clouds of an aerated ordinary object (Batty, 2007; Lycan, 1996, 2000; Matthen, 2005; Smith, 2002; Tye, 2000, 2002) is not specific enough, because an explanation of how we individuate and identify these amorphous entities is not forthcoming.

The best criterion of an olfactory object is generated using the key posits of chemistry. The olfactory object is a chemical object. We smell the structure of molecular compounds, as suggested by our ability to smell enantiomers (simple chemical compounds that only differ in their chiral property or handedness) (Boelens & Van Gemert, 1993; Li et al., 2008; Turin, 2006) and our ability to recognize functional groups within a chemical compound (Klopping, 1971).Both of these features have been replicated in animal models of olfaction (Glinwood, Du, & Powell 1999; Wilson & Stevenson, 2006).

Chapter 3 – The Nonconceptual Content of Olfactory Experience

In Chapter 3 I argue for two controversial claims regarding the mental content of our cognitive states. First, the olfactory system processes smells in a structural manner that is unlike the composition of thoughts or language. Second, some of the content of our olfactory experiences is represented in a format that does not involve concepts.

Evidence for the first claim is supplied by the combinatorial nature of our olfactory experience and our thoughts about smells, which challenge Fodor's (1976, 1987, 1981, 2000) Language of Thought Hypothesis (LoTH), according to which, thought occurs in a representational medium similar to language, such that each thought is the concatenation of its constituents. LoT theorists insist that all thoughts must occur in such a compositional rubric due to the putatively infinite systematic and productive nature of our cognitive and linguistic abilities (Fodor, 1981, 1987; Fodor & Pylyshyn, 1988; Fodor & McLaughlin, 1990).

Using the work of van Gelder (1994) on functional compositionality, I have shown (Young, 2003) that the minimal requirements of a compositional system that has the aforementioned capacities are a determination of the atomic elements of the system in combination with rules of formation, transformation, and well formedness. Aside from being a viable theoretical alternative, olfaction actually implements functional compositionality. Research on the olfactory system's transduction mechanisms demonstrate that while we can detect the difference between enantiomers (Dyson, 1938; Boelens & van Gemert, 1993; Wright, 1982), we can at best identify four of the component odorants when simple smells combine to form complex odors (Laing, 1998; Livermore & Laing, 1998). These findings, together with research on olfactory mixtures and imagery[7], provide empirical evidence that functional compositionality is not a mere theoretical alternative to the classical story but that olfaction actually implements this minimal kind of compositionality.

Evidence for the second claim, and a new conception of the structure of the contents of our cognitive states, is offered using ?<facts about>? our aforementioned olfactory sensory and perceptual states, as well as the ?<evident>? richness of our olfactory experiences. The functionally compositional format of olfactory content is used to resuscitate the so-called 'Richness of Experience' argument (Dretske, 1981; Crane, 1988; Martin, 1992; Heck, 2000). Our experience of smell exceeds our conceptual repertoire not due to either a lack of smell concepts or access to linguistic mediums to enrich our conceptual

[7] See chapter 3, section 2 for a detailed explanation of these phenomena.

repertoire. Rather, the formative functionally compositional nature of the olfactory experience does not permit our conceptualized thoughts to capture the full sensory percept. The consequence of focusing on olfaction is that its content occurs in a representational medium that is not similar to vision or language, thus generating evidence for a new way of thinking about the structure of our cognitive states.

Chapter 4 – Stinking Neurobiological Theories of Consciousness

In Chapter 4, I group theories according to their claimed necessary conditions for the neurobiological realization of consciousness and demonstrate the negative impact that neglecting olfaction, in favor of these current theories, has.

Subcortical theories of consciousness are the clearest casualty given what is known about the olfactory system's anatomy and in particular, Merker's (2007) centrencephalic theory. The anatomy of the olfactory system, with its direct projection to the cortex, provides serious difficulties for the centrencephalic claim that consciousness need not involve the cortex nor corticothalamic loops. The olfactory system establishes that cortical connections are necessary for consciousness in some modalities.

Intermediate-processing theories (*IPT*) of consciousness all concern the nature of awareness and share the claim that consciousness occurs at a representational stage between sensory and conceptual states. Jackendoff's IPT

(1987), Prinz's Attended Intermediate-Level Representations theory (2000, 2005, 2007), and Mandik's Allocentric-Egocentric Interface theory (2000, 2005, 2009) all agree that consciousness occurs at some middle point within the stream of cognitive representations, thus explaining their shortcomings in accounting for olfaction. Neuroscientific evidence suggests that the olfactory system is not structured anatomically or functionally in the manner that the intermediate level theories of consciousness suppose and in particular their intermediate stage does not generalize to olfaction. In their current guise, some of theconditions that these theories claim are necessary for consciousness are not applicable to smell.

The anatomical structure of the olfactory system is problematic for current neuroscientific theories of consciousness, which maintain that a thalamic relay is, or corticothalamic loops are, a necessary condition for consciousness. While a thalamic relay is necessary for analyzing odorants (Pially, et. al., 2007), it is not so for consciously discriminating between odorants. This provides good reason to doubt Crick's theory (1984, 1994) (Smythies, 1997), Crick & Koch's theory (1998) (Shepherd, 2007), Koch's neurobiological theory (2004), Global Workspace Theories (Baars, 1988; Dehaene et. al*.,* 2006), and the Information Integration Theory of Consciousness (Tononi & Edelman, 1998; Tononi, 2004, 2009). Furthermore, research on the functional encodings of odorants in the olfactory bulb (Friedrich & Laurent, 2001), shows that these theories cannot maintain that the olfactory bulb plays an equivalent functional role to that of the thalamus for vision (Kay & Sherman, 2006). Thus, the posited necessary thalamic connections cannot be replaced by positing a functional equivalence within the olfactory system.

Chapter 5 – The New Game: Olfactory Cognition and Consciousness

I conclude by offering an alternative approach to explaining phenomenal consciousness, which builds upon the findings that the olfactory object is the chemical structure of molecular compounds, that olfactory experiences are partially nonconceptual, and the failure of contemporary neurobiological theories of consciousness. I argue that phenomenal consciousness arises from sensory states, that these are necessary for awareness, and that our olfactory consciousness occurs in a nonconceptual format.

Evidence for the olfactory sensory states being qualitatively conscious derives from research on blind smell (Schwartz, 1994, 2000; Sobel, 1999), mate selection (Wilson & Stevenson, 2006), and the selection of social preference (Li et al., 2007), as well as an argument from absence derived from considering anosmia and its detrimental effect on the quality of life. When these results are combined with the conclusions of Chapters 2 and 3 it suggests that olfactory consciousness occurs in a nonconceptual format such that we are in direct contact with a qualitative aspect of reality.

Chapter 2

Smelling Matter – The Olfactory Object

> **"Smell and its objects are much less easy to determine then what we have hitherto discussed; the distinguishing characteristic of smell is less obvious than those of sound or color."**
>
> - Aristotle *DA* II 9 421a7-9

What does your current location smell like? Close your eyes for a second. Can you identify the things around you by smell? Most likely you did not notice the smells enveloping you, but you surely knew what your environment looked liked without being asked. There is no doubt that we are primarily visual beings who sense and navigate the world using vision. However, we are constantly bombarded with smells, which continually shape our perception and interactions with our surroundings.[8] Yet most people would be reluctant to admit that their behavior is caused by olfactory experiences.[9] Nevertheless we do smell things. We smell the wet dog entering the elevator, the cookies from the bakery down the block, and, on a warm autumn night, the musty rotting leaves outside the window. Smells are intuitively individuated by reference to the ordinary objects from which they arise. In this chapter I challenge this folk view and argue that the olfactory object and its qualitative character is in fact constituted by the chemical structure of molecular compounds.

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[8] Olfaction guides our food choices (Fallon and Rozin, 1983), dietary preferences (Rozin, 1978; Rozin et al. 1986; Rozin et al.,1992), our selection of mates (Wilson & Stevenson, 2006) and social acquaintances (Li et al*.,* 2007), and is responsible for identification of kin (Russell, 1976; Porter, Cernoch, & McLaughlin, 1983; Porter et al., 1986).

[9] While human olfactory accuracy is excellent and on a par with dogs, we systematically mistrust our olfactory abilities (Sela & Sobel, 2010).

Contemporary philosophy of mind and perception is shaped both by empirical research and thought experiments that take vision as its starting point and makes the tacit assumption that any evidence or conclusions drawn from vision will generalize across all perceptual modalities.[10] However, ancient philosophy from Plato and Aristotle, through to their Medieval Commentators, sustained a debate regarding how the nature and mechanisms of olfaction differed from the other modalities.[11] The time has come to rectify contemporary philosophy's neglect of olfaction by re-examining the objects of our olfactory experiences without simply assuming that our best theory of vision will generalize to olfaction.

We do perceive objects using our sense of smell, but the objects of these experiences are not the same as when we sense objects through touch, sight, or audition. The objects of vision have sharply delineated spatial characteristics and the objects of audition have clear temporal boundaries. Smells, however, seem to be neither spatially nor temporally bound objects. Rather than considering olfaction as an aberrant modality that is best left aside, a theory of the olfactory

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[10] While the tyranny of the visual has been challenged based upon our auditory abilities (O'Callaghan, 2007), no one has stepped forward on olfaction's behalf. Even Clare Batty (2007, 2009a, 2009b, 2010) who has the most developed contemporary theory of smell, assumes a Unification Thesis according to which all the sensory modalities should be held accountable to all the same problems. The motivation of this chapter is certainly contrary to Batty's methodology and more in line with Lycan's (2000) approach to olfaction, since I aim to demonstrate how the olfactory object is unique and different from what we would expect if vision and audition were our only models of perception.

[11] Plato's theory of smell is contained within two paragraphs of the *Timaeus* 66d-67, while Aristotle's theory is developed in *De Anima* and *De Sensu*. Johansen (2006) provides a detailed assessment of the differences between Aristotle's theory in *De Anima* and *De Sensu*. See Kemp (1997). for an introduction to the Commentators' debate on Plato and Aristotle's theories of olfaction.

object matters, precisely because olfaction is special. Olfaction works differently than vision and audition, and provides unintuitive results, which bring into question our theories about how we perceive the world and what we perceive about the world.[12] Consequently, in this chapter I generate a comprehensive theory of the objects of our olfactory experiences (the things that we smell) by uncovering both the nature of the object that we perceiveand what is responsible for its smell (the olfactory quality of the olfactory object). Thus, it is not sufficient to identify what is responsible for our sense of smell: an explanation of what constitutes the object's smell is also required.

The object of olfactory perception is unlike our common sense conception of ordinary three-dimensional objects, identified visually. Smells are not ordinary objects, but the chemical structure of simple molecules or mixtures within odor plumes. Our olfactory perceptions are of the material objects of chemistry. We smell the chemical structure of matter.

2.1 Ordinary Objects

Pre-theoretically our conception of an object concerns ordinary objects, as these are what we most naturally refer to in our everyday discourse. Ordinary objects are three-dimensional entities that we would single out as objects in observation and ordinary language - they must have clear boundaries as perceived by sight or touch. For instance, we recognize apples, chairs, trees, and

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[12] See the introductory chapter, sections 3.3-3.6, and chapter 3, sections 3-4, regarding olfactory stimuli transduction.

garbage trucks all as objects. We certainly claim to have olfactory experiences of ordinary objects. Commonly, we individuate smells by reference to the apples baking in the pie or the stench emanating from the back of the garbage truck. Our ordinary language usage most likely derives from tracking olfactory experiences that are of ecological import[13], thus making it natural to individuate the objects of olfactory experience by reference to the ordinary objects from which we correlate their emanations. Our ordinary language usage and pre-theoretical conception of perceptible objects makes it intuitive to assume that olfactory objects are ordinary objects, however, the spatiotemporal boundaries and chemical composition of ordinary objects make them ill-suited to be considered olfactory objects.

The entities that we commonly talk about as smells do not have the same boundary conditions as ordinary objects. The things that we smell are spatially and temporally less truncated then the same object that we identify by touch or sight. The smell of honeysuckle occupies a greater space for a longer period of time than the object that we identify tactilely and visually. Additionally, consider the experience of smelling the autumn leaves outside your window, on the ordinary object conception there is no sense in which these entities are in the room, yet you are not hallucinating and the experience is certainly veridical (Batty, 2007).

Furthermore, it would be an ill-advised theoretical starting point to assume that the object of our olfactory experience is the object that we see or touch,

[13] Ecological theories of the olfactory object are preferred by contemporary scientists, but rejected for reasons dealt with in section 2.3.

since not all of the ordinary object is necessary for generating an olfactory experience.[14] The average mid-size object is composed of hundreds of different molecules, yet only a dozen or so of these are responsible for its smell. Modern flavor and fragrance houses are so profitable[15], because they are able to identify the minimum number of chemical components from an ordinary object that are required to produce the same sensation.[16]

The mimicry of natural odors using synthetic chemical compounds yields the problem of olfactory misrepresentation (Lycan, 1996). I can erroneously believe that I am smelling a rose without the presence of the ordinary object, since synthetic chemical compounds mimic the same odor. When undergoing these experiences I am not misrepresenting the olfactory quality of my experience (I am undergoing the olfactory experience of a rose smell) nor is it a hallucination, rather I am just misrepresenting the true source of the smell. Ordinary objects should not be considered the objects of our olfactory experience, since we can have veridical perceptions of olfactory qualities in the absence of an ordinary object. However, if olfactory objects are not ordinary

[14] It might be objected that I am being unfair, since the entire ordinary object is not required for my visual experiences of say a bowling ball. However, this might merely show that the ordinary object conception is not tenable for the perceptible objects of visual experiences as well. Furthermore, the objection treads upon a longstanding debate within the philosophy of perception regarding whether we do in fact visually perceive aspects of an ordinary object that are not within our line of sight, such as the back of a bowling ball (Noë, 2005).

[15] Flavor and Fragrance businesses generate multibillion-dollar revenues that on average exceed that of Hollywood and the entertainment industry.

[16] Gilbert (2008) has a nice description of how the headspace model of International Flavors and Fragrances (IFF) is utilized in creating flavors and fragrances.

objects then the claim that olfactory states have objects might be called into question.

2.2 Criteria of Visual and Auditory Objects

To assuage the worry that olfactory experiences might not be object directed, this section shows how olfactory objects satisfy the criteria used to ascertain the nature of visual or auditory objects of perception, such as having spatiotemporal boundaries, being separable from against a background, and having a mereologically-complex nature across time and presentations. Our olfactory experiences meet these criteria, thereby generating support for the claim that our olfactory perceptual states are object directed. However, I will argue that none of these criteria are adequate to capture the robust nature of our olfactory experiences.

2.2.1 Spatial Temporal Entities

Our conception of objecthood is shaped by vision and consists in the notion of a spatiotemporal entity with clear boundaries. Visual objects are prime examples of perceptual objects in this sense, since they are either “punctate spatiotemporal clusters” (Scholl and Pylyshyn, 1999, p. 26) or spatiotemporally bound entities that maintain their features across movement through an environment (Matthen, 2005). Seemingly, our olfactory experience are not object directed, according to either of these conceptions of a visual object, since they can occupy vast spaces at varying concentrations levels and at times they might outlast the ordinary visual object from which we think the smell emanated.

The lack of strict spatiotemporal boundaries of smells has lead most philosophers to argue that olfaction is an outlier or counter-example to this notion of a perceptual object. They claim that our olfactory experiences do not have as a proper part, the location or direction of the smell (Matthen, 2005; Smith, 2002; Lycan, 2000; Peacocke, 2008; Batty, 2007, 2009, 2010a, 2010b, 2010c). But they are mistaken; olfaction satisfies both the spatial and temporal requirement, but in a less truncated form. The olfactory object is just more dispersed in time and space than the visual or auditory object.

Empirically it has been demonstrated that we can locate smells within 7-10 degrees of their location (von Bekesy, 1964), and that binaural airflow allows us to locate smells (Zhou and Chen, 2009), just based upon the anatomical structure of each nostril being slightly different (Yeshurun et al., 2008). There is also research showing that we can track olfactory objects through an environment across time (Porter et al., 2005, 2007). Thus, the aforementioned philosophers are simply mistaken. The olfactory object has spatial boundaries, but it is diffused across an environment in a manner that is not similar to visual objects.

It would be foolish to claim that the olfactory object is not a spatial entity simply because its boundary conditions are not as truncated, especially given the aforementioned empirical work that shows we can demarcate the olfactory object given the concentration gradient of the olfactory object's odor plume.[17] However, our ability to do so requires an added temporal variable of either sniffing or moving oneself relative to the olfactory object. Perhaps their argument should be charitably construed as the claim that olfactory experiences are not object directed, since they do not present us with a spatiotemporally bound entity synchronically. Diachronically, we may supplement this experience by moving around, but this is not the case when it comes to vision.[18] Just opening my eyes I am immediately presented with three-dimensional objects in a spatial environment. The olfactory object might have spatial boundaries, but its temporal aspect makes it unlike the spatiotemporally bound entities of vision.

However, this line of argument is predicated on the assumption that we can identify and individuate our olfactory experiences merely using our phenomenal experiences by giving an account of our olfactory experiences as they present themselves to us first-personally. Lycan (2000) states that the

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[17] A perfume's silage is an excellent example of the spatial aspect of an olfactory object, as it is the diffusion rate across space of a perfume, which perfumer chemists (perfumers) must consider in designing a new product. Some want a scent that announces once presence or that turns heads as they navigate a room, while colognes usually are designed to only be noticeable within a small radius of the wearer.

[18] The assumption that vision automatically presents us synchronically with spatial objects might be questioned, since similar temporal processes occur in vision. To see things, my eyes must be in constant motion either through volitional control or through saccadic movement. If the eyes were to stop moving your visual field would shrink and eventually turn a uniform grey (this can easily be demonstrated by holding your eyeballs still in their socket or by using a ganzfeld). Seemingly this presents an analogy to inhalation in olfaction. If inhalation cannot be considered part of the olfactory experience or an enabling condition of the olfactory percept, why not disallow saccadic eye movement? Smith (2002) anticipates this reply and argues that the sniff is not equivalent, because we do not volitionally control our saccadic eye movement, while we must always volitionally control our sniffing when we attempt to locate and direct ourselves towards a smell.

reason we should not consider olfactory experiences to be spatial in nature is because the synchronic experience of smells do not seem to contain any spatial information as part of the experiential content. Even though we can locate and inferentially direct our attention to an odor's source overtime, they deny that this aspect is inherent to our experience of smell. Using this line of reasoning, Matthen denies that our experiences of smell can be characterized in the usual object attribute form, thereby allegedly bringing into doubt the very existence of olfactory objects. Smith goes so far as to use this line of reasoning to question whether we can smell physical objects at all. Following their lead, Batty questions the notion of an olfactory object and concludes that it is best thought of as some loosely defined existentially quantified object (something surrounding me has a smell) that cannot be determined in subject predicate form like our other sensations.

Perhaps when I consider synchronic visual and olfactory experiences side-by-side, the olfactory experience has fewer spatial qualities. However, at times I am presented with a smell appearing from a location.[19] Moreover, phenomenological evidence may be quite misleading here. I agree that we should account for the phenomenology of our experiences in generating a theory, but phenomenology should not be the sole factor. I think there is a better explanation of our lack of spatial phenomenology in our olfactory experiences.

[19] Aside from our mundane olfactory experiences occurring with a spatial component, Mizobuchi, et al. (1999) provide an interesting case study of olfactory hallucinations that have spatiotemporal properties (for more details see chapter 3, section 1.2).

Both Plato (Timaeus, 66d-67) and Aristotle (DA II 7 419a31-419b2) correctly recognized that while inhalation is necessary for olfaction, we are not usually aware of consciously modulating our breathing.[20] So most of the time, an odor seemingly presents itself to us as if it has just appeared before our nose or occurred within our nostrils. However, though our breathing patterns are under volitional control, we do not usually notice this and only attend to our sniffing once an interesting olfactory object catches our attention. Furthermore, recent studies on the role of sniffing suggest that the sniff itself is part of the olfactory percept (Kareken et al., 2004; Kepecs et al., 2006; Koritnik et al., 2008; Mainland et al. 2006; Sobel et al., 1999). The reason that our olfactory experiences seem to lack a spatial phenomenology is that we do not commonly attend to our breathing patterns, which are necessary for the olfactory experience and provide the spatial aspects of the experience. When we diachronically attend to the olfactory object, we become aware of its spatial aspects, because we are attending to our own breathing patterns and the movement of airflow around us.

Our olfactory experiences are of spatiotemporal bounded entities. However, the criterion of a perceptual object derived from vision does not aptly capture the nature of our olfactory experiences, given the distinct spatial and temporal characteristics of smells. A more accommodating criterion is required

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[20] While both agree that inhalation is necessary for olfaction in humans, whether it is a constitutive part of the olfactory percept or merely a precondition of receiving the olfactory object is questionable when it comes to Aristotle. He asserts that inhalation is necessary for humans to lift the inner flap that covered the olfactory receptors that receive the form of the olfactory object, whilst for fish inhalation was not necessary as the olfactory receptor site is not covered.

that accounts for the variegated spatiotemporal nature of the object of each modality.

2.2.2 Figure-Ground Separation

Our auditory and olfactory experiences have spatiotemporal boundaries that exceed those of vision. *Prima facie* it is far from clear if the objects of our auditory experiences can be defined in a similar manner to vision using mere spatiotemporal criterion. What is readily apparent is that we are constantly bombarded with sounds, yet our auditory system is able to separate and group together auditory stimuli that belong to one as opposed to another stimulus. For example, while sitting in a coffee shop having a conversation against the background of a tremendous amount of noise, we are able to separate out our interlocutor's voice from the surrounding cacophony. As a result, defining perceptual objecthood using the criterion of figure ground separation makes sense for auditory objects.

In addition to using spatial extent criterion, we can use figure-ground separation to establish that olfactory objects are spatial. The olfactory system is constantly bombarded by stimuli, yet we are able to separate and group together stimuli that belong to one as opposed to another stimulus. For instance, I can smell the roses within the bouquet of lilies and gerbera, the rosemary on the roasted chicken, or the honeysuckle from the fresh-mown grass in the meadow. The theory of indispensable attributes (i.e. essential attributes for each modality that allow us to perceive more than one object at a time) is proposed to account for our ability for figure-ground separation as a general criterion for perceptual objecthood across modalities (Kubovy and Van Valkenburg, 2001; and Kubovy, 1988). For vision, the essential attributes are space and time, while for audition they are pitch and time. The theory does not consider or generate essential attributes for olfaction, but the olfactory object satisfies this criterion of objecthood as well.

Chemicals compounds, which could lead to smells, constantly surround us. Nonetheless we are able to separate out different smells from the environment. I am not presented with an olfactory smudge with everything jumbled together; rather I can differentiate one smell from another. We can identify the smell of a peach across changes in intensity and concentration (when it is unripe, ripe, or overripe), in different contexts (as a fruity drink, in a baking pie, or in a perfume), yet throughout all these changes we still recognize these token experiences as all falling under a particular type i.e. the peach smell. The olfactory object can meet the criterion of a perceptual object using figure-ground separation. But, the criterion still does not sufficiently capture the nature of our olfactory experience. We also discriminate, recognize, and identify an odor across multiple contexts, presentations, and changes in its properties. The spatiotemporal and figure-ground characterization of a perceptual object is not adequate to fully accommodate the olfactory object.

2.2.3 Mereologically Complex Entities

In an attempt to determine the nature of the auditory object, O'Callaghan (2008, 2009) suggests thinking about perceptual objects as entities with mereologically complex structures such that we can recognize it across contexts and changes in properties. The object of vision, audition and olfaction might be defined as an entity with a mereologically complex structure such that we can recognize it across contexts and changes in properties. The mereological structure of the auditory object is responsible for our ability to discriminate it from against the background of other similar stimuli, changes in context, and through changes in its subordinate structure or properties. For example, I can recognize the sound of a Bach sonata, across performances, orchestras, places where it is performed (i.e. the concert hall, my car, in the mall, or on headphones) and yet still recognize the sound of the Sonata, despite changes in loudness, tempo, or the arrangement of the strings.

What is seductive about the mereologically complex structure criterion for olfaction is that it nicely fits with ecological views of the olfactory object (Wilson and Stevenson, 2006; Gottfried, 2010). The methodological assumption of these theories is that the olfactory object should be identified with complex set of molecular compounds that enable us to track, locate, and secure objects that are of value to us in maintaining our homeostatic needs. Ecological theories define the olfactory object in terms of the function of olfaction in guiding our ability to identify ecologically valuable information about our environment.

Wilson and Stevenson's (2006) theory is the most exhaustive scientific account of the olfactory object, which is in keeping with the criteria of a perceptual object being a mereologcially structured entity. Central to their theory is the question of how we are able to recognize certain chemicals as bound together to form the perception of objects, while we are constantly enveloped by countless other chemical structures. Since we could parse our chemical surroundings in a nearly infinite manner, how is it possible for us to bind the necessary odorants together to create the percept of the odor of an apple? Their theory is motivated by an olfactory variant of the binding problem, since their aim is "to provide a conceptual framework for understanding how perceptual object can be created by the central nervous system from a sensory world that is not inherently nor necessarily composed of isolated object" (ibid., p. 23). Given their overall methodology, they think that the odor object partially depends upon synthetic processing, such as memory processing that is modulated by the organism's current mental state, previous olfactory states, expectations, and the situation. Their olfactory object is a learnt entity, which requires tracking over time through changes in concentration, intensity, and hedonic value from the constant bombardment of other odors. Accordingly, they identify the olfactory object with a complex of molecular compounds that is responsible for our ability to locate mid-size ordinary objects in our environment.

Wilson and Stevenson's robust theory of the olfactory object as a complex chemical mixture composed of multiple molecular compounds that derive from an

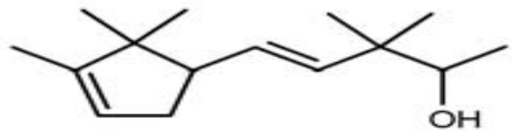

Figure 1. Polysantol – (4-Penten-2-ol, 3,3-dimethyl-5-(2,2,3-trimethyl-3-cyclopenten-1-yl)) gives off a robust sandalwood smell.

ordinary object is not satisfactory for the following reason. Our ability to recognize, identify, and discriminate an olfactory object across contexts and against the background of other odors can be accomplished for simple molecular compounds and not merely complex ecological odors. Singular synthetic molecules provide the simplest counterexample. For instance, Firmenich's Polysantol (figure 1) can be recognized across presentations and varying levels of concentration.[21] The shortcoming of Wilson and Stevenson's approach is that it only accounts for complex mixtures, while simple odors composed of a single molecular compound are experienced in the same manner, yet they are not mereologically complex in their ecological sense. Additionally, Wilson and Stevenson's theory of the olfactory object is not adequate, because it only generates a theory of how we produce a perception of the olfactory object. Their theory might provide us with an answer to how we recognize, identify, and discriminate one smell from another, but they do not answer the further question: what constitutes the smell (olfactory quality) of these objects?

[21] One might even debate whether the current formulation of Montale's Aoud Pur Oriental contains this synthetic or Firmenich's Oud Synthetic 10760 E, but certainly not Givaudan's Black Agar Givco 215.

Our olfactory experiences are certainly object directed, since they satisfy the aforementioned criteria used to ascertain the nature of the object of perception in vision and audition. The olfactory object has been shown to be a spatiotemporal entity that we can separate from against a background of competing stimuli, one which maintains a mereological structure such that we can recognize and identify it across changes in its location and properties. But none of these criteria are sufficient to capture the nature of the olfactory object, which is less spatiotemporally truncated than the objects of vision and audition and at the same time mereologically complex even when as miniscule as a simple molecular compound.

2.3 Platonic Vapors

An option that repeatedly appears in different guises is that the olfactory object is the vapor, effluvia, or chemical gases given off by an ordinary object. Two kinds theories are inspired by olfactory emanations: Platonic vapors; and contemporary Odor theories. Vapor theories consider the olfactory object to be detached proper parts of the source object itself (e.g. you literally smell the blood of the Englishman). Alternatively, Odor theories claim that the olfactory object is a detached subset that is not indicative of the entire ordinary object. According to Odor theories, while the objects of our olfactory experience are chemicals given off by the ordinary object, which are diffused in odor plumes, one does not perceive the entire ordinary object nor the form of the object. Rather just some aspects of the object are responsible for our experience of smell.

Plato's theory of smell consists of little more than two paragraphs within the *Timaeus*, where he claims that while we smell the vapors of objects as they transform from one elemental shape to another, they cannot be identified with these elemental entities themselves. He asserts that ordinary objects give off particles as a substance becomes gaseous or condenses. We perceive the ordinary object as it transforms between elemental kinds thereby making the smell of an object the aerated form of the object proper. But, we do not smell the elemental object (since our nostril cannot accommodate entities of such size) but rather the form of the object.

> As for the power belonging to the nostrils, there are not types within it. This is because a smell is always a "Half-breed." None of the elemental shapes, as it happens, has the proportions required for having any odor. The vessels involved in our sense of smell are too narrow for the varieties of earth and water parts, yet too wide for those of earth and air. Consequently no one has ever perceived any odor coming from these elemental bodies. Things give off odors when they either get damp or decay, or melt or evaporate; for when water changes to air or air to water, odors are given off in the transition. All odors collectively are either vapor or mist, mist being what passess from air to water, and vapor what passess from water to air, and this is why odors as a group turn out to be finer than water, yet grosser than air. Their character becomes clear when one strains to draw ones breathe through something that obstruct one's breathing. There will be no odor that filters through. All that comes through is just the breath itself, devoid of any odor (Plato, Timaeus, 66d-67).

What requires clarification in Plato's theory is the nature of the vapor. He asserts that ordinary objects give off particles as substances become gaseous or condense. But, it is unclear if the vapor is identified with the object or some subset of particles that the object emits while undergoing the process of transformation. The phrase “Things give off odors when they either get damp or decay, or melt or evaporate” suggests that the elemental shape loses parts of the object that serve as a good sample of the entire entity, while his claim that olfactory objects are merely half-breeds without elemental types could be interpreted as claiming that only certain kinds of particles might be given off, which could be identified as the object of olfaction. Personally, I am inclined to the first interpretation that the vapor is the object proper and that we perceive the ordinary object as it transforms between elemental kinds and not a subset thereof. The first interpretation closely matches the text and the folk view that the smell of an object is simply some aerated form of the object proper. The alternative that vapors are diffused subparts of the ordinary object is equivalent to the theory that what we smell are odors, which will be dealt with in the next section.

While Plato’s vapor theory interpreted as detached proper parts of an object (or the form of ordinary objects) does not explicitly endorse the ordinary object view, it nonetheless suffers from the same problems. As argued above, olfactory objects are not ordinary midsize objects, because only a small chemical subgroup of its material makeup is required for our experience of smell and certainly not the form of the entire object. Also, the ability of synthetic chemicals to mimic the smell of natural objects suggests that the form of ordinary objects is not necessary for creating the experience of a smell.

2.4 Odors

Odor theories are a contemporary outgrowth of the vapor view, which pay no homage to their ancestral predecessor. According to these theories, the olfactory object is an odor, which is identified with a gaseous emanation of the object we smell. For instance, roses give off parts of themselves and it is these diffused rose parts that we smell. Most philosophers, who discuss olfaction, assume that smells are odors (Batty, 2007, 2009, 2010a, 2010b; Lycan, 1996, 2000; Matthen, 2005; Smith, 2002; Tye, 2000, 2002). Odors are certainly an interesting perceptual object, since their spatiotemporal boundaries are less truncated than those of the other modalities. What makes the odor view enticing is that it explains olfactory misrepresentation, since the olfactory quality of an odor does not depend upon the ordinary object, thereby allowing that we can misrepresent the source of a smell. Additionally, since only diffused subparts of the object (and not the entire ordinary object) are required to elicit a smell, odor theories can explain how our olfactory experiences can be veridical when the ordinary object is not present in our immediate surroundings.

Odor theory is partially correct, but it lacks an explanation of what is it about the odor that we consider to be its smell. Given that the experience of a smell changes across the spatially diffused odor and can be spotty across presentations within the odor's gradient, odor theory only gets us so far. What is responsible for the odor smelling as it does? What is it about these objects that are responsible for their olfactory qualities?

The most obvious reply would be to individuate the qualitative character of the odor by reference to the natural source from which it emanated (Tye, 2000, 2002), but this would be to return to the ordinary object view that was already rejected (Section 2.2.1). We cannot individuate olfactory qualities by reference to ordinary objects, because not all aspects of the ordinary object are required for generating the smell and we can have veridical olfactory experience of an olfactory quality in the absence of any ordinary objects (a synthetic rose smell still smells just as sweet). Even if it were possible to account for these phenomena by appealing to what typically gives off these odors, it would still not generate an account of what determines the quality of an olfactory object. Why is it that a particular synthetic rose smell has almost exactly the same olfactory quality as a Gardenia? We need a way of specifying the olfactory quality of an odor independent of its ordinary object source. Gibson's theory of olfaction might be used to complete odor theory's explanation of olfactory qualities.

According to Gibson (1966) we are sensitive to the ecological properties of an object through smell. When smelling an apple we smell its ripeness and edible nature, which he nicely identifies with the chemical mixtures given off by the apple. The affordance of a smell allows us to discern things about the environment based on our chemical sensitivity. However, he qualifies this by claiming that while our olfactory receptors are activated by simple chemical compounds these are not responsible for the quality of olfactory objects, there is some information carried by mixtures of chemical compounds about the essence or affordance of the object that is not necessarily identical to their chemical nature (Gibson, 1966, p. 149-150). Interpreted in this manner, the odor view can be rejected in the same manner as the ecological view, for not accounting for the olfactory quality of simple molecular compounds, which satisfy the criteria of being a perceptual object (Section 2.2.3). Synthetic simple molecular compounds generate olfactory experiences with a clear olfactory quality, yet they are not composed from multiple compounds combined into a mixture nor is their olfactory quality due to the essence or affordance of the objects from which they emanate. Thus, there must be something about the chemical compounds themselves that generates their qualities.

In contrast to molecular views of odors, Batty's theory (2007, 2009, 2010a, 2010b 2010c) embraces the opposite extreme by claiming that odors are best thought of as non-localizable clouds. She argues that we can only account for an odor's objecthood in terms of an existential generalization that there is an olfactory object in my surroundings, and it has properties f_1-f_n. Motivation for this view depends upon the previously discussed claims regarding the non-spatiotemporal nature of the olfactory object based on our phenomenology of olfactory experiences, which were rejected in Section 2.2.1. Additionally, her theory is untenable, because it does not explain what it is about these existentially quantified entities that account for the nature of their olfactory quality. Since odors - as interpreted in light of Gibson - are too large to capture the full range of olfactory objects, and Batty's theory is empirically untenable, it might be best to consider far smaller entities such as those posited by chemistry.

2.5 Aristotle – Medium Smell

Until modern times, Aristotle had developed one of the most exhaustive accounts of smell. The theory is biologically well motivated, since it draws upon his knowledge of marine biology, and generates a theory of smell inhering within media that can be detected equally across species. Furthermore, his view lends support for my introductory claim that we can use animal models of olfaction in generating a theory of olfactory content and consciousness: the sense of smell is phylogentically the most basic perceptual modality, is shared by more or less all animals and only differs as a matter of degree and not in kind.

Though contemporary philosophers prefer odor theories, whose historical ancestry might be traced to Plato's vapor theory, my own sympathies are more Aristotelian in purpose. My approach of separating the two questions of what the olfactory object is and what about it constitutes the olfactory quality of the object (what is a smell and what about them explains how they smell), which found odor theories wanting in the second instance, is similar to Aristotle's methodology that there might be different criteria of a perceptual object for different purposes. Aristotle treats the definition of the perceptual modality of smell in accordance with its proper object and the nature of olfactory object as separate issues.

Aristotle's purposes are not identical to my own, but they converge to an extent. The focus of this chapter has been to answer the following two questions: what is the olfactory object (what are smells) and what is it about the olfactory object that is responsible for its quality. Aristotle's questions concern the definition of each modality in light of its proper object, as well as what is the material (chemical) composition of these objects. To define each sense, his methodological assumption is that we can identify and demarcate the senses in accordance with their proper objects, while the nature of these objects can be treated in a separate discussion. Aristotle's theory, and my own, are certainly at odds regarding the details of the olfactory object. However, his approach of attempting to define the object in light of its material underpinnings is certainly shared by my own approach and might even find a modern extension in some aspects of the theory that I offer.

Aristotle's theory is developed in *De Anima* and *De Sensu.*[22] In keeping with his overall theory regarding the senses in *De Anima*, we can determine the olfactory sense in accordance with its proper object. Each modality is defined in light of its special object that is perceivable by that sense alone (*DA* 6). Thus, the proper (*idion*) object can be used to define the sense (Sorabji, 1971). Aristotle's theory is that we perceive smells, which are the effects of flavored stuff that can be received through a medium in either air or water.

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[22] Johansen (2006) provides a detailed assessment of the differences between Aristotle's theory in *De Anima* and *De Sensu*, which is quite enlightening but not pertinent to the his theory of the olfactory object.

For Aristotle though reality is composed of matter and its form, we never directly perceive matter; rather we receive the form of the material object as conveyed through a medium. What differentiates the senses is not only the transduction mechanisms, which receive a full treatment in *De Sensu*, but that also each modality has its own proper object. In *De Anima*, Aristotle is true to his purpose of determining the senses in light of their proper object and leaves aside the nature of these objects until he gives a more detailed treatment in *De Sensu*.

In *De Anima* the proper objects of olfaction are identified as smells. However, smells are troublesome, since on the one hand they are similar to the objects of vision and audition that occur at a distance through a transparent medium, while on the other hand they are similar to touch and taste, because smells deal with that which has nutritious value. Aristotle settles on smells being similar to flavors, but which can only occur at a distance from the object and never through direct contact. Additionally, they are similar to flavors in terms of their varieties and names, such that sometimes we use flavor terms to pick out smells due to our anemic olfactory vocabulary. Thus, we arrive at the nature of olfaction by way of taste: “smells are of what is dry as flavors of what is moist. Consequently the organ of smell is potentially dry” (DA II 9 422a7-8). Olfaction perceives smells, which are the effects of flavored stuff that can be received through a medium either in air or water. However, the nature of flavored stuff is still unexplained.

In *De Sensu* the chemistry of the proper objects receives its full treatment and it is here that we learn that smells and flavors share some of their material composition: "We have next of smell and flavor, both of which are almost the same physical affection, although they each have their being in different things" (4 440b28-441a3). Smells are similar to flavors in that they are produced by flavored stuff (5 442b28-443a21), that is the combination of dry stuff and liquid (5 443b3-5), but unlike flavors they might be absorbed in air or water to explain the observation that both land animals and aquatic animals perceive smells.

It is here that Aristotle's scientific acumen is apparent, since he must explain the observation that animals that live in water also perceive smells. Both here in *De Sensu* and in *De Anima* (II 7 419a31-419b2) he is careful to recognize that though the medium of smell has no special name, there is a quality located both in air and water, which serves as the medium for what has a smell. The major difference between land dwellers and those that live underwater is not the perceptual modality nor the object, but the mechanisms of transduction. Humans and land animals must breathe to perceive smells. The posited explanation is that inhalation causes a flap to open within the nose thereby allowing air to come into contact with the receptor site, which also would explain why we cannot smell underwater due to the lack of air.

As reluctant as I am to force historical debates into conformity with modern contexts, it is possible to see an extension of Aristotle's theory within the current scientific theories of primary olfactory transduction. If what we smell is the same as the chemical components responsible for flavor then it is possible to reinterpret Aristotle's theory such that the olfactory object is the chemical composition responsible for causing our experiences of flavor in taste and smell. Given Aristotle's recognition of the similarity of the perceptual object between the chemosenses it seems plausible to think of the next section, that considers the olfactory object to be the chemical structure of molecular compounds, as just filling in the science required for Aristotle's theory. However, a better way of putting it is that the next section is extending his suggestion that we can demarcate the senses in terms of their proper objects whose nature depends upon the composition of matter. In what follows my theory has similarities to Aristotle, but his claimed lack of direct contact with matter presents a point of contrast, since direct contact between the structure of matter (which I think explains it qualitative character and allows for an explanation of the olfactory quality) seemingly happens at the olfactory receptor sites.

Alternatively, Aristotle's view might be updated using Turin's vibrational account of primary olfactory transduction.[23] According to his theory our sense of smell is not caused by direct contact with a molecule that is lodged within a receptor, but rather the vibrations caused by its electrons tunneling between the odor and olfactory receptor neurons. This would allow the idea that the olfactory object and smells require some manner of mediation and not direct contact. Since my own theory allows for Turin's account of primary transduction, we

[23] A detailed exposition of Turin's theory is offered in Section 2.6.2.2below.

should now turn to consider the view that the olfactory object and its quality have something to do with the structure of chemical objects.

2.6 Chemical Objects (Material Objects)

If olfaction is a perceptual modality sensitive to chemicals then *prima facie* it is best to specify olfactory objects in light of chemistry. Since chemistry studies matter, which is defined as anything with mass and volume, the criteria of a material object ought to be any object that has a chemical structure such that it has mass and occupies space. For human beings we can specify which material objects are olfactory objects by noting the size of molecules (not larger than twenty chemical groups and no smaller than three) that we are biologically able to detect.[24] The general requirements for an odorant are that it should be volatile, hydrophobic and have a molecular weight less than approximately 300 daltons (Ohloff, 1986).[25] However, our biological limitation should not exclude chemical structures outside of this range from having a smell. What we can experience as having a smell should not limit our view of what metaphysically can have olfactory qualities.

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[24] Specifying the olfactory object in this manner rules out ordinary objects, for while they might satisfy the criterion of being composed of chemicals and having mass and volume, their chemical size would clearly fall well beyond our bounds of perception.

[25] In humans, the cut off for a chemical structure's size having a quality of smell is not gradual. This was demonstrated by Wrobel and Wannagat (1982) who documented (using benzenoid musk in which a carbon atom was replaced with a larger silicon atom) that the addition of the larger silicon atom caused the entire molecule to become odorless.

Most of the things that we smell are chemical mixtures composed of multiple molecular compounds, so one might wonder if the olfactory object is best identified with either the molecular structure of chemical compounds or the molecular mixtures reminiscent of odor theories (Section 2.4). I think that the answer is that the olfactory object is the molecular structure of simple molecules and the molecular structure of the components of a chemical mixture. Both give rise to full olfactory experience of an entity that has extension and can be tracked across an environment through its changes of properties. The olfactory object is the structure of molecular compounds within an odor cloud, where the later is defined as the diffusion of molecules in space and time. Thus identified, the olfactory object includes both the posits of the ecological and odor theories with the advantage of allowing for the olfactory qualities of simple molecular compounds.

2.6.1 Olfactory objects are the chemical structures of matter

The olfactory object is the chemical structure of molecules, not the molecules themselves nor the elements that compose the molecule, but the actual three-dimensional structure of the molecular compound (see figure 3). What is meant by 'the molecular structure' is not any abstract property or specification of the molecular compound, but its actual three-dimensional structure. While it is natural to think of molecular structure as two-dimensional as

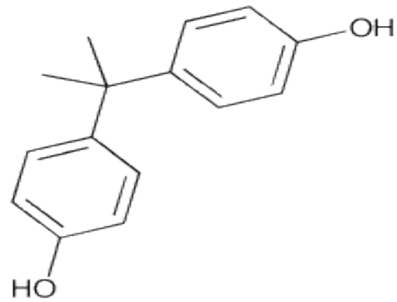

Figure 2: Two dimensional depiction of Bisphenol A (4,4'-(propan-2-ylidene)diphenol)

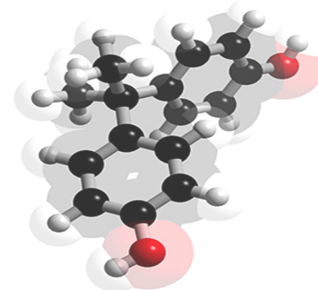

Figure 3: Three dimensional depiction of Bisphenol A (4,4'-(propan-2-ylidene)diphenol)

in a similar fashion to the depiction in Figure 2, a more accurate aid to conceive of molecular structure is shown in Figure 3. Empirical evidence for identifying the olfactory object with the molecular structure of elemental compounds is derived from the leading scientific theories of primary olfactory transduction, our physiological olfactory capacities, psychological olfactory abilities, and animal models of olfaction.

Within the scientific community it is uncontroversial that what is responsible for our olfactory experience and what we smell, is the structure of the molecules coming into contact with our olfactory epithelium. What is debated is the precise property of the molecular structure that determines an olfactory object's quality. The leading explanations are that either the shape of the molecule determines its smell or the vibrational patterns of the functional groups within the molecule determine its quality. Both approaches agree that in principle the molecular structure is the olfactory object, but disagree about the property of the structure which determines the olfactory quality of the chemical structure. The next section discusses two interpretations of the relationship between the molecular structure of an odorant and its qualitative character (what it smells like). My exposition is neutral between shape theories and vibrational theories, since the issue of primary sensory transduction is still under debate. Claiming that the olfactory object is the chemical structure of molecular compounds leaves it open as an empirical matter that can be settled in the future as to the precise property of these objects which is responsible for their qualitative character.

Evidence for smelling the structure of matter

2.6.2 Physiological evidence

Evidence that the olfactory object is the molecular structure of matter can be derived from studies on stimuli transduction by the olfactory system. While the details of primary transduction are contentious, given the aforementioned shape versus vibration debate, both sides agree that the molecular structure is the olfactory object but disagree about what aspect of the structure is responsible for olfactory qualities. Odotope theory (Mori & Shepherd, 1994; Shepherd, 2005) and Turin's biological spectroscope theory (Turin, 1996, 2002, 2006; Turin & Yoshii, 2002) share the view that a distributed activity pattern across multiple ORNs determines the qualitative character of the olfactory object, but disagree about both the aspects of the structure and the mechanisms of stimuli transduction that are responsible for the olfactory quality of the object of our olfactory experiences.

2.6.2.1 Shape Theory

Traditionally the olfactory object is identified with the three-dimensional shape created by the molecular structure of the odorant. The strength of this approach derives from its cohesion with the general idea that the shape of a chemical structure is responsible for its molecular reactions within biological organisms. Linus Pauling (1946) is credited as the originator of the shapist approach, because of his general biological assumption that the shape of chemical structures is responsible for the molecular interaction that occurs between a stimulus and receptor. The best analogy of his ligand receptor model of molecular interaction is the lock and key model of enzymes or antigens in the immune system. According to the lock and key model, the stimulant literally binds with the receptor molecule by fitting into part of the molecular structure, i.e. the enzyme or antigen binds to the receptor molecule and the fit of the two together determines whether or not a chemical interaction ensues. The assumption that primary transduction is a matter of the shape of the odorant, places the mechanisms of smell firmly within well-documented and accepted biological processes. The theory could not be tested until recently, with the determination of the genetic basis of the receptor cells in olfaction by Buck and Axel (1991). While we now know the genetic nature of the ORN, we still do not understand how primary transduction is accomplished.

Pauling's assumption, that shape determines the molecular interactions in biological organisms, was developed into the shape theory of olfaction by

Moncrieff (1949), Amoore (1970), Rossiter (1996) and Frater, Bajgrowicz, and Kraft (1998). Their core claim is that the spatial location of the atoms within the molecule determine its shape and thereby its smell. More specifically, the molecular structure is determined by the lowest-energy position of the compound's atoms as determined by quantum chemistry (Turin, 2002). Accordingly, it is the shape of the molecular compound that determines its quality (what it smells like to us). Modern varieties of the claim that the shape of an odorant determines its smell come in two strengths: a strong theory and weaker theory.

According to the strong view there must exist one ORN for each odorant that we can detect, discriminate, recognize, or identify, since each ORN is specifically sensitive to one and only one molecular shape. To return to the lock and key analogy, there must exist one particularly shaped lock for each odorant that we can smell to bind with. What is problematic about the strong shape theory is that the research of Buck and Axel demonstrates that we only have one thousand genes responsible for generating ORNs, which produce at best three hundred functional receptor types, while our olfactory discriminative ability is seemingly unbounded. It has been claimed by many olfactory scientists that we can identify somewhere between 1,000-10,000 different odorants, however, no study has actually demonstrated this result and at best it is a rough estimate pulled out of thin air.[26] Thus, the strong shape view is untenable, since the

[26] For a fantastic treatment of this issue, which nicely shows the history of this estimate see Chapter 1 of Gilbert (2008).

number of odorants we can smell vastly exceeds the number of ORN we possess.

A more plausible shape theory can be generated by weakening the isomorphic structural relation condition, which by claiming that either a single ORN is sensitive to more than one shape or the shape is recognized by a distribution of ORNs that the molecule comes into contact with. The first option is the low-affinity model, according to which the receptors of the ORNs entirely swallow the odorant, but the shape of certain molecules fit the receptor's cavity better than other. The degree of binding is supposed to create different firing patterns based on the affinity of the receptor with the odorant, which should allow a combinatorial explosion of sensitivity from a limited number of receptor types. The second option is the odotope theory, which claims an odorant's smell is determined by the shape of the molecule as encoded by a pattern of activity across multiple receptors (think blind people feeling an elephant). Since odotope theory is the most prevalent and biologically plausible candidate, I shall only explain odotope theory in what follows.[27]

The odotope theory and its name was introduced by Mori and Shepherd (1994) who claimed that the smell of a molecule is determined by a pattern of excitation and inhibition across the receptors it binds to. Their theory focuses on the receptive fields of ORNs for stimuli transduction. Each odotope is typed using

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[27] Additionally, the only mention of the low-affinity model that I can find appears in Turin (2002), who argues for the alternative Vibration theory.

the receptive fields or patterns of activation at the level of glomeruli and not within the epithelium itself.

> The activity pattern may be termed an 'odor map' or 'odor image', representing the information in the 'odor object', just as a 'visual image' represents the information in a 'visual object'. A key challenge for current studies is to understand how these images represent the world of odor molecules in two-dimensional neural space as the basis for smell perception, just as retinal images become the basis for visual perception. The images evolve during stimulation, adding a time dimension to the representation (Shepherd, 2005, pp. i3-4).

Our experience of the smell is caused by how the shape creates a distributed pattern of activity across the glomeruli within the olfactory bulb, which suggests that the quality of smell is determined by the shape of a molecule.

Additionally, Shepherd (2005) argues that the odotope theory can specify the sensory primitives of the olfactory systems using the minimal detectable difference between molecules. The primitives are specified in terms of molecules differing in one carbon atom based on the work of Imamura et al. (1992). Consequently, what determines the type of smell an odorant might possess can be as small as one functional group. The further problem of explaining how these sensory primitives realize the quality of a compound molecule is an ongoing research project.

The strength of the odotope theory is that the biological mechanism responsible for our experience of a smell is well-documented throughout biological organisms, thereby placing olfaction on a continuum with other biological systems such as digestion and immunology. Furthermore, it is part of a successful research project documenting the feed forward activation patterns within the olfactory system responsible for stimuli transduction.

What is problematic about this approach is that it cannot predict the smell of a molecular compound from its sensory primitives, i.e. it cannot predict the smell of a molecular compound from its shape alone. While the shape theory cannot predict the smell of an odorant from its molecular shape and generally the generation of new odorant compounds is performed by a brute strength approach of the large Flavor and Fragrances houses, the approach has had some predictive success with violet smells (Rossiter, 1997; Kraft, 1999). Nonetheless these are but few cases of success within a sea of mistrials. Additionally, there are many molecules that smell alike, but are completely different in shape or that are similar in shape, but differ in smell. Thus, the shape theory cannot be the whole story at this point in time, but must be supplemented with further research.

A further problem for the odotope theory is that if the quality of smell is based on the mere shape of the molecular structure of chemical compounds then we should be able to generate antagonists of smells in the same way that antagonists are generated for enzyme reactions. However, no antagonists have been discover and certainly not for a lack of trying. Currently, we cannot block smells, rather at best a deodorizer can mask a foul odor with another more pleasing smell. Thus, discovering an antagonist for smells is a huge industry with tremendous resources, which is unsurprising given how lucrative an odor blocker could be for application in industrial livestock farming.

2.6.2.2 Vibration Theory

The vibration theory of smell fell out of favor in the seventies, but has been recently revived by Luca Turin. Though Turin is not a trained olfactory scientist, his expert knowledge of perfumery, work on electron tunneling between proteins, and interest in biophysics led him to develop a biologically plausible account of the vibrational theory. His theory proposes that the olfactory system employs a spectroscope to detect the smell of a molecular compound's structure based on the vibrational frequencies of its functional groups. Turin's theory combines Dyson's vibrational theory, with Wright's spectroscope and proposes a plausible mechanism of biological spectroscopy based on electron tunneling across the functional groups of a molecule thereby allowing the receptor to be sensitive to the vibrational frequency of the molecular compound.

Dyson (1938) claimed that the nose is sensitive to the vibrational frequencies of molecules. The mechanism that he thought was responsible for frequency transduction was a spectroscope. However, his approach was problematic, because physical spectroscopes are too large to fit within the nose and biological spectroscopes seem implausible. A spectroscope consists of a light source, a prism or lens, and a detector. While the light source often used is infrared, such a light could not exist within humans since it would simply be too hot. Since we are mostly composed of water having an energy source of this variety within us would cause much damage, as well as create serious transduction issues with odorants that are volatile but hydrophobic. Thus, Wright

(1954) rejected the spectroscope assumption of the vibrational theory in favor of mere mechanical transduction. The mechanical transducers in the nose were meant to be sensitive to the thermal motion of molecules and thereby capable of determining their vibrational frequency. What became problematic about Wright's mechanical vibration theory was the range of vibrational frequencies that we were mechanically sensitive to. The range he posited was simply too limited relative to the full range of the frequencies of odorants to which we are in fact sensitive.

What makes the vibrational theory attractive is that it can account for why no two molecular structures possess an identical smell, our unbounded ability to easily detect novel smells, as well as our capacity to discriminate odorants based on their functional groups alone. The downfall of the theory came about based on Dyson's vibrational calculations being incorrect, leading people to doubt his posit of an olfactory spectroscope. Compounding the problem was that Wright's approach limited the frequency range too drastically. The final blow to vibrational theories came with the discovery of enantiomers, identical molecular structures that differ only in their chirality's (molecules that are structurally identical, but are mirror images of each other). The enantiomers of Menthol and Carvone had equivalent vibrational properties, but were discovered to have different smells, thus creating a simple counterexample to the claim that vibrational frequency of molecular structures alone determines the quality of smell.

Turin's theory rejects Wright's mechanical transduction of vibrational frequencies and posits a plausible biological spectroscope, which is sensitive to the vibration of chemical groups, based on inelastic electron tunneling. The crucial piece of the puzzle that Turin added was that different receptors are sensitive to different energy levels based on electrons tunneling through the molecular group within the receptor cell's gap, thereby allowing us to build a composite representation of the entire molecular structure from the frequencies of its functional groups.

> The range of vibrational energies is covered piecewise by a series of receptors tuned to different energies. …To cover the vibrational spectrum, several receptor classess would be required, each tuned to a different segment of the vibrational spectrum. A small number might be sufficient, much as three pigments with broad, partially overlapping absorption spectra suffice for color vision…. A similar arrangement exists in the other spectral senses, vision and hearing, in which broadly tuned receptors classess cover segments of the complete spectrum (Turin and Yoshi, 2002 pp. 10-11).

Although electron tunneling was commonly known in physics, what Turin (1996) added was the idea that electrons can tunnel not just between metallic compounds, but between proteins as well. Electrons are known to be able to jump over gaps between two compounds so long as the energies of each are identical. Electron tunneling occurs when an electron covers the same distance between two compounds that differ in their energy levels by entering an intervening object that allows the electron to change energy levels. To put things in terms of olfaction, if we conceive of the receptor as having a receptacle which the molecule fits into, then the electrons of the receptor site can tunnel through the odorant by changing energy levels, thereby creating a prediction of the functional group within the receptor by calculating the change of energy level the electron undergoes from one side of the cleft to the other.

Turin's theory can explain how two molecules possessing the same shape can differ in their quality of smell since their functional groups might differ, which would create a difference in vibrational frequency, but not shape. Moreover, the theory predicts that molecular structures differing in shape can nonetheless share a common smell so long as their vibrational frequencies are similar. The prediction of a shared smell between differently shaped molecular structures was validated by nitral functional groups smelling the same as boranes (Turin, 1996).

The vibrational theory also accounts for our ability to detect functional groups, explains how isoteric molecules and isotopes smell different, as well as how isotope substitution creates a different smell (Turin, 2002; Turin and Yoshi, 2002). However, vibrational theory cannot account for how molecular structure can yield changes in intensity, while the quality remains constant.

The greatest problem for Turin's theory is that his transduction mechanism is novel and unproven. While Turin (2002) demonstrates the predictive nature of his theory it does not prove it to be biologically accurate. Furthermore, one might doubt a great deal of his results, since none of his comparisons between molecular structures have been tested in any empirically rigorous manner. Most of his claimed results depend upon either his own olfactory experience of an odorant or the acceptance of others testimony (usually perfumist and chemical experts) regarding the quality of molecular compounds and functional groups. Without proper psychological and neurophysiological experimentation, his claims regarding the similarities and differences of molecules and functional groups must be treated within a certain degree of scepticism. Perhaps his claims are best treated as phenomenologically valid with a rational theory to support his approach. But, as things currently stand a great deal of experimental work still needs to be accomplished.

For my purposes, I shall leave the debate between shape and vibrational theories aside, since the issue of primary sensory transduction is still under debate. My claim that the olfactory object is the chemical structure of molecular compounds leaves it open, as an empirical matter that can be settled in the future;

> In summary, it seems fair to say that if the ultimate goal of a theory is predictive power, then both odotopes and vibration still fall short. Neither theory, when faced with a novel molecule, is yet able to predict reliably what its odor character will be (Turin and Yoshi, 2002, p. 27).

2.6.3 Psychological evidence for smelling matter

Aside from perfume chemists[28], most of us would be surprised to learn that we can detect, discriminate, and perhaps even identify the molecular structure of the things we smell. Yet, we can discriminate miniscule differences between and

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[28] Burr (2007) gives a wonderful example of a perfume chemist who can name the chemical structure of common smells throughout an entire plane journey from the lemon smell of the hot towels through the chemical odorants used in the bathroom disinfectants at their destination.

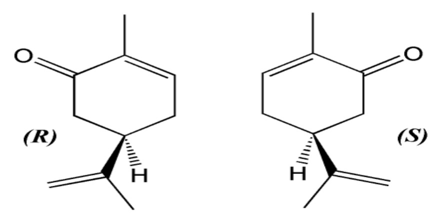

Figure 4: R-carvone and S-carvone

within the molecular structure of odorants. The greatest source of evidence for this claim is enantiomers. Enantiomers are molecular compounds whose structure and functional groups are identical, but whose chiral properties (handedness) differ, such that the molecules cannot be symmetrically superimposed on top of each other. While most enantiomers have the same smell (and we cannot always detect both)[29], some do not, such as carvone where the R molecule smells minty, while the S smells like caraway (Figure 4) (Boelens and van Gemert, 1993).[30] Thus, some of the time the symmetry of the functional groups and the orientation of a molecular compound is responsible for a different quality of smell.[31]

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[29] Since anosmia of a given enantiomer varies across populations, most flavor and fragrance products contain both enantiomers to ensure that the entire population is sensitive to the odor.

[30] The most exhaustive list of the smells of enantiomers is maintained by John Leffingwell. According to Turin's (2006) calculations of Leffingwell's listing, 64% of enantiomers smell the same, 17% smell different and the remaining 19% are currently unknown. Interestingly, for at least 17% of the known enantiomers our sensitivity to their chemical structure creates a different experience of smell.

[31] It might be argued that the structure is responsible for the smell only some of the time, while in most cases something else must be responsible for smell, since their structures differ, yet this does not yield a different sensation of each. For this criticism to be

Furthermore, even when we are aware of the enantiomers as smelling the same, we can still discriminate between the two structures. Li et al.'s (2008) work on olfactory sensory conditioning using classical conditioning demonstrates that the difference between the enantiomers structures can be detected. Their results suggest that while the optical isomers are supraliminally indistinguishable, we can nonetheless through training discriminate between these two structures. which can be interpreted as evidence for phenomenally conscious differences between each experience even in the absence of awareness.

Li's work is novel for its use of indiscriminate stimuli to see whether or not conditioning could create an ability to discriminate between sensory conditioned stimuli that were previously perceived as identical. To demonstrate that conditioning can change our sensitivity to previously subliminally identical stimuli, they paired a shock together with one of the perceptually identical enantiomers. The experiment design was quite simple and initially subjects were tested in a set of trials using three bottles containing the enantiomers. Two of the bottles contained the same chiral, while the third held the alternative chiral molecule. The results of these trials showed the subjects performing at chance. However, after pairing the conditioned stimulus (one of the enantiomer) with a shock the individuals discriminative abilities increased by a factor of two. Their results suggest that while the optical isomers are supraliminally indistinguishable we can

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effective what would need to be determined is the number of enantiomers within the set that have the same smell and the percentage of these with which we can detect both enantiomers. What needs to be generated is the ratio of anosmias relative to both optical isomorphs.

nonetheless through training discriminate between these two structures. This can be interpreted as evidence for non-conscious qualitative differences between each experience. A point of interest is that though the smell of these two objects was the same for the subjects and their ability to discriminate between the two was trained, the subjects ratings of the valence, intensity, or familiarity of these structures did not change. This further suggests that while two objects might be different structurally the properties of the objects themselves remain static, since their structures do not give rise to a change of the qualitative character of the olfactory object.

Enantiomers are but one example of our ability to discriminate between the molecular structures of chemical compounds, since we are also able to distinguish between compounds differing in one carbon group. Lamura et al. (1992) have documented our ability to detect a difference of one carbon group between odorants. The case of Aldehydes[32] nicely demonstrates our sensitivity to changes in functional groups. What is so intriguing about Aldehydes is that as carbon groups are added, the smell of the compound changes (Turin, 1996, 2006). Aldehydes C-8 through C-12 display an interesting shift as each carbon group is added - the compounds with an even number of carbon groups smell fruity, almost orange-like, while the compounds with an odd number have a floral waxy odor (Arctander, 1994).

[32] You might recognize Aldehydes, but not by name. The primary synthetic ingredient in Chanel No. 5 (and what makes it so distinctive) is Aldehydes.

Further evidence for our ability to psychologically detect the structure of molecular compounds is yielded by our capacity to detect the presence of functional groups (Klopping, 1971). Functional groups are atomic groups within a molecule that account for its chemical properties and structure. Functional groups can be interchanged within molecules to create a change in the qualitative character of an odorant in a predictable manner:

> The case of thiols (-SH) is familiar, but other chemical groups such as nitriles (-CN), isonitriles (-NC) oximes (-NOH), nitro groups (NO2), aldehydes (C=O(H)), can be reliably identified once the odor character the functional group character confers is known. When nitriles are used as chemically stable replacement for aldehydes, they impart a metallic character to any smell: cumin nitrile smells like metallic cumin (cuminaldehyde), citronellyl nitrile smells like metallic lemongrass (citronellal), and nonadienylnitrile smells like metallic cucumber (nonadienal). Oximes give a green-camphoraceous character, isonitriles a flat metallic character of great power and unpleasantness, nitro groups a sweet-ethereal character, etc. (Turin and Yoshi, 2003, p. 11)

Treating the olfactory object as the structure of molecular compounds fits with these results, since the chemical structure of functional groups determines the characteristic smells of molecular compounds in a predictable manner.

In a rather odd way, identifying the olfactory object with the structure of the molecular compound explains the Laing effect. Laing and Livermore (1998) and Laing (1998) have nicely documented our ability to identify odorants within a complex odor. They discovered that even if we have access to the individual odorants on their own, when these are combined into a chemical mixture subjects can identify at most three to four of the components. These results are actually not surprising given the combinatorial nature of olfactory perception as outlined in the introductory chapter and my thesis that the olfactory system employs a functionally compositional system, (this will be argued for further in Chapter 3).

The Laing effect makes sense if the olfactory object is the structure of molecular compounds, because when simply chemical structures are put together to form complex molecular mixtures the chemical parts no longer behave as they would on their own (Earley, 2005). Additionally, our inability to identify parts of a complex odor might be explained by the format of the combinatorial representation as outputted from the piriform cortex (Wilson and Stevenson, 2006). According to this line of thought, while discrimination and detection might be a synthetic process at the receptor level, identification and recognition might require cortical feedback from the piriform cortex, which itself is not representationally fine-grained enough to encode the minute differences between the structural components within the molecular mixture.

2.6.4 Evidence from Animal models of olfaction

In keeping with my introductory assumptions[33], since the olfactory system is ontogenetically ancient, we may infer a great deal about our olfactory experiences from animal models. Aside from being a generally accepted practice throughout the sciences, Aristotle also supports the methodology of treating our sense of smell on a continuum with other organisms. Animal models do not provide any further evidence, but only reinforce the claim that the olfactory object

[33] Chapter 1, Section 2.

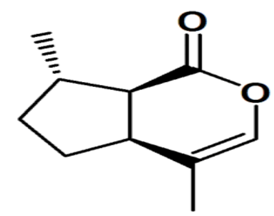

Figure 5.
(4aS,7S,7aR)-nepetalactone

is the structure of molecular compounds given the shared ability of rodents and aphids to discriminate between enantiomers, as well as the circuitry of animal olfaction showing a similar effect to Laing's, when transducing molecular mixtures of more than two components.

Enantiomers have different behavioral effects across species. For instance *Aphidius ervi* is attracted to one enantiomer of nepetalactone (7S), but not the other enantiomer of nepetalactone (7R) (Figure 5) and when the two are combined the effect is an overall reduction in attraction (Glinwood, Du, and Powell, 1999). However, since this example concerns the effects of pheromones using the vomeronasal system, which is absent in humans[34], it is questionable whether these results should be generalized to humans. Luckily, further studies of enantiomers using animals have been conducted using rats. Rats can discriminate between caravone (R) and (S), which we have already noted smell different to humans without any training. Also, with some training, rats can learn

[34] Pheromones and the vomeronasal system in humans are mentioned in Chapter 1 in the introduction to Section 3, but they will not be dealt with here since their existence and role within human olfaction is questionable.

to discriminate between limonene (R) and (S) (Wilson and Stevenson, 2006). These results further strenghten my claim that the object of olfaction is the molecular structure of chemical compounds and that it turns out the olfactory object is identical across species.

2.6.5 Olfactory properties

Having argued for the identification of the olfactory object with the chemical structure of molecular compounds, what remains is to specify the properties of these objects. Aside from the spatiotemporal properties, which are best determined empirically for each molecule or mixture according to the laws of chemistry, the other properties of the olfactory object are intensity, concentration, valence, and hedonic value.[35]

Intensity is simply the strength of the quality of smell. Concentration is best thought of as the density of molecules of a particular odorant within its spatiotemporal boundary.[36] Thus, one might have a smell that is not intense, but highly concentrated. For example, the intensity of Coumarin[37] is quite weak, but

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[35] Experimental evidence for these properties of the olfactory object can be derived from the study in Li et al. (2008), for while subjects' ability to discriminate between enantiomers that smell the same were trained, their ratings of the valence, intensity, or familiarity of these structures did not change. Since the structure did not give rise to a change of the qualitative character of the olfactory object, the properties of the object remained static.

[36] Further evidence for concentration being a property of the olfactory object derives from the finding that as one increases the level of concentration of an odorant in a given spatiotemporal location, a new olfactory percept will be formed (McNamara et al., 2007), in the same way that changing the saturation of a given hue will result in a different color.

[37] Coumarin smells of golden green, fresh, cut grass on a long, sunny, summer afternoon.

walk through the men's fragrance department of Macy's and the concentration level of these particles becomes unbearable.

The nauseating smell of any department stores fragrance section nicely segues into the next property of valence[38] or pleasantness of an odor.[39] The last property I would like to posit, is hedonic value for the subject as opposed to just valence. Some people, like myself, find the smell of skunks disgusting, but nonetheless quite pleasant.[40] The later properties are certainly a matter of learning and enculturation, while the first two seem to be neurophysiologically driven.

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[38] Yeshurun and Sobel (2010) recently produced a rather exhaustive review of the literature on olfactory detection, discrimination, and identification. Given our strong capacity for the first two and utter incapacity at identifying olfactory objects based on their quality of smell, they argue that the molecular structure and pleasantness of an odor determines the olfactory object. The theory is certainly novel and interesting, but their criteria of objecthood is unclear, especially given their claim that the olfactory object is a combination of external molecules together with a subjective judgment of pleasantness based on one's homeostatic state. However, it might be possible to reject their theory on more serious grounds by generating a more plausible explanation of the data cited in support of their theory.

Their argument depends upon the assumption that if we are bad at identification tasks, but good at labeling pleasantness then the olfactory object is determined by hedonic value. But, we might be poor at odor identification, because this requires the linguistic deployment of concepts something that we are particularly bad at for olfaction. The alternative explanation of our poor capacity for naming and identifying olfactory objects is that it is a performance issue and not due to the nature of the object. Our olfactory experiences cannot be fully captured using concepts, because the representational format of olfactory experience occurs in a combinatorial, but not classically compositional system that is employed for concepts. Additionally, it might be better to consider pleasantness as a property of the olfactory object that can vary across time and situations, since steak always smells like steak, but if I have just consumed thirty-two ounces of prime rib it might be the most repulsive thing I have ever smelled.

[39] There have been a few cross-cultural studies demonstrating that valence is not innate, since it varies across cultures such that the smell of fish in certain island nations such as Japan is treated as neutral, while in landlocked nations, such as Bhutan, fishy odors are considered most unpleasant (for a good review of these studies see Gilbert, 2008).

[40] While an extremely intense odor might cause a shift in valence, Wilson and Stevenson (2006) are careful to point out that intensity is a property separable from hedonic value.

2.7 Objection 1: But aren't smells subjective?

Often people claim that smells and what we smell are subjective. If interpreted extremely charitably, they could be referring to the hedonic value, or valence of an olfactory object. However, attributing this level of sophistication about olfactory properties to the average human is quite dubious, aside from the fact that it is not the smell of an object (its quality) that is often thought to be subjective, but the very object of the olfactory experience. What is more likely is that our intuition about the subjectivity of smells is similar to the view found in sensational theories of the olfactory object.

Sensational views (Locke, 1690; Peacocke, 1983, 2003; Reid, 1764) are characterized by the claim that smells are subjective and require a perceiver or mind for their existence. Smells are merely sensations within the mind. The rose smell does not objectively inhere within the rose, rather the only time a rose smells like a rose is when it is being smelled.

Motivating the sensationalist theory is the reflection that when we experience smells, the olfactory object often presents itself to us as arising in an unmediated manner within our inner consciousness. Phenomenologically our experience of smell quite often seems to be internal, entirely qualitative, and non-representational (Lycan, 1996, 2000).[41] Yet, the claimed phenomenology of olfactory experience should not handicap our theories if a better explanation can

[41] Lycan (1996, 2000) does not endorse these claims, but merely identifies them as our default folk psychological pre-theoretic conception of olfactory experiences, which he refutes in favor of an odor theory of the olfactory object.

be generated that accounts for this phenomenology without being held captive to the appearances of our experience.

Though he only mentions olfaction in passing, while drive-by theorizing, Christopher Peacocke echoes the sensationalist idea that smells might be subjective and mere sensations. In *Sense and Content* (1983) Peacocke asserts that our olfactory experiences are not representational or world-directed, but merely sensational in content. Peacocke (2008) is only slightly more elaborate and allows that our experience might represent the air in our nose as having a scent, but “what it is for the air to have this scent is plausibly explicable only in terms of an experience of this scent; that is, only in terms of the sensational property of his olfactory experience” (p. 2).[42]

Peacocke’s key claim is that olfactory experiences are sensational. He does not offer any argument for his claims about the nature of olfaction, but simply offers them up as terse assertions. His general arguments (1983) derive from the nature of our visual experience in size constancy, the difference between monocular vs. binocular vision, and switching aspects of a three-dimensional figure in visual illusion. Using these phenomena, he argues that the experiential content cannot be adequately captured in a representational

[42] I shall not deal with either his anti-representational or world-directed claim here, since it will be shown in Chapter 3, Section 1.1-3 that olfactory experience can misrepresent or occur in the absence of an olfactory object, both adequate evidence for olfaction’s representational nature. Regarding his world-directed claim, if the empirical evidence and arguments of Section 2 regarding the spatial-temporal characteristics of smells are correct, then it seems that the olfactory object is located externally to us within a three-dimensional space – a pretty good candidate for world-directedness.

(conceptual) manner. There is something more about the experience (qualia) that outstrips our representational systems and concepts. Yet, the examples he provides are visual with an auditory example thrown in from time to time, thus without some form of olfactory outstripping argument, he is making unsubstantiated assumptions about olfaction functioning in the same manner as vision without any supporting evidence. If I am correct that the olfactory object is merely the chemical structure of molecular compounds, there can be no outstripping of the qualities of smell. For every change to the chemical structure there will be a corresponding difference in the quality perceived by the subject, and as such our experience of the smell is never outstripped by its chemical and causal categorical foundation. Peacocke is wrong in assuming that the experience of a scent is only explicable in terms of it sensational properties. However, Peacocke's cursory theorizing about olfaction is not indicative of sensationalist theories. Reid generates one of the most exhaustive philosophical accounts of olfaction and the strongest case for the olfactory object being identified with mere sensations.

Reid (1997/1764) argues that smells depend upon sensations, since we cannot have the experience of a smell if the object is not present and we cannot cease having an olfactory sensation when the object is present. What he has in mind is a conception of the olfactory object as being sensations, which are directly caused by the object, yet at the same time relational secondary properties of the object. Reid notices that our vulgar common sense intuitions suggest the tension between the belief that a rose would not have a smell if not smelled by sentient creature, whilst the rose has powers to cause the experience of smells in us. The sensation of the smell of rose is a relational mind dependent property, but the rose has causal properties to bring about this sensation in us under the right conditions. Our common sense view is that something in the object is responsible for the smell, which the vulgar call smell and that exists even when it is not smelled. The object has the power to cause in us the experience of smell, but objects do not have smells independent of a nose attached to a mind sniffing them.

Reid's treatment of olfactory qualities as secondary qualities might be best elucidated in relation to Locke's secondary qualities. Reid upholds Locke's (1959/1690) distinction between primary and secondary qualities in an importantly different manner. Locke's distinction is best interpreted as a claim regarding the resemblance of the properties of our experience to their causal source, such that the primary properties are intrinsic to the entity and our representation of them resembles the causal source. Secondary qualities are mind-dependant, since their qualitative experiential nature does not inhere within the causal source and they in no way resemble their source. While primary qualities might be mind independent aspects of reality, secondary qualities are creations of the mind based on the causal powers of an entity's primary qualities. The most pertinent example of secondary qualities from *An Essay Concerning Human Understanding* is Locke's example of the smell of a violet:

> After the same manner, that the ideas of these original qualities are produced in us, we may conceive that the ideas of *secondary* qualities are also produced, viz., by the operation of insensible particles on our senses. For, it being manifest that there are bodies and good store of bodies, each whereof are so small, that we cannot by any of our senses discover either their bulk, figure, or motion, -- as is evident in the particles of the air and water, and others extremely smaller than those; perhaps as much smaller than the particles of air and water, as the particles of air and water are smaller than peas or hail-stones; -- let us suppose at present that the different motions and figures, bulk and number, of such particles, affecting the several organs of our senses, produce in us those different sensations which we have from the colours and smells of bodies; e.g. that a violet, by the impulse of such insensible particles of matter, of peculiar figures and bulks, and in different degrees and modifications of their motions, causes the ideas of the blue colour, and sweet scent of that flower to be produced in our minds. It being no more impossible to conceive that God should annex such ideas to such motions, with which they have no similitude, than that he should annex the idea of pain to the motion of a piece of steel dividing our flesh, with which that idea hath no resemblance (1959, Book II, Ch. 8, Section 13, p. 173).

In contrast to Locke's distinction, Reid considers both primary and secondary qualities as intrinsic to the object, their difference being simply understood as an epistemic issue regarding two ways of knowing about the object. Primary and secondary qualities are intrinsic to the object, which we can know directly, however, the primary qualities are intrinsic and can be known as such, while the secondary qualities are known directly, but through our sensation as relational properties of the object. To elucidate the difference between each conception of the distinction: for Locke smells might be construed as secondary qualities derived from powers in the object to cause a sensation of smell in us, while the smell might only be explicable in light of mind-dependent sensations; for Reid the object intrinsically has an odor quality, but we can only know of it via our sensations of the object.

Reid does not waver from his initial claim that smells are mind-dependent and explains the common sense tension as being a matter of imagination or the workings of the mind constantly conjoining the sensation with the causal object. The smell of an object (i.e. what it smells like) is nothing more than the “affection or feeling of the mind” (p. 40), but as this is constantly conjoined with the presentation of an object we misidentify the object with its smell:

> From what hath been said, we may learn, that the smell of a rose signifies two things. *First,* A sensation, which can have no existence but when it is perceived, and can only be in a sentient being or mind. *Secondly,* It signifies some power, quality, or virtue, in the rose, or in effluvia proceeding from it, which hath a permanent existence, independent of the mind, and which, by the constitution of nature, produces the sensation in us (pp. 42-3).

So long as Reid admits to realism regarding the effluvia of the rose then a research strategy might be employed to combat the slip to mind-dependent sensational objects of smell. If it can be shown that the sensational properties are the power, quality, or virtue in the rose, which can be specified in a mind independent and non-relational manner then the object of olfaction is not a relational mind-dependent sensation. The research strategy that the objects of olfaction must be specified in light of the chemical criteria of being a material object, combined with the evidence provided in the last section that what we smell is the chemical structure of molecules, provides just such a strategy which shows that smells are mind independent external and public objects. If in the future a theory of primary olfactory transduction is supplied, we should be able to ontologically reduce a smell to a molecular structure in a public and mind independent manner (which is not to claim that we could know what the molecule would smell like without sniffing it).

The most comprehensive theory of smell in contemporary philosophy is very similar to Reid's lengthy treatment. Perkins (1983) argues for an indirect-realist account of smell that is quite similar to Reid's sensationalist solution to our vulgar tension of identifying the smell as sensational and directly caused by its external source. Rather than identify the smell with some aspect of its source, Perkins conceives of the "sensible character of an odor as the odor's disposition to smell a certain way to us" (1983, p. 90). The smell of an object does not inhere within the object itself nor is it due to the causal powers of the object to cause in us a certain sensation, rather the sensation of the olfactory object includes a dispositional judgment that the ordinary object is attributed with that property. So we are not directly aware of the chemical structure that is responsible for our sensation of smell. The object of smell is an internal sensation, which we later project upon the object to which we attribute the cause of the sensation.

Perkins charitably develops an opposing direct realist theory of the olfactory object, however, his rejection of this alternative theory derives from a scientific lack of understanding of the olfactory system that existed during the Nineteen-Eighties. If it can be shown that the olfactory sensuous property does inhere in and is intrinsic to the chemical structure of odors then the direct realist theory he so painstakingly develops and rejects might be resuscitated. The evidence documented in Section 2 of this chapter regarding the olfactory object's ability to meet the criteria of being a visual or auditory object should provide reason to reject the idea that smells are merely mind-dependent entities. Furthermore, the previous section provided ample reason to think that the quality of smell is inherent to the chemical structure of molecular compounds and mixtures, which we directly perceive.

Based on the evidence covered in Section 6, the olfactory object is the chemical structure of molecular compounds, which determines both what we are smelling and what constitutes the objects olfactory quality (what it smells like). Thus, sensational and projectionist views are simply wrong headed. The olfactory object is an external object, whose quality is publicly accessible in an objective manner across subjects.

The olfactory object is not subjective. The quality of an olfactory object is inherent to its very chemical structure. What something smells like is not in the mind of the beholder, but an objective and publicly assessable aspect of the universe. What kinds of material entities are considered olfactory objects should be treated as separate metaphysical and epistemological issues. Metaphysically, everything composed of matter that has a molecular structure has a smell. However, how we know about their smells is an epistemic matter best left open for empirical discovery. For human beings, we can specify which material objects are olfactory objects by noting the size of molecules that we are biologically able to detect, as well as the conditions necessary for us to perceive these chemical structures (Section 6). However, our biological limitations should not exclude chemical structures outside of this range from having a smell. What we can experience as having an odor should not limit what metaphysically has olfactory qualities. Thus, animals or sentient creatures with a different biological system might be able to perceive odorants outside of our experiential range in the same way that we do not assume that the color spectrum begins and ends with our own sensitivity, but allow that some species might perceive colors in ultraviolet or infrared electromagnetic frequencies.

2.8 Objection 2: If we smell the chemical structure of matter does that mean we see photons?

It might be objected that if my theory of the olfactory object is extended to vision, it creates the absurd conclusion that what we see are photons. After all, the visual system is sensitive to the wavelengths of photons at the first stage of stimuli transduction within the retina, since these are the environmental stimuli received by the rods and cones. The stimuli received visually are just photons of given energy states. However, generalizing my theory of the objects of olfactory perception to the other perceptual modalities would commit the same theoretical crime this dissertation is meant to rectify. We should not assume that all perceptual systems work the same way and perceive the same kinds of entities. The object of our visual experience is best treated as outlined above (Section 2.1) in terms of spatiotemporal entities with clear boundaries.

The visual system is stimulated by photons, but this is not what it is primarily sensitive to or what we perceive. The primitives of the visual system are not infinitesimal dots, but lines and edges, whose encoding begins to occur at the ganglion level of photoreceptors (one step up from the rods and cones). What we see when we open our eyes are three-dimensional objects. We see structured spatiotemporally objects with clear boundaries, such as coffee mugs, tables, and the piece of paper in front of you. The visual system is wonderfully organized to be sensitive to the lines, edges, and their orientation that compose an ordinary object. The visual system is sensitive to photons with differing energy levels depending upon what they have been reflected off, however, we do not detect or discriminate between these entities either physiologically or psychologically. What we visually perceive are the spatiotemporal properties of bound ordinary objects, Moreover none of the arguments given for the view that the olfactory object is not an ordinary object, apply to the objects of visual experience.

The olfactory system is sensitive to the chemical structure of molecular compounds and these are what we perceive as smells. In olfaction, the objects that the olfactory receptors are sensitive to are the very same entities that we can physiologically and psychologically detect and discriminate between. The olfactory quality of the olfactory object is constituted by the three-dimensional chemical structure of the molecular compound as derived from the composition and placements of its functional groups. Thus, there is a very strong reason to suppose that my conclusion regarding the objects of olfaction should not be extended to vision.

2.9 Objection 3: But we don't report smelling chemical structures.

What is responsible for our olfactory experience is fully explained by positing external olfactory objects that are structured molecular compounds, yet we do not report that our experiences are of chemical structures. Phenomenologically, our olfactory experiences seem to present themselves to us as subjective sensations within our own consciousness. However, we have already seen reasons to reject phenomenology as the only source of data for theorizing about olfaction. Perhaps flavor and fragrance chemists have olfactory experiences of the chemical structures of molecular compounds, but for the rest of us, chemistry is something that we endured in high school. So how is it that the things we smell are chemical structures of molecular compounds and their functional groups? While undergoing an olfactory experience we do not report being aware of any variety of the posits of chemistry. I think the simplest reply to this objection is that we need not experience odors as the molecular structure of chemical compounds. Given that what we experience are smells and these are identical to the chemical structure of molecular compounds, it would seem that the only line of reply is that they possess different modes of presentation or senses.

The objection that this is not how our awareness of smells presents itself to us tacitly assumes that the olfactory object must be specified using the experiential content of which we are aware. Awareness of something usually carries with it the connotation of having an experience against the background of deployed concepts. To be aware of a smell as a molecular structure would require the use of a vast repertoire of concepts from chemistry, which most of us do not possess or deploy on a regular basis. However, I could also undergo the same experience, while deploying a different set of concepts.[43] Thus, my reply is simply that we can experience a smell where this is the molecular structure of some chunk of matter, without experiencing it as the chemical structure of matter. After all, someone might claim to be smelling a sweet flowery putrid undertone in Chanel No. 5, yet deny that their experience is of a large concentration of Aldehydes, since these differ in their mode of presentation even while being co-referential.[44]

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[43] If olfactory objects can be considered intentional objects based on the evidence in Chapter Three then there is a well-worn history of claiming that we cannot quantify into intentional attributions or reports of our beliefs or perceptual experiences (Frege, 1892/1997; Quine,1953,1956; Davidson, 1969). Thus, I might smell the chemical structure of molecular compounds, but not as such and I might even go so far as to deny that my experience was of such odd entities.

[44] Further evidence for this reply is provided in Chapter Three, where it isdemonstrated that our experiences of smells are represented in a nonconceptual manner. The nonconeptual format of smells strengthens my claim that while the object of our experiences is the molecular structure of matter, we do not experience them as such (based on first, our inability to deploy olfactory concepts with this level of precision based on the formative nature of our nonconceptual olfactory representations, and second, the fact that the richness of olfactory experiences outruns our conceptual repertoire).

2.10 Conclusion

Our intuitions and everyday linguistic practices often serve as a theoretical starting point in philosophy, yet they are not always accurate guides. We certainly talk about smells and claim that our olfactory experiences are object-directed. In everyday life, smells are individuated using our intuitive grasp of ordinary objects, thereby making the emanations of ordinary three-dimensional objects, picked out visually, our most natural conception of the olfactory object. However, our pre-theoretical intuitions and linguistic practices are themselves theory-laden. In this dissertation I have challenged our folk conception of smells, since it tacitly assumes a conception of the object of our olfactory perceptions that is generalized from vision. While we are doubtlessly primarily visual creatures, the visual system should not be the sole arbiter on what we can perceive.

Our best theory of the object of perception derived from vision does not adequately capture the nature of our olfactory experiences. The object of olfaction is not an ordinary object nor do the criteria used to ascertain and individuate the objects of vision and audition fully capture the olfactory object. Our olfactory experiences are of objects that are both spatiotemporally less truncated than those of vision and audition, yet at the same time are able to arise from such minuscule entities as simple synthetic molecular compounds. These aspects of the olfactory object generate reason enough to reject ecological theories of olfaction, yet at the same time they provide evidence that our olfactory experiences are of external objects in our environment.

Contemporary odor theories were also found wanting because they either cannot account for the qualitative nature of their olfactory objects (what is responsible for the objects smell) or are empirically untenable. Thus, I argued that the olfactory object was the structure of matter. What we smell is the chemical structure of molecular compounds within odor plumes. Support for my theory derived from empirical evidence based on our physiological abilities and from psychological data regarding our ability to detect, distinguish, and recognize the chemical structure of molecular compounds. Additionally, the olfactory object so conceived allows an explanation of what is responsible for the olfactory qualities of these objects. What each olfactory object smells like is constituted by the structure of the chemical compound as determined by its functional groups.

What we smell and what these objects smell like is not subjective, it is an objective fact about the nature of the material fabric of reality. The objects of our olfactory experiences are not similar to those found in vision, nor are they what we would expect pre-theoretically, based on either our linguistic practices or our first-person phenomneological reports of our olfactory experience. We smell the chemical structure of matter and the chemical structure of matter smells.

Chapter 3

The Nonconceptual Content of Olfactory Experience.

Treatments of the nature of experience tend to discuss the conscious aspect of the experience independently of the content of the experience. Though the division of labor entailed by this approach allows for clarity and precision, it should not come at the cost of giving a coherent account of our experiences. Studying olfactory experience provides novel insights into the nature of both mental content and consciousness. However, the magnitude of these topics requires treating them separately in this and the next chapter. I conclude by combining the consequences the case of olfaction provides for debates regarding consciousness and mental content to generate a more unified account of phenomenal consciousness and its content.

Olfactory experiences are different then visual or auditory experiences in ways that go beyond the mere difference in their perceptual objects. The content of our olfactory experience might have spatiotemporal dynamics in a similar fashion to vision or audition, but how they are encoded and represented is quite different. It is argued in this chapter that a novel understanding of nonconceptual content emerges from studying the representational content of olfactory experience. Olfaction suggests treating nonconceptual content as nothing more than mental content that is formatted in a nonconcatenative compositional manner. Methodologically, I sidestep the quagmire of a debate over the nature of nonconceptual content, by accepting that there is no consensus on the nature of concepts and by extension nonconceptual content. Yet it is widely agreed that whatever these creatures of the dark may be, they must to some extent be compositional. Thus, by process of elimination we can identify nonconceptual content as the content of cognitive states that are representational, but not compositional.

I argue in this chapter for two controversial claims regarding the mental content of our cognitive states. First, the olfactory system processes smells in a structural manner that is unlike the composition of thoughts or language. Second, some of the content of our olfactory experiences are represented in a format that does not involve concepts.

Evidence for the first claim is supplied by the combinatorial nature of our olfactory experience and our thoughts about smells. Together they challenge Fodor's (1976, & 1987, 1981, 2000, 2008) Language of Thought Hypothesis (LoTH), according to which thought occurs in a representational medium similar to language, such that each thought is the concatenation of its constituents. LoT theorists insist that all thoughts must occur in such a compositional rubric as evidenced by the systematic and productive nature of our cognitive and linguistic abilities (Fodor, 1981, 1987; Fodor & Pylyshyn, 1988; Fodor & McLaughlin, 1990). Using the work of van Gelder (1994) on functional compositionality, I have shown (Young, 2003) that the minimal requirements of a compositional system that can account for these abilities is a determination of the atomic elements of the system in combination with rules of formation, transformation, and well-formedness. Aside from being a viable theoretical alternative, olfaction actually implements functional compositionality.

Evidence for the second claim and a new conception of the structure of the contents of our cognitive states is offered using our aforementioned olfactory sensory and perceptual states, as well as the richness of our olfactory experiences. The Richness of Experience (RoE) argument is resuscitated using the functionally compositional format of olfactory content (Dretske, 1981; Crane, 1988; Martin, 1992; and Heck, 2000). Our experience of smell exceeds our conceptual repertoire not because of a lack of smell concepts or access to linguistic mediums to enrich our conceptual repertoire. Rather, the formative functionally compositional nature of the olfactory experience does not allow our conceptualized thoughts to capture the full sensory percept. The consequences of focusing on olfaction are that its content occurs in a representational medium that is not similar to vision or language, thus generating evidence for a new way of thinking about the syntax of our cognitive states.

3.1 Olfactory experiences have representational format

Studying the olfactory system yields a coherent theory of nonconceptual content as simply nonconcatenative compositionally formatted mental states. To generate this conclusion, the representational status of olfaction must first be established. Once it is allowed that olfactory states are representational, the nature of their representational format is dealt with by discussing mental syntax (or as I shall refer to it, 'psychosyntax'). The key claim of the latter part of this section will be that the minimal constraint of a state having conceptual content is that it must be classically compositional. Since some olfactory states are structured in a combinatorial manner, which is not concatenatively compositional, this allows for the conclusion that some olfactory mental states have nonconceptual content.

To establish that our olfactory experiences have representational content, some *prima facie* criteria for the representational status of the content of mental states and perception will be applied to our olfactory experiences. Rather than taking one standard of representational content as the sole criterion, the methodology employed is to survey a host of different intuitive and *prima facie* plausible criteria from across the spectrum of the debate regarding representational content.If olfactory content minimally represents things in such a way that goes beyond mere constant conjunction or isomorphic causal patterns, then our olfactory experience can represent x.[45] If it can be shown that our olfactory experience do not simply causally covary in a manner that suggest a mere isomorphic constant conjunction then the content of our olfactory experiences are representational. If our olfactory cognitive states occur in a manner that is not simply attributed to a closed causal system of stimulus to

[45] All that needs to be shown is that in some sense the content of our experiences or perceptual states represents something. I merely aim for the claim that they have representations of the stimulus. Whether or not they further represent things as x (in some conceptual fashion) will also be dealt with, but it is tangential to the main thrust of the argument.

sensory state pairing then I will presume that our experiences of smells have representational content. The key tests of this claim will be whether misrepresentation, intentional inexistence, and representing the objects of experience according to different modes of presentation can occur within olfactory experiences.

One of the key tests for representational content that separates perceptual states from mere sensory states is whether or not the state is brought about by isomorphic causal covariation such that if a given stimulus is in the receptive field of the animal it automatically creates a behavioral or sensory response (Fodor, 1987, 1990; Fodor & Pylyshyn, 1981; Dretske, 1981; Papineau, 1987, 1993; Milikan, 1984, 1993, 1994, 2000). The stimulus response behavior of cognitive states varying between stimulus detection and transduction should determine if the content of the state is representational in any sense.[46]

It was for concerns regarding the causal isomorphism between stimulus and sensational response of olfactory experience that led the sensationalists and Reid in particular to claim that olfactory experiences could not be representational (Chapter 2, Section 7). According to Reid, since we are forced to undergo an olfactory experience whenever the causal source is present and we can only have the experience when the causal source is present then the

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[46] Many naturalistic theories of semantics and intentionality are based on causation, but my claim in no way runs contrary to them. Olfactory states must go beyond causation to have representational content, however, this is perfectly in keeping with teleosemantic theories of content. Regardless whether one holds a consumer or producer based version of teleosemantics it is not enough for the state to be caused by a given stimulus: it also matters how the state is used by the system.

olfactory experience must be sensational. However, if it can be shown that we may abstain from undergoing olfactory experiences even in the presence of an olfactory stimulus or that we can elicit olfactory experiences in the absence of a causal source, in a manner that is not explicated purely in terms of brute physiological processes, this should be sufficient to show that these states are representational. That we can misrepresent what we smell both in terms of misattributions of the causal source and the identification of the object demonstrates that these perceptual states are representational.

3.1.1 Misrepresentation

The greatest test of whether or not a given state is representational is if it can misrepresent. If the content of the state can vary across presentations of the same stimulus then the perceptual or cognitive system must be capable of representing the initial sensory state in different fashions that go beyond mere causal connections. What concerns me here is only to show that misrepresentation does occur, as an explanation of the mechanisms behind misrepresentation is beyond the scope of this section. Olfactory misrepresentation most commonly occurs in two different forms: misattribution of the olfactory experience's causal source and misidentification of the olfactory object itself.

Misattributing the causal source of an olfactory experience occurs more frequently than one would expect. We commonly misrepresent what we smell.

We do not misrepresent what the odor is, but we misrepresent the nature of the olfactory object. The most prevalent contemporary cause of misattribution can be attributed to the ease with which industrial chemical companies produce a synthetic compound that causes an extremely similar odor, without the involvement of the usual natural ordinary object sources. For example, when walking by a Subway sandwich shop one is often presented with the delicate and sumptuous smell of freshly baked bread. However, the causal source of your experience is not freshly baked bread as you believe, but some chemicals being disbursed via aerosol cans around the shop. There is a sense in which the experience is not misrepresented, because the smell of freshly baked bread might be multiply realized by different complexes of molecular compounds that are present both in the vicinity of freshly baked breads and aerosol cans. The olfactory quality produced by both causal sources really seems the same. However, my attribution of a smell to something in my immediate vicinity gets the true nature of the present olfactory object wrong. While misattributing the causal source of our olfactory experiences is not a gross misrepresentation given that the synthetic chemical source produces a very similar type of olfactory experience, the exact chemical structure and particularity of each token experience is nonetheless different.[47]

Another example of misrepresenting the content of our olfactory experience is misidentifying the olfactory object. For instance, human vomit and

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[47] You are undergoing an experience that presents itself as the smell of baked bread, but you are not smelling freshly baked bread.

Parmesan cheese share some key chemical compounds responsible for their distinctive smells (Gilbert, 20008). While the smells of each of these entities are not chemically identical, when subjects are presented with one compound they commonly mistake it for the other and accordingly rate their valence and hedonic value based on the perceived identity of the object.[48] Thus, we misrepresent the olfactory object including its properties of valence and hedonic value.

Misattribution and Misidentification taken together support the representational status of our olfactory experiences. Based on these examples of the olfactory experience misrepresenting the initial sensory object, we can infer that the content of our olfactory experience occurs in some representational medium. Consequently, the constant conjunction of stimulus and response in a manner that does not allow for causal variation across parings of stimulus and mental state is ruled out by these examples.

3.1.2 Intentional Inexistence

A further criterion for whether a cognitive state can have representational content is whether the state can be contentful in the absence of a causal stimulus. Can the state represent something in the absence of a perceptual object or can it represent something nonexistent? If our olfactory experiences can occur in the absence of an olfactory stimulus this will at least falsify Reid's second claim that we cannot have an olfactory experience in the absence of an

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[48] From my own experience, this example works best with fresh room temperature Parmigiano-Reggiano and baby spit-up, though I must admit to not fully testing this claim across all types of parmesan cheese and human vomit.

olfactory object. There are at least three good example of contentful olfactory experience in the absence of an olfactory object. The first two deal with disorders of the olfactory system involving some manner of hallucination, while the third concerns olfactory imagery in normals.

Olfactory hallucinations are quite common in those suffering from Schizophrenia (Mueser, Bellack, and Brady, 1990), however, the underlying biological mechanisms of schizophrenia are not clearly understood and as such these symptoms might be attributed to cognitive dysfunctions instead of the olfactory experiences occurring in a representational system. Nonetheless, a large subset of olfactory specific disorders regard cacosmia, which is the experience of unpleasant odors in the absence of any causal source. Cacosmia's pathology is particularly troubling since the individuals entire life is pervaded by the experience of noxious odors. Based on olfactory hallucinations it appears that the content of our olfactory experience can represent something that does not exist.

An interesting case study of olfactory hallucination was reported by Mizobuchi et al. (1999), regarding a patient that had hallucinations of a bad smell that always presented itself as coming from a particular direction. The experience represented a foul odor as arising in the left side of the room. The directional component is suggestive of the fact that not only do these experiences represent an occurent foul odor, but also represent it as having spatial dimensions with an identifiable location. While it might be questionable to infer the nature of cognitive states and content from cases of pathology, these examples show that olfactory experience can occur in the absence of an olfactory stimulus, which suggests that our olfactory experiences have representational content.

Olfactory hallucinations are not the only instance of olfactory experiences occurring in the absence of a stimulus, as there is a large and growing experimental literature on olfactory imagery (Algom & Cain, 1991; Bensafi et al., 2007a, 2007b, Gilbert, 1998; Kosslyn, 2003; Kosslyn, et al., 2003; Pylyshyn, 2003; Rinck et al., 2009; Stevenson et al., 2005), which is meant to parallel the debate on visual imagery (Kosslyn et al., 2006; Pylyshyn, 2006). However, olfactory imagery is not analogous to visual imagery, which is clearly a debate about whether the format of mental content involves visual depictions or merely descriptive content. Here the nature of the format of olfactory experiential content is left aside, with the focus instead upon whether or not we can experience smells by imagining or introspecting them.

Olfactory imagery is simply the occurrence of olfactory experiences in the absence of incoming stimuli, such that if I can imagine a smell or introspectively access a memory of a previous olfactory experience that includes a reoccurrence of the smell experience. Not only do imaginary olfactory experiences commonly occur, but also by just increasing our attention to olfactory experience this increases our capacity to retrospectively access smell experience (Gilbert, 1998). Olfactory imagery demonstrates that we can experience smells in the absence of an olfactory object.

A good example of volitional olfactory imagery or perhaps hallucination is derived from an anecdote told about a professor, who on a particular day of class announced, as he opened an empty utility jar, that he had released an unpleasant odor in the lecture hall and asked that people raise their hand when the odor reached them. Even though he had not released an odorant, hands went up in a manner that simulated a normal odor plume moving backwards towards the top of the lecture hall. Taken on its own this does not suggest they were undergoing a smell experience, but might simply be explained as the class tacitly employing their knowledge of chemical diffusion. However, some of his students claimed the odor they were experiencing was so noxious that they needed to leave, since they felt nauseous. Anecdotally the story suggests that people can have olfactory experiences in the absence of any stimuli that even mimics the ability of noxious odors to induce nausea.

3.1.3 Representing *x* as *f*

Another test for being a representational system might be whether the stimulus can be represented in different ways. Can we accurately identify or report the olfactory stimulus, yet in so doing perceive it in different ways given its properties and our conceptual repertoire? Do olfactory modes of presentation exist?

Examples of representing an olfactory object as instantiating certain properties or under different guises can be derived from perfume. Perfumes can be identify as being of brand X, such that one can smell that a perfume was created by Jean Claude Ellena for Hermes, that it is some manner of Armani product, and quite often Dior's perfumes have a distinctive amber quality. Additionally, perfumes like all fashions have trends. The smell of perfume *x* might be recognized as being of the latest fashion (this past spring and summer it was vanilla scents, while the past fall and winter were replete with Ouds). These perfume trends make it possible to identify a scent as being from a particular time period. The male scents of the 1970s were strong over the top fragrances that one imagines were worn by well-groomed truckers and cowboys with hairy chests, while the perfumes of the 1980s were powerful florals that easily occupy a room, which explains the rather anemic scents of the 1990a that smell like metallic aerated melons.

Our ability to represent an olfactory object under multiple and dissociable guises, demonstrates that our olfactory experiences have modes of presentations. This provides evidence that our experience of smell occurs in some representational medium. The examples surveyed in this section of misrepresentation, intentional inexistence, and representing olfactory experiences as *x*, all rule out that the relation between the olfactory object and our experiential states as simply being a matter of isomorphic causal connection. The contents of our olfactory experiences are representational. However, what now remains to be dealt with is the syntactic nature of the content.

3.2 Nonconceptual content and Psychosyntax

(All states are compositional, but not all compositional systems are created equal.)

If the content of olfactory states is representational then the further question arises as to the nature of its structure. In this section I argue that the syntax of representations within the olfactory systems is at times nonconceptual. To arrive at my conclusion, the nature of nonconceptual content must be clarified. Unfortunately, the nature and debate regarding nonconceptual content is a philosophical quagmire filled with confusion and disarray. Luckily, the nature of olfactory experience provides a new understanding of nonconceptual content that harks back to its roots in Evans (1982), as being a simple matter of the content of some of our representational states not sharing the same structure as concepts. What I would like to suggest in this section is that the difference between conceptual and nonconceptual contentful states is simply a matter of the format of their structural parts and relations within a system of representations. Nonconceptual states differ from their conceptual counterparts due to the nature of their representational format, which may be assessed based how these states are accessed and employed within perception and cognition.

The methodology employed in this chapter is to bypass the debate regarding nonconceptual content. Nonconceptual content might be an issue of access[49] (Block, 2003; Heck, 2000; McDowell, 2003; Evans, 1982; Stalnaker,

[49] According to the access approach there is no difference between the types of content it is simply a matter of how one accesses the content of the mental state, representation, or experience.

1998), counterfactual attribution of attitudes[50] (Kelly, 2001; Peacocke, 1992, 1995, 1998, 2000; Speaks, 2005; Stalnaker, 1998; Tye, 2005), linguistic capacities[51] (Block; 2003; Fodor, 2008; Peacocke, 1992, 1995), or information bearing representational states[52] (Block, 2001; Dretske, 1981; Evans, 1982; Fodor, 2007; Tye, 1995, 2005), with theorists weaving between these approaches, while generating further notions of content that are nonconceptual. The traditional understanding of nonconceptual content is to contrast it with conceptual content, as such whatever conceptual content is, nonconceptual content is not. Using this methodology nonconceptual content becomes a contrastive notion, which is either not conceptual or unconceptualized content. Accordingly the nature of conceptual content and concepts in general must be clarified to define these two further types of content.

The traditional understanding of nonconceptual content leads to the unsatisfactory state of play that each theorist brings to the table their own theory of concepts and then proceeds to criticize the opposition's theory of nonconceptual content. With this overall state of play it is quite clear why the

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[50] The counterfactual approach usually appears in the course of discussing the content of infant or animal cognition. The claim is that these creatures have mental content, but do not possess the concepts necessary to explain certain competences, so we ascribe to them certain contents that they would have were they able to have concepts. Sometimes this approach appears as the claim that there is a content of mental states or experiences that could be characterize as being conceptual if the organism were to possess certain concepts.

[51] According to the linguistic approach the difference between conceptual and nonconceptual content is simply whether or not the content has linguistic syntax or structure.

[52] According to this approach the difference between the two types of states is due to the nature of the structure of their content. This is similar in ways to the linguistic model, but takes a more permissive stance on the nature of concepts and their format.

debate is difficult to grasp, murky, and theory-laden. Furthermore, the traditional methodology can obscure the issue of whether it is sensory states, perceptual states, cognitive states, or some combination of these states that can be ascribed nonconceptuality.

Using the contrastive methodology, I suggest not entering the entrenched battles between theories, but circumventing them by assuming that whatever constraints a representational state must meet to be considered a conceptual state can be used to ascertain by process of elimination what kinds of representational states might be nonconceptual. Aside from the overarching assumptions that concepts can be conceived of as mental particulars, it is widely held that whatever the minimal constraints of being a concept might be at the very least they must be compositional (any state that is compositional should be systematic and productive as well – leaving aside inferential coherence). As such, if we can identify states that do not meet the classical understanding of compositionality, yet have representational content, then these should be identified as nonconceptual states. To demonstrate I will borrow Fodor's LoTH (1976, 1981, 1985, 1987, 2000, 2008) strategy of inferring the representational structure (psychosyntax) of mental contents from our cognitive abilities, but in this case our olfactory perceptual and cognitive abilities. What results from this methodology is a novel way of understanding nonconceptual content as different from conceptual content not in terms of what it is a representation of nor its role within the realm of reason, but in how the representation is formatted.[53]

The theory of nonconceptual content that I propose might look similar to Fodor's (2008) and Pylyshyn's (2003, 2006) preconceptual content, since it is predicated upon the assumption that different kinds of representational formats aside from normal descriptive concepts might be required to explain some of our perceptual or cognitive abilities. Formative nonconceptual content claims simply that nonconceptual states can be identified by contrast with the structure of conceptual states. What differentiates these kinds of representational states is their syntactic nature: while both kinds of content are compositional they are not so in the same manner. Contentful representational states might not satisfy the extremely strong requirement of concatenative compositionality necessary to be descriptive concepts, but they are compositional in a weaker sense to be elaborated below. Formative nonconceptual content is simply different from conceptual content in terms of the system of compositionality that is employed to generate complex representational states.

My defense of formative nonconceptual content within the olfactory system will proceed as follows. First, the distinction between conceptual and

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[53] To an extent my approach makes the same moves I criticize above, since it borrows the contrastive notion, stipulates a constraint on concept identity, which is then used as a criterion of concepts, thereby allowing nonconceptual content to be identified by proxie. However, my approach is less controversial, because I am in no way advancing my own theory of concepts and while compositionality might seem preferentially biased towards some theories of concepts, it is a viable criterion, which is certainly required to explain our cognitive abilities of systematicity, productivity, inferential coherences, and perhaps object tracking. For a more detailed discussion see Young (2003), Chapter 4.

nonconceptual content has already been redefined as an issue of whether there are representational states that do not obey the constraints of LoT compositionality. To clarify this methodological shift, a distinction - between classical compositionality according to the LoTH and what distinguishes it from functional compositionality - will need to be introduced and clarified. Following an introduction to functional compositionality, the section ends with evidence for olfaction being productive and systematic, thereby requiring a compositional system. Second, using the contrastive methodology, I suggested that nonconceptual states might be identified in accordance with our cognitive capacities in the same way the syntax of LoT is argued for by Fodor. The third section offers an empirical argument to the best explanation that we need nonconceptual content (i.e. representational states that are not classically compositional), given the nature of olfactory transduction and olfactory experiences as accomplished using a functionally compositional system of representation.

My argument should not be interpreted as proposing a necessary condition of nonconceptual content, rather in accordance with nonconceptual plurality (Bermudez, 2007), nonconcatenative functional compositinality is offered as a sufficient condition for nonconceptual content. There might be other kinds of states that should be considered nonconeptual, yet which are generated by concatenative composition representational systems. Nonconeptual content might turn out to be modality relative and other representational systems might be considered nonconceptual, but employ a different format for encoding stimuli. Borrowing from both Pyslyshyn's and Fodor's[54] methodologies of arguing for a kind of content from empirical evidence garnered from a cognitive capacity, I suggest that Olfactory Representational States (ORS) employ a different kind of representational system that is nonetheless compositional, as well as productive and systematic.

3.2.1 Psychosyntax: concatenative and functional compositionality

For a system of representations to be compositional what needs to be specified are the primitive or atomic elements together with rules of formation of these into molecular complex state, as well as rules of transformation, decomposition and well formedness. Minimally, compositionality does not require much, however classically the proposed manner of accomplishing this feat was using concatenation where the complex representation literally tokens each of the atomic constituents. The constituents are literal tokens of the atomic

[54] While I am certainly in agreement with Fodor that we should identify nonconceptual content with nondiscursive compositional systems, I would prefer to part company with his ideas beyond this claim. Formative nonconceptual content might include the iconic representations, however, given his claim that these do not have canonical decompositions combined with the picture principal, I think it is best to leave these theory-laden assumptions aside. The picture principal needlessly complicates matters in an unintuitive manner and once again sets our focus upon vision, which I do not think easily generalizes to olfaction. Second, I think that if formative nonconceptual content is identified and argued for, based on functional compositionality, and these representational states have canonical decompositions, then iconic representations are not compositional in the same sense. Overall formative nonconceptual content simply claims that nonconceptual content consists simply in contentful states that are representational and compositional, but not in a classical concatenative manner. Perhaps iconic representations are included as well, but I wish to remain neutral on their status, since it is their cause and not mine to fight.

constituents, which are parts of the whole. The alternative suggested by my interpretation of van Gelder is if syntax and compositionality is relative to a representational system, compositionality could be accomplished functionally. The atomic representations are transformed into a complex molecular representation in a manner that they are no longer identifiable or literally tokened within the complex. These complex states do not literally have constituents. Rather, they might be treated by the system as complex symbols. So long as the rules of formation, transformation, and well-formedness are accomplished in a reliable and systematic fashion such that the same atomic constituents yield the same functional complex consistently and are decomposable into these same constituents across multiple processes in time, then the system can be said to implement a functionally compositional system. Olfaction makes this theoretical idea plausible. The olfactory object is the chemical structure of molecular compounds, allowing us to empirically specify the atomic constituents literally atomistically and show how olfactory transduction implements a combinatorial and functionally compositional system of representation.

Cognition requires a compositional system to explain our cognitive capacities of productivity, systematicity, inferential coherence, and perhaps tracking, which then drives our quest for psychosyntax.[55] The Classical Computational approach provides an answer to how this is accomplished by characterizing our cognitive architecture as employing a symbol system, which is syntactically structured so as to be compositional. However, Connectionist and

[55] See Young (2003), Chapters 4-5.

neural network architectures have a great difficulty explaining how their systems can be considered compositional, since they do not employ a system of symbolic structures that is either classically syntactic or compositional. In this section, compositionality is explored with the intention of unearthing a new type of compositionality that suggests an alternative conception of psychosyntax to that of classicists. The new conception of syntax allows it to embody only functional structure and specifically not concatenative structures.

A compositional system is most easily thought of as a system of mental representations with rules of how the atomic parts of the representation can be combined to form a complex (molecular) whole. The complex representation's semantic value can be derived from the semantic values of the atomic parts in conjunction with the rules of formation and interrelation between the constituents. A compositional system must specify either the relations between the atomic parts in a constituency or the constituency relations. Normally one is intuitively pushed toward thinking of compositionality in terms of part/whole relations between constituents and complex mental representations, which naturally militates in favor of a concatenative notion of compositionality. But, this does not bar alternatives. Compositionality understood in this manner suggests the following minimal conditions for a representational system to be considered compositional:

> Conditions of Compositional representational scheme:
> **(a)** There is a set of primitive types (symbols, words, etc.) Pi; for each type, there is available an unbounded number of instances or tokens.

> **(b)** There is a (possibly unbounded) set of expression types Ri; likewise, f or each type, there is available an unbounded number of tokens.
> **(c)** There is a set of transitive and nonreflexive constituency relations over these primitive and expression types. Thus, expressions of type Rj (such as ((P&Q)&R) might have as constituents expressions of type Ri such as (P&Q), in which case the situation can be described more succinctly using the general schema C(Ri, Rj) (van Gelder, 1990, p. 357).

An interesting aspect of compositional systems is that they are infinite in terms of the types of expressions that the system can generate and this unboundedness is what makes them so attractive for explanations in the cognitive sciences. The system is formulated through recursive rules that specify how to generate the unbounded number of expression tokens from the types. These rules will create the unbounded nature of the compositional system based on the mode of combination and formation for expression types.

Since the mode of combination is what enables the system's unboundedness and this property is what we are after then it may be used to differentiate the different computational approaches and representational systems. The model that Fodor and Pylyshyn (1988) work from is one of concatenative relations between the expression tokens, which is also thought of in terms of co-tokening relations. Classical constituency relies on part/whole relationships - tokening of a complex mental representation requires actual tokening of constituents: "For a pair of expression types E1, E2 the first is a classical constituent of the second only if the first is tokened whenever the second is tokened" (Fodor & McLaughlin, 1990, p.186). Thus, classical computational compositionality is merely concatenation based on the spatial and temporal juxtaposition of expressions within the complex mental representation. This linking or ordering of successive constituents to form a complex expression suggests the following:

> Minimal Condition for Concatenative constituency:
> The complex representation must preserve tokens of an expression's constituents (and sequential relations among tokens) in the expression.
> **Formally**- Given any expression type Rj, then for every primitive or expression type Ai such that C(Ai, Rj), it must at least be the case that any Rj token contains a token of each Ai, in the sense that some part of the Rj token satisfies the identity criteria for counting as an instance of type Ai. (van Gelder, 1990, p. 360)

A simpler way of stating this might be to say that the complex representation must have as a proper part a token of each of the constituents within the complex representations. Thus, (P&Q) tokens '(', 'P', '&', 'Q', ')'.

The aforementioned condition is not the only requirement on what makes a compositional system concatenative - the syntactic structuring of the expressions within the complex mental representation is also required. The internal structure of the system's states must be of a formal nature such that the constituency relations among the expressions are directly mirrored and instantiated in the physical structure of the corresponding tokens. Thus, classical computational systems employ a syntactic structure in which the internal structure of the physical instantiations of tokens mirror the abstractly specified constituency relations.

The mode of combination is assigned a great deal of importance and forms the keystone of van Gelder's distinction between classical concatenative and functional compositionality. The mode of combination for classical syntax is concatenative in the sense of involving part/whole relations within and between the tokened expressions in the complex representation, with the additional requirement that the constituent's internal expressions both have a structure and relational properties such that they mirror the abstractly defined mode of combination. This internal syntactic structure allows for a great deal of clarity and explanatory power when it comes to the classical architecture explaining our cognitive capacities. Yet, classical syntax is additional and not something necessarily required of our cognitive architecture.

All that is minimally required for a system of mental representations to be considered compositional is that there be an abstract relation specified for the combination of expression types and primitives. All that is required is that there is a systematic and mechanistic manner for creating compound expressions, given the constituents, and a similar systematic mode for decomposing the complex representations into their constituents. Functional compositionality minimally requires that some computational function is utilized to create the complex representations from constituents and a transition function utilized to decompose these complex expressions back into their constituents. This sparser notion of compositionality can aptly be called "functional compositionality" - the conditions of which are as follows:

> Functional Compositionality. Requires - general, effective and reliable processes for (a) producing an expression given its constituents, and (b) decomposing the expression back into those constituents (van Gelder, 1990, p.361).

A system of the kind above is compositional according to the conditions set out, yet is not concatenative nor does it require classical syntax. Functional schemes encompass and include concatenative systems. While all concatenative implementations of compositionality are functionally compositional, not all systems that are functionally compositional are concatenative implementations.

The notion of syntax at play in functionally compositional systems is quite different from the classical notion presented above. Functionally compositional representations are not concatenative and thus the tokened complex expressions do not have token parts to which we can refer to as its internal structure. However the complex representation is endowed with its causal powers by virtue of being formed from constituents, the complex representation certainly has some type of internal structure and in some sense must have an internal syntax. This internal syntax should be considered functional syntax, as the complex representations are functionally composed of their constituents. Mental representations with functional constituent structure do not co-token their own constituents, rather they are formed from the constituents and can be decomposed back into them.[56] Thus, it is a theoretical possibility that a complex

[56] Though I find this the best explanation and construal of van Gelder's conditions for functional compositionality and syntax, there are two alternative interpretations. The first is that all that is required is that the mental representation with functional constituent structure be decomposable into parts and that this needs be merely counterfactually supporting. The other alternative is an expansion of the first alternative such that once the system has decomposed the complex representation, the system must be able to reform the complex representations based on the decomposed constituents.

representation with constituent structure does not require an internal compositional structure of the classical concatenative type.

3.2.2 Olfactory Productivity and Systematicity

The olfactory system implements a combinatorial system of functionally compositional representation states The requirement that a representational system must be compositional is motivated by its capacity to explain the productivity[57] and systematicity of cognition and language. Having introduced the distinction between concatenative compositionality and functional compositionality, I demonstrate in this section that the olfactory system is productive and systematic, thereby requiring a compositional system of representation. In the next section I will then seize upon these capacities and provide evidence that the kind of compositionality implemented by the olfactory system is combinatorial and non-classically compositional.

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[10] Productivity is championed as a human cognitive capacity that seems to offer reasons for accepting Classical Computationalism and specifically, the Language of Thought Hypothesis (LoTH) (Fodor, 1985, 1987; Fodor & Pylyshyn, 1988). In fact, productivity can be seen as the precursor of the Systematicity Argument, due to its shortcomings and the ease by which it can be dismissed for being empirically unverifiable. The common conception of productivity is that we have the capacity to think an unbounded number of novel thoughts (Behold the angelic winged talking donkey). Conceived of in this manner it is a capacity that we can only do in theory. No one claims that we can literally exercise this unbounded capacity, because we, as mere mortals, are constrained by the limitations of mortality and the weakness of memory and attention (to name but a few). There are two ways of arguing for productivity. The first takes the cognitive capacity as a given that is explained if one assumes our cognitive architecture operates over a compositional system of syntactically structured mental representations (Fodor, 1987; Fodor & Pylyshyn, 1988). The second, convolutedly argues for our cognitive capacity of productivity by way of explaining our productive linguistic abilities (Fodor, 1981, 1985, 1987) . Both approaches require a compositional system of syntactically structured mental representations to explain how this capacity can be realized according to standard models of cognitive architecture.

While there is evidence for olfactory productivity and systematicity it is scant and only offered here as a motivation for the arguments of the next section. The reason for thinking olfactory states are productive is quite straightforward. We have roughly six hundred olfactory receptor genes each of which produces an ORN that is sensitive to a range of odorants in a combinatorial and non-linear manner. This suggests we might be able to smell an unbounded number of novel odorants.[58] Turin (2006) explicitly claims that we could in theory smell a unlimited number of novel odorants. As detailed in the Chapter 1, some have claimed the number of odorants we can be sensitive to be, at a minimum, 10,000. However, given neurogenesis, together with the prevalence of different odorants being predominately present within an environment across time, the primitive odors within this estimate can change across time thereby allowing an increase even for this rather meager estimate. This being said, there seems to be no actual evidence for this estimate of odors, which combined with the nature of olfactory stimulus transduction sketched in Chapter 1 suggests that we can smell as many odorants as can be chemically composed that fall within the range of chemical structures that humans are capable of detecting. Furthermore, evidence from the sensory information represented within the piriiform cortex suggests that the olfactory system is partially organized to accommodate our ability to recognize, detect, and identify a near infinite number of odors (Isaacson, 2010).

Systematicity has received the greatest amount of attention of all the

[58] See Chapter 1, Section 3.3 for more details.

cognitive capacities offered in favor of the LoTH. Systematicity was originally proposed as a cognitive capacity by the Classical Computationalists (Fodor, 1987; Fodor & Pylyshyn, 1988; Fodor & McLaughlin, 1990). The cognitive capacity has never been clearly defined in any of the literature by Classical Computationalists. While the empirically testable ability of linguistic systematicity is quite clear, how this translates into a cognitive ability is not as straight-forward. Additionally, since this is a capacity identified by Classicists to support their model of cognitive architecture, it is hard to find an exposition of this capacity that is not already conceptually loaded in favor of Classicism.

Some theorists (Block, 1995b; Kaye, 1995) view Fodor's and others' original systematicity argument as an outgrowth of the productivity argument. It is thus no surprise that the classic case for systematicity concerns language. How this capacity translates to cognition or other modalities without begging the question is quite troublesome. Therefore, I propose that systematicity should be considered as the basic claim that any state with content that represents an aspect of the experience in some relation to some other aspect of the experience can also swap these aspects around, while holding the relation constant.[59] Systematicity might be most uncontentiously schematized as the requirement that any representational system that can represent aRb must be able to also

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[59] For a complete discussion of visual or auditory examples see Young (2003). For linguistic or propositional thoughts a decent example is: if we can comprehend or think that "Fodor likes Brown Cows" then we can also comprehend or think the variant "Brown Cows like Fodor."

represent bRa.

Olfactory systematicity might be demonstrated based on our own experiences of smells. One can easily recollect the smell of lilies within a bouquet of roses and, conversely, roses within a bouquet of lilies; or perhaps, the smell of garlic roasted with rosemary chicken and, conversely, chicken roasted with rosemary and garlic. While the syntax of these states does not perfectly mimic the garden-variety linguistic example schematized as aRb, bRa (Cummins, 2001), these examples certainly go some way towards showing that olfactory experiences might be somewhat systematic, since they can represent an aspect of an olfactory experience in relation to another, as well as the opposite state of affairs. These *prima facie* examples are instances of olfactory overshadowing.

Empirical evidence for olfactory systematicity may be garnered from the overshadowing effect in odor mixture qualities. It is quite unsurprising that when combining odorants in a mixture if the constituents smell similar on their own, it is harder to tease them apart when combined; if they smell dissimilar on their own they are quite easy to distinguish 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. Using mere concentration levels of the components of complex odor mixture we can manipulate whether you smell *a* with *b* or *b* with *a*, thereby satisfying the general schematization of systematicity as aRb or bRa.

Following from the contrastive methodology prevalent throughout the nonconceptual content debate, I have suggested that the olfactory system employs a functionally compositional system of representations, as opposed to a classical concatenative compositional one . As such they should be treated as nonconceptual since - whatever concepts are - they must at the very least be compositional. Furthermore, olfaction is systematic and productive, thereby providing a nice counter-example to LoT's stranglehold on compositionality and psychosyntax.[60] However, all that has been established is that olfaction is productive and systematic, which requires that it use a compositional system of representation of a kind that has yet to be ascertained. The next few sections offer empirical evidence that olfaction implements a functionally compositional system, and therefore uses a nonconceptual system of representations.

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[60] It might be complained that my notion of nonconceptual content, even contrastively defined, is still compositional and, as such, by my own methodology conceptual because the representational content of these states is in some manner compositionally formed, as well as having the same causal powers as concatenative states. However, I think these objections while worthy would miss the point. Even if functional compositionality is in good standing as a kind of compositionality, it does not have part-whole relations in the same way as most theorists conceive of concepts having. Furthermore, it might simply be replied that at the very least I assume that concepts must obey the syntactic constraints set out in a Fodorian LoT and that, as such, I might be assuming conceptual Atomism in opposition to Holistic theories. However, a conceptualist might even not consider concatenative compositionality a reasonable condition for conceptual identify and by extension the weaker notion of functional compositionality will certainly not be conceptual.

3.3 Olfactory Content is *ƒ*-compositional

Not only is functional compositionality a viable theoretical alternative, it is employed by the olfactory system. Evidence that the olfactory system operates a functionally compositional system can be derived from stimuli transduction, how the OB and its projection to the olfactory cortex do not employ a line-line system, but rather encode odorants distributed spatially across multiple receptor neurons, glomeruli, and mitral cells. Aside from what looks to be subpersonal evidence that the sensory aspects of the olfactory system employ a combinatorial, yet nonclassical compositional system, further evidence can be derived from the olfactory imagery debate regarding olfactory mixtures, as well as the Laing effect, and mixture suppression.

Since functional compositionality was proposed as a model of the syntax of cognition within connectionist networks my working methodological assumption will be that we can infer the nature of the format of the representational content from our olfactory capacities. The section is split into two sections: the first section concerns the nature of our olfactory abilities at the level of stimulus transduction and identification, which occurs within the initial stages of olfactory processing from the ORN, OB, and Piriform Cortex; the second section is devoted to those of our olfactory cognitive abilities that are psychologically states.[61]

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[61] My reason for splitting the stages in this manner is due to the worry that some might not consider sensory states as good candidates for nonconceptual content or might simply dismiss this evidence since they already allow nonconceptual sensory states. Thus, even if the first stages of processing are judged to miss the mark, the second

The aim of this section is to provide the best explanation of our olfactory abilities in light of what is the best proposed syntactic structure of the system responsible for realizing these capacities, which I have argued is one that is functionally compositional. With this methodology in hand the first part regarding stimuli transduction can either be taken at face value as evidence for nonconceptual functionally compositional sensory states or as a means of explaining the next part's psychologically abilities (i.e. the combinatorial, yet noncompositonal nature of olfactory stimuli transduction as explaining our olfactory cognitive abilities).

A system that uses functional compositionality is the most basic type of compositional system, because all that is required is that it have a specification of the atomic elements together with rules of formation and transformation such that the complex molecular representation it uses can be treated as if it had parts and can be reliably composed and decomposed from these parts. One of the difficulties facing compositional cognitive systems is specifying the atomic elements of thought. Within the olfactory system the problem of specifying olfactory primitives disappears, because these are identified with the olfactory object, which is nothing more than the chemical structure of molecular compounds. Thus, to support the conclusion that the olfactory systems implements functional compositionality, what needs to be discussed is how these primitives are handled by the system.

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section provides strong evidence for the claim that olfactory states might not be conceptually formatted.

Olfactory mixtures provide the test case for functional compositionality, as these should display the same properties that would be expected from such a system (as opposed to a classical compositional system). Since functional psychosyntax is relative to a compositional system, I argue that at a minimum, these systems need only be combinatorial and not concatenatively compositional. By ‘combinatorial’ all that is meant is that the complex representations are formed via a computation, which combines the individual elements to form complex representations. Being a combinatorial system is neutral regarding the mechanism or format of the complex states, while being a compositional system requires a great deal more. Thus, what I aim to show is that the olfactory system is combinatorial such that complex odors are formed in a functionally compositional manner. While complex molecular representations are formed from individual atomistic molecules these are not literal parts nor are they co-tokened within the complex representation, which would be expected if the system employed a classical concatenative system of compositional representation.

3.3.1 Combinatorial Olfactory stimuli transduction

The atomic constituents of the olfactory system are transduced in a combinatorial manner. If the olfactory object is the chemical structure of molecular compounds then according to either odotope or vibrational theory the way the system recognizes these structures is in a parallel and distributed fashion across multiple ORN. Just as many blind men might tactilely identify an elephant, ORNs encode a simple molecular structure either by being sensitive to different parts of the structure (i.e. carbon chains and functional groups) or by the frequency of different parts of the chemical structure. On either account the encoding of simple atomic representation within the system occurs in a combinatorial fashion, which is done in a spatially extended and parallel fashion across multiple ORNs.

Furthermore, the glomeruli and mitral cells within the OB are required to make sense of the incoming input from across multiple ORNs by piecing it together into the concentration level and identity of the olfactory object. However, even at this level there is no clear chemotopic map similar to a retinotopic map. Simple odorant encoding occurs in a combinatorial manner unlike the line-line systems of vision and audition and it is not surprising that complex odors are processed in the same parallel and distributed manner across multiple neurons. What provides further evidence for olfactory functional compositionality then is that complex odorants are not encoded as the sum of their parts.

Complex odorants have qualities that extend beyond those of their mere parts, which suggests that the atomic parts are not literal constituents of the molecular representation and are encoded in a combinatorial format that is not concatenative. The mere lack of both chemotopic maps and a line-line organization within the olfactory system shows that odors are encoded and processed in a manner that is not simply concatenative. Further evidence regarding the processing of complex odors within the OB demonstrates that glomeruli and mitral cell activity does not function in a classically computational manner.

The olfactory bulb is functionally unlike any of the other intermediate stages of processing within the perceptual modalities. It is unlike the cochlea of the ear. ganglion cells of the retina and the thalamic connections in both of the relevant systems. It might be possible to read off the nature of the visual or auditory stimuli from these sensory stages since each system's thalamic relay does not distort the structural nature of the representation at these levels of cognitive processing. Thus, the simple isomorphic and strict causal mapping of the stimulus features to the auditory and visual sensory transducers is radically different than the activity of the olfactory system from the ORN through the processing of olfactory stimuli within the OB. For example, if a photon of the right energy state interacts with the chemicals within a cone in the right sort of way then a color experience of a given variety will occur in a reliable fashion such that we should be able to predict the color experience reported in area V1 of the visual cortex without much work. Similarly, with regard to the cochlea and wavelength transduction, if certain hairs in a certain part of the tympani vibrate then we can predict what sound is being produced. In a sense these are line-line systems – there is a direct line from the perceptual quality through the sensory system to the cortex. However, with olfaction we cannot look at one single cell or even a group of cells in a given location within the olfactory bulb to predict the nature and quality of a complex odor (Hildenbrand & Shepherd, 1997). Aside from the fact that olfactory stimuli are encoded differently, the mechanisms of transduction also work differently within the glomeruli and mitral cells of the olfactory bulb.

The olfactory bulb might not have a strict chemotopic map like the retinotopic map of vision (Bozza & Mombaerts, 2001), but it does seem to have a coarse chemotopic organization. Similar activation patterns can be observed when odorants are similar, and when they contain similar molecular properties (Fredrich et al., 1997), such that the qualitative identity and concentration of the odor is encoded by glomerular activity in the OB (Hildenbrand & Shepherd, 1997). We cannot simply read off the quality nor concentration of the odor from a single glomerulus. Rather, the combinatorial coding of a stimulus is distributed across multiple regions throughout the glomeruli level, with each glomerulus being sensitive to different parts and combinations of the chemical structure. Thus, the olfactory object, whether complex or simple, is encoded by activity patterns spatially distributed across different glomeruli (Fredrich et al., 1997).

As already noted in Chapters 1 and 2, aside from the spatially distributed nature of stimuli transduction, there is a gap between the molecular biology of odorant receptors and the functional organization of the olfactory system. Odor identification (i.e. odor quality) and chain length of the olfactory object might be encoded by different sets of glomeruli allowing the olfactory bulb to extract and encode different aspects of the target in different ways (Bozza & Mombaerts, 2001). What makes this interesting is that the glomeruli layout seems to be genetically hardwired such that the different types of glomeruli are located in (what looks to be) the same random placement across humans (Zou et al., 2009). The map of glomeruli while seeming completely random across each olfactory bulb is invariant across species, thereby allowing the conclusion that their placement is selectively hardwired and seemingly purposeful (Bozza & Mombaerts, 2001). Thus, their placement and the nature of distributed encoded olfactory representations is systematical combinatorial and distributed.

In addition to the global encoding of olfactory stimuli across multiple glomeruli being spatially different than vision or audition, the temporal dynamics of the olfactory encoding is also different. Evidence for the temporal coding of stimuli within the olfactory bulb comes from animal models of olfaction (zebra fish, locust, and rats), which - given the evidence that glomerular placement is invariant across species - seems to further support the introductory assumption that olfaction's phylogenetically ancient status allows an easy and valid means of inferring human capacities from animal performance.

Based on the convergence of olfactory receptor cells firing rates overtime and, in particular, the convergence of firing patterns within the odor-coding assemblies of mitral cells in the olfactory bulb of zebra fish, Laurent et al. (2001) suggest that the olfactory bulb might encode odorants in a combinatorial manner such that there is not a discrete representation of each aspect of the encoded stimuli, but rather that the representation of the stimuli is holistically encoded in the firing pattern of the glomureli and mitral cells across the entire olfactory bulb. They nicely highlight this key difference between the functional organization of the olfactory system from all other sensory systems in terms of the variable of time. They argue that given the slow transduction speed of the olfactory system, as compared to vision, time can be used as a computational variable in encoding the presence of an odor across olfactory bulbs within an individual circuit. This phenomena of temporally distributed representations across a circuit is unlike the other modalities. Olfactory stimulus encoding is accomplished by large groups of glomeruli and mitral cells firing across time, such that stimuli transduction is spatially and temporally distributed. Therefore, olfactory stimuli are not represented in accordance with concatenative compositionality, since they do not have literal part-whole relationships at or across time. Further work done in Laurent's lab provides more evidence for the claim that odors are encoded in a spatial and temporal manner throughout the glomeruli and mitral cells of the olfactory bulb;

> Odors appear to evoke distributed spatiotemporal patterns in which many neurons contribute to encoding both concentration and identity; the firing of PN population analyzed over individual PNs and over time (with oscillation-cycle length resolution) can be used by an observer to identify both concentration and identity (Stopfer et al., 2003, p. 997).

Given that classical LoT systems must obey concatenative compositionality such that the atomic representations are literal parts and co-tokened within the molecular representation, it is *prima facie* not obvious how this could be accomplished by the olfactory bulbs encoding of odorants. Co-tokening is certainly not possible at a given time, but relaxing the synchronic condition of compositionality - to allow for distributed temporal parts - would still not circumvent the problem as they would still be spatially distributed in a manner that is not formally like any example that has literal and formal parts within a complex representation. Thus, olfactory stimuli within the olfactory bulb are not encoded by a classically compositional system of concatenative representations.

What makes the work of Laurent's lab even more interesting is that it serves as the basis for their claim that the representational system of the olfactory bulb is best analyzed using transient state dynamical systems analysis, which has a similar basis to Smolensky's (1987a, 1987b, 1988a, 1988b, 1990, 1995a, 1995b) vector space analysis used in connectionist representations within his *Integrated Connectionist Symbolic* (ICS) system. According to this line of thought, the computational processes within the olfactory bulb are best modeled and interpreted as employing a vector space dynamic systems analysis. While Broome, et al. (2006) suggests using vector space models within dynamic space analysis to model the processing of the olfactory bulb, Laurent et al. (2001), Stopfer et al. (2003), and Rabinovich et al. (2008) show that modeling the olfactory bulb, for stimuli transduction and olfactory mixture processes, is more successful using a Transient State dynamic system model as opposed to an attractor state model. The details of the debate are inconsequential for my purposes, since on both analyses the best model of olfactory processing involves connectionist computations. Thus, the only way these systems can be seen to have a compositional syntax capable of systematicity and productivity is if they employ functional compositionality. So it would seem that I have the only game in town.

While sensory transduction and olfactory stimuli encoding certainly provide strong defeasible and non-demonstrative evidence that the olfactory system employs a syntactic representational system employing functionally compositional representations, some worries yet lurk. So far it has not been explicitly shown how the olfactory system treats olfactory complex odors in a combinatorial manner. Additionally, the evidence thus far regards only sensory-level processes that are arguably not available for psychological reports (making them perhaps not psychological real). By extension if these are not psychological states, but mere biochemical happenings within our neural processing they might not be a valid inferential starting point for ascertaining the format of olfactory psychosyntax. Another way of putting this last problem is that it looks awful odd to consider a system compositional, even functionally compositional, if its states have no possible semantic analysis. In short, what role is all this evidence meant to play?

The combinatorial and stimuli encoding evidence outlined above, I think on its own, provides reason for thinking the OB employs a functionally compositional system of syntactically formatted representations. However, if this stronger claim seems to beg any questions, the aforementioned evidence can be used to explain our cognitive abilities within olfaction. Primarily, deficits within our capacity to identify, detect, recognize, and imagine components within olfactory mixture are best explained by positing a functionally compositional system of representation for encoding and presenting olfactory experiences.

3.3.2 Olfactory mixture sensory transduction and encoding

Olfactory mixtures occur when two or more olfactory objects (odorants) are combined to form a complex odor. The vast majority of the ordinary objects that are of ecological value to us are composed of a vast number of molecular compounds, making the nature of olfactory mixture of great importance in attempting to understand how it is that we recognize, identify, and individuate ordinary objects from a vast array of other entities given the slow transduction speed and adaptive mechanism of the olfactory system. Some aspects of these problems were mentioned in Chapter 2 (Section 2.3), when discussing Wilson and Stevenson's (2006) theory.

An interesting study that serves as a nice junction between ORN and OB stimuli transduction and encoding is Zou and Buck's (2006) neural encoding study of olfactory ORN and OB neurons using olfactory mixtures. They discovered that upwards of 30% of neurons that responded to the complex odor did not respond to the component odorants. Using simple pairs of odorants that were combined into complex odors, they presented the complex odorant and then each individual component to see the differential between the complex and simple olfactory stimuli. They discovered that a good portion of the neurons that responded to the complex odorant (depending upon the order of presentation of complex odors to individual odorants) did not respond to the atomic parts of the complex mixture. Thus, they propose that a complex mixture has extra qualities above and beyond what would be expected if the mixtures qualities were simply additive. While their findings are to be expected given the chemical nature of olfactory objects, as noted in Chapter 2 (Section 6), what it adds is an explanation of the chemical interactions at work underlying our capacities to identify components of compound olfactory objects. At the sensory level these effects are explained by the nature of the ORN, glomeruli, and mitral cells combinatorial nature of stimuli encoding together with the nature of the olfactory object given its chemical nature. However, even at the cortical level where the Olfactory Cortex plays an integrative role these effects still occur given the Laing effect.

3.3.3 Laing effect

Laing and Livermore (1998) and Laing (1998) have documented our ability to identify odorants within a complex odor. They discovered that even if the subject had access to the individual odorants, the subject could identify at most three to four odorant components when these were combined into a chemical mixture. These results are not surprising given the combinatorial nature of olfactory perception as outline in the Chapter 1 in combination with my claim that the olfactory system employs a functionally compositional system. It is surprising that the Laing effect makes sense given that the olfactory object is the structure of molecular compounds, since when these are put together to form a molecular mixture the chemical parts no longer behave as they would on their own (Earley, 2005). Additionally, the limitation in identifying parts of a complex odor might be due to the format of the combinatorial representation as outputted from the piriform cortex (Wilson & Stevenson, 2006). According to this line of thought, while discrimination and detection might be a synthetic process at the receptor level, identification and recognition require cortical feedback from the piriform cortex, which is not representationally fine-grained enough to encode the minute differences between the structural components within the molecular mixture.

3.4 Olfactory mixtures

Olfactory mixtures are their own field of study not only because of their ecological import, but also for their industrial uses in creating artificial flavors and fragrances. When two or more odorants are combined into a complex odor one of two possible mixtures results: a homogenous mixture such that a new odor is created and is different from the previous components which are furthermore not identifiable; and a heterogeneous mixture such that no new quality of smell is created and the components are easily discernable from one another (Berglund et al., 1973). As a general rule odorants that are similar to one another combine to form homogenous mixtures, while those drastically differing in qualities usually create heterogeneous mixtures.

What is especially fascinating about homogenous mixtures (but also apparent to some extent in heterogeneous mixtures) is that a mixture's quality is not simply determined by a simple additive process such that one can predict the new smell from its individual components (Berglund et al., 1973). Rather the best explanation of this effect for modeling psychological reports of the quality intensities in humans uses vector space computational modeling. Leaving aside heterogeneous mixtures, the inability to identify components within the homogenous mixture (as they create a novel quality independent of the components) shows that the olfactory system processes and encodes olfactory mixtures in a nonconcatenative fashion.

Using optical imaging of the locust's olfactory bulb[62], Yaksi et al. (2009) looked at the connection between the course chemotopic maps, within the glomeruli and mitral cell activity and areas Vv and Dp within higher processing levels.[63] The objective of the study was to see how mixtures and their components were processed at both levels of processing as opposed to just looking at the olfactory bulb. As they expected there was a great deal of mixture suppression within the mitral cells activity, where one component seemed to be dominant within the mixture and suppressed the firing of mitral cells sensitive to the other components. However, their underlying question was how it is that the rough topographic map of the olfactory bulb with its mitral cells, which are

[62] Locusts are used, since their olfactory bulbs are inverted and thereby optically visible without any need for surgical interventions, thus allowing a noninvasive way of studying animal models of olfaction.
[63] Vv is slightly precortical and Dp is a homolog of the mammalian olfactory cortex

selective primarily just to individual chemical properties of parts of the overall structure, gives rise to the overall percept of a complex mixture. What they discovered is that Vv responded broadly and primarily just to mixtures. In contrast;

> Activity patterns in Dp were more distinct, but the average response selectivity and pattern overlap were not significantly different from the previous stage of processing. Dp therefore transforms one combinatorial odor representation into another. Odor representations in the olfactory bulb and Dp are qualitatively different because Dp neurons associate multiple molecular features, whereas mitral cell responses are constrained by the molecular receptive ranges of individual odorant receptors. Hence, Dp seems to establish synthetic representations of complex odor objects. The pronounced mixture interactions associated with this transformation may explain, in part, why the perceived quality of an odor mixture is often distinct from the components alone. In addition, transformations in Dp and homologous areas may subserve other functions such as pattern storage and pattern completion during the formation and recall of odor memories (Yaksi et al., 2009, p. 481).

One interpretation of these results within animal models is that the OB, and the mitral cells in particular, forms the initial representation of the atomic components of the mixture, which are then transformed into a complex representation within the olfactory cortex.

The transformation and interaction between the components representations within Yaksi et al*.* (2009) provides a partial explanation of the Laing effect in humans. What needs to be added to this explanation is the assumption that the best computational model of olfaction employs functional compositionality, since while complex molecular representations are literally formed from atomic parts, the olfactory system does not allow strict decomposition, that is, the identification of the components of the complex mixture. While we cannot identify the components, they might be partially available for decomposition, since we are capable of estimating the amount of each component within the mixture (Broome et al., 2006).

Combining the findings of Yaksi et al. (2009) together with Wilson and Stevenson's aforementioned claim regarding the role of the Piriform cortex in creating complex representation of olfactory mixtures there is suggestive evidence that olfactory processing from the OB through the cortical areas is synthetic and combinatorial, but not fully compositional in the classical sense. Complex olfactory mixtures do not have literal parts, nor do they co-token their components as distinct entities within their complex molecular representations.

3.4.1 Configural, Elemental, and Overshadowed mixtures

Recent findings regarding Homogenous and Heterogeneous olfactory mixtures have adopted the linguistic convention of referring to the former as "configural" (the components create a new quality and are not identifiable nor recognizable within the complex molecular representation) and the latter as "elemental mixtures" (each of the individual components can be identified as distinguishable elements of the mixture). While the existence of these different kinds of mixtures with different kinds of compositional representations has been widely documented, the underlying mechanisms have not been fully explored. One of the first steps in understanding the mechanism responsible for these effects began with the question of what kinds of components create each kind of mixture. Wiltrout et al. (2003) tested how the similarity of the components affected the quality of the complex mixture. Using habituation tasks in rats ,they discovered, that the mixture's quality is dependent upon the identity of the odorants. Perceptually similar odorants yield configural mixtures, while dissimilar odorants yield elemental mixtures.

It was further discovered that binary olfactory mixture quality could not just be determined by the perceptual similarity of the odorants, but is dependent upon the similarity of chemical structure as detected by biopsychophysics at the receptor level. In keeping with the conclusion of Chapter 2 and the findings of the previous section, we can explain the representational format of olfactory mixtures given that ORNs, glomeruli and mitral cells are sensitive to the chemical structure of molecular compounds. Thus, Kay et al. (2003, 2005) demonstrated that the configural or elemental (synthetic) nature of the olfactory mixture can be accounted for by receptor biophysics. Odorants that have a similar structure will activate similar sets of receptor neurons thereby generating configural mixtures, while those differing in structure will yield elemental mixtures. Their results even predicted the results of studies that showed configural effects using dissimilar perceptual odorants (such as the Laing studies) since the odorants used in these studies might have been dissimilar in their qualities, but were similar in their chemical structure. Olfactory mixtures of structurally similar components, yield configural mixtures that are compositional in the mere functional sense. However, this does not establish that the olfactory system wholly employs a functional compositional system of syntactically formatted representations due the nature of elemental mixtures.

The concentration effect counters a worry raised by elemental mixtures for the claim that the olfactory system employs a functionally compositional system of representation. Kay et al., (2005) confirmed their earlier (2003) findings regarding the structural nature, but also quite unexpectedly noted that similar and dissimilar components can yield both kinds of mixtures depending upon the concentration levels of these parts. So olfactory object identity and ORN & OB biopsychophysics cannot be the whole story. According to my theory of the olfactory object in Chapter 2, we should expect that varying the concentration of the odorants has an effect on the nature of the olfactory mixture's quality. Since concentration is a property of the olfactory object, we can infer that if the properties of any object are changed to a great extent this will eventually yield a different perceptual object. By analogy suppose that visual objects are determined according to punctate spatiotemporal boundaries and that shading or color is one of the object's properties. It has been documented the degree to which vary the shading or color of an object, while fixing the shape and location, will yield a perceptually new object (Feldman, 2006; Feldman & Tremoulet, 2006; Tremoulet & Feldman, 2006). Additionally, by varying the concentration of odorant components one can influence whether the complex mixture will be perceived as configural or elemental (McNamara et al., 2007). The concentration effect goes some way towards demonstrating that olfactory mixture quality is not a simple matter of additive processes and that a functional compositional system must be available for encoding and representing not just similar olfactory objects, but dissimilar ones as well.

The overlap hypothesis - that perceptually similar components generate mixtures differing in quality, since they overlap in the ORN and OB neurons that they activate - is discredited by the concentration effect and the study by Frederick et al. (2009) on the biophysics and mapping of component input maps onto behavioral-perceptual responses. The study shows that the input patterns of components cannot predict whether the mixture is configural or elemental: "Therefore, we conclude that odor mixture quality is not the result of the linear sum of component input patterns" (Frederick et al., 2009, p. 431).

It may be validly inferred what the cognitive format of olfactory representation is, since the above results are drawn from recordings and observations of sensory state activity, as well as actual perceptual and behavioral responses. Furthermore, the results confirm that the sensory levels of processing from the ORN through the OB employ a functionally compositional system. One question that might remain, of course, is how elemental mixtures are even possible since it seems that the components are fully available within the complex.? Two replies are possible: the first is to bite the bullet and agree that the olfactory system might employ both concatenative and functional formats of compositionality, which would still be compatible with my conclusion; the alternative would be simply to note that - based on the work of Frederick et al.

(2009) - it is quite clear that elemental mixtures cannot be determined at the sensory state level, which in turn (based on the findings of the previous section on stimuli encoding and transduction, as well as olfactory mixtures in general) suggests that the sensory system is functionally compositional,and that the atomic parts can be decomposable depending upon the functioning at the cortical level or processing.

An even stronger response is possible to this objection, which takes the elemental mixtures as further evidence for olfaction implementing functional compositionality. Since any mixture is invariant between elemental and configural percepts (based both on the concentration of the atomic primitives and on the findings of functional compositionality of the complex sensory mixtures), a resulting elemental mixture can simply be interpreted as demonstrating that the decomposition of the atomic parts from a functional compositional representation occurs in a way that satisfies my preferred interpretation of van Gelder's theoretical minimal conditions for functional compositionality. Thus, elemental mixtures demonstrate that the functionally compositional molecular representations can be decomposed into the atomic constituents from which they were initially composed.

3.4.2 Olfactory Imagery mimics complex odor mixtures

Olfactory imagery shows that even in cases of introspection the olfactory system employs the nonconceptual format of functional compositionality. Algom and Cain (1991) originally showed that olfactory imagery mimics real odor mixtures. Generally mixtures of perceptually similar components are judged as less intense than would be expected if the intensity consisted in merely the summation of the parts. Subjects in their study generated the same imagistic percepts in accordance with this naturally occurring perceptual phenomena, thereby yielding imagined mixtures that mimic the intensity of that found in actual mixture percepts. The far-ranging implication of their conclusion is that we can mentally combine mixtures with the same combinatorial and noncompositional results as those of actual olfactory mixtures.

One possible reply to these results might be that the subjects are not using a functionally compositional format in performing these cognitive tasks, but rather they are tacitly employing implicit knowledge of how olfactory mixtures work.[64] Subjects might be using a classical LoT system and these processing similarities are nothing more than them simulating without employing functional psychosyntax, thereby making these personal level cognitive abilities invalid for inferring the formative nature of olfactory cognitive states. Certainly at some level olfactory mental states must be conceptual. Nonetheless in allowing that we can simulate nonclassically compositional perceptual states, the objection allows that

[64] Criticisms of this variety are commonly employed by Pylyshyn (2003, 2006) against evidence in favor of Kosslyn's (2006) pictorial theory of mental representations. Secondary processing effects such as speed, reliable errors, and verbal reports that mimic our expectations of a format might be attributed to our tacit knowledge of how the experimental tasks is commonly accomplished outside of the lab setting, when cognition is not the only tool available to us.

some olfactory states are formatted nonconcatenatively, thereby allowing room for my conclusion that some olfactory states are nonconceptually formatted.

To summarize, it has been shown that olfactory content is partially non-compositionally formatted in the classical sense, thus it is nonconceptual. Olfactory formative nonconceptual content has been demonstrated both using the methodology of defining conceptual content contrastively, as anything not concatenatively compositional in accordance with the LoTH, while at the same time borrowing the LOT strategy of inferring the syntactic nature of the content of representational states from our cognitive abilities.

3.5 The Richness of Olfactory Experience

The Richness of Experience (RoE) Argument has been put forward under many guises, but most have used visual examples as evidence that some of the contents of our perceptual states are richer than our conceptual repertoire, thereby providing reason to conclude that some of the contents of our perception are nonconceptual. Aside from providing a different source of evidence for the RoE argument, the content of olfactory experience provides a novel version of it following from the formative nature of olfactory sensory, perceptual, and cognitive states. Our olfactory experiences are richer than our conceptual resources not due to a lack of concepts, since these could be updated over time, but simply because of a difference in format between our conceptual states and our olfactory states. Olfaction provides an explanation of why our olfactory perceptual and sensory states cannot be captured using only (descriptive or demonstrative) concepts, which demonstrates that nonconceptual content is required to explain the richness of olfactory experience.

To arrive at this conclusion the section progresses in the following steps. First, the most basic skeletal sketch of the argument structure is stated. Following this, the richness of experience argument is distinguished from the Fineness of Grain (FoG) argument with which it is often confused. Further, it is argued that the RoE argument is favorable, based on its neutrality regarding the nature of concepts. Next, a brief historical overview of RoE arguments is given. The section then concludes with a discussion of the nature of the richness of content for olfactory experiences.

3.5.1 Richness of Experience vs. Fineness of Grain

The richness of content argument has the following structure: first, it is noted that certain experiential states have content that is quite rich (experientially robust); second, it is argued that the nature of this experience or content cannot be captured in a conceptual manner; it is thus concluded that the content of these states must be nonconceptual.[65] The first premise is difficult to demonstrate making the second even more contentious, since it must be argued that given the nature of concepts these cannot account for the content of the experience. Given the strategy of the previous sections on formative functional compositionality,

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[65] These skeletal arguments are meant only as schema and are not indicative of all forms that the RoE argument has historically taken. The schema is only meant to capture the most general claims and moves that the argument usually makes.

once it has been established that olfactory states are in fact rich, then so long as olfactory states occur in a functionally compositional format (in stark contrast to the concatenative compositionality expected of concepts), it should be pristinely clear[66] why concepts cannot capture the rich content of olfactory content.

Closely related and often conflated with the Richness of Experience Argument is The Fineness of Grain Argument (FoG), which is more frequently called upon to demonstrate the existence of nonconceptual content. The fineness of grain argument follows a similar structure with the first premise being the only difference , which states that some of the content of our experiential states is fine-grained. The grain of content of these states cannot be captured using concepts, thus we must conclude that the content of some of our experiences is not conceptual. The general assumption behind the FoG argument is that concepts must occur in such a manner as to be stable and public, which cannot capture the full particularity and details of the perceptual scene. Presumably the idea is meant to be that concepts are course-grained, since they track types and not particulars or tokens. However, it must be noted that this presupposes - without any indication of how this is meant to be determined - that conceptual and nonconceptual content not only capture different aspects of a perceptual scene, but that this is due to a difference not just of content or vehicle, but the very structure of these states.

The fineness of grain argument has been argued for by Cussin (1990), Kelly (2001) and Speaks (2005) and might be attributed to many more theorists

[66] It's the format.

who claim to be stating a RoE argument. What distinguishes these two arguments is readily apparent by noting the difference between the initial premises. Given their differences, evidence for and criticisms against each argument are not applicable to the other (Chuard, 2007). I will focus on the RoE argument, since it is neutral with regards to the structure or the nature of conceptual content, whereas the FoG argument assumes some notion of conceptual content. If there is anything clear within the literature on concepts it is that there is no consensus regarding the nature of conceptual content and the kind of grain required for concepts. Hence the RoE argument provides a more neutral argument for the existence of nonconceptual content.

3.5.2 Past arguments for the RoE

Historically the richness of content argument has been put forward using examples derived from vision. Fred Dretske (1981) puts forward the first version of the RoE argument, stated as the ‘richness of information argument’, using his notion of informational nesting and the distinction between analog and digital encoding of information. The general idea is that while cognitive processing occurs in a digital format, both sensory and perceptual information occur as analog representations. The distinction between these two forms of representations is easily summarized:

> I will say that a signal (structure, event, state) carries the information that s is F in digital form if and only if the signal carries no additional information about s, … When a signal carries the information that s is F in analog

> form, the signal always carries more specific, more determinate, information about s than that it is F (Dretske, 1981, p. 137).

Dretske's argument might be criticized based upon his overall theory of information processing and informational nesting. However, I think, its true weakness lies in the scant evidence he provides for sensory and perceptual states occurring in an analog form, as opposed to cognitive process which are digital, since they presumably involve linguistic abilities and something like a LoT. Though I do not endorse Dretske's information processing account of content, my own argument for the Richness of Olfactory Experience might be seen as similar, because I distinguish nonconceptual sensory and perceptual states from cognitive states based on the representational format of these two domains. That being said, functional compositionality is not similar to Dretske's analog content even if concatenative compositionality could be captured by something like his notion of digital content.

Tim Crane (1988) introduces a rather interesting visual illusion in support of the second claim of the RoE argument. He claims that the content of the experience produced by the waterfall illusion cannot be accounted for by using concepts, typed using an adaptation of Frege's criterion of difference as applied to predicative concepts, to capture the content of our perceptual experiences. The waterfall illusion occurs when one stares at a moving scene such as a waterfall for a period of time and then fixates on a portion of the scene that is stationary. For instance, if one were to gaze upon the Horseshoe Falls in Canada for a period of time and then look at a boulder along the edge of the falls, the phenomenology of the experience would be of the rock moving, but not relative to the background. The experience presents the object as moving, yet stationary. Additionally, it is worth noticing that this example concerns the content of the experience as appearing contradictory to the subject, thereby not making it analogous to the Muller-Lyer illusion that produces a contradiction between the content and attitude of the experience. Accounting for the waterfall illusion becomes problematic if it is assumed both that we can individuate concepts in accordance with something like Frege's Criterion of Difference and (in accordance with Peacocke) that we can only have the representational content of an experience for which we have concepts. The combination of these assumptions yields the result that we cannot have representational experiences whose experiential content is inherently contradictory, since this would require having the concept that a is F and not-F at the same time:

> The problem for the defender of concepts in perception is to say exactly which concepts are being exercised here, without denying that there is a conflict in how the perceived scene seems to be (Crane, 1988, p.234).

Crane's argument amounts to the claim that the logical structure of concepts does not allow for contradictory contents of experiences, and therefore that concepts cannot capture the nature of the experiential content of the waterfall illusion. Though his argument provides support for the second premise of the RoE argument it is predicated upon the explicit assumption that one can individuate predicative concepts in the same manner as senses and as such they have some semblence of logical structure. However, aside from Fregean's such as Peacocke, the assumption that concepts function in such a format is far from universal. Additionally, the argument requires that the phenomenology of the content of the experience is synchronically contradictory, which I think is debatable.

More recently, the richness of content argument has been attributed to Richard Heck (2000) on the basis of one of his examples: while sitting at one's desk the visual scene one is confronted with has such richness that it could not be adequately captured using concepts. Put in this manner it seems to fit the aforementioned scheme, but what Heck's argument amounts to is that the full detail of each particular within an imagined recreation of the visual scene of one's desk cannot be captured using descriptive concepts simply because we do not possess enough. The driving claim is that we lack the descriptive resources that are required to capture the detail of the visual scene, which makes his argument about not the richness of the experience but rather the level of detail required to correctly describe the visual scene. Heck's argument read carefully regards the fineness of grain of visual experiences and should not be treated as evidence for the first premise of the RoE.

Another theorist who has been incorrectly thought of as using the RoE argument is Sean Kelly. His argument is situated within the debate between Peacocke and McDowell regarding whether demonstrative concepts can capture the full richness of our experience. However, what the debate amounts to is not the richness of the experience, but the level of detail required to capture the content of our experience. According to Peacocke, nonconceptual content captures more detail, since it regards aspects of the token and not mere typehood of the perceptual scene, yet it is more coarse than a demonstrative concept, which captures just the particularity of the perceptual object.

Peacocke thinks McDowell's demonstrative concept strategy won't account for the richness of our discriminative visual abilities, because they are too fine grained. In contrast, Kelly (2001) claims that demonstrative concepts are not detailed enough, since they won't capture the full context of the experience that is relevant to the experiential content. The same color tile appears as different shades depending upon the context and lighting conditions. Demonstrative concepts cannot capture the particularity of a given shade, because the relevant lighting conditions need to be accounted for to fully capture the particular shade.

The conceptualist could reply that we can accomplish this level of specificity using clusters of demonstratives to capture the richness of the experience. But, the strategy's demonstrative explosion will become a needlessly cumbersome operation and might be dubious based on the time of processing, cognitive load, and phenomenology of how we experience fine-grained differences in shades. What is most questionable about this whole debate is the nature of demonstrative concepts. Since Frege himself does not specify nor argue for the nature of demonstrative thoughts, I can think of no reason why one could not assume something in the spirit of his theory from "Thought" (1918-

19/1997) in which he claims the time of utterance must be specified in addition to the content of the thought. There seems no principled reason for not building the full context of the experience (including time of day, luminance conditions, and shade) as part of the demonstrative, which would certainly make them detailed enough to handle Kelly's worries. Thus, this debate also devolves into an argument regarding the formative nature of concepts, but now problematically compounded by the nature of demonstrative concepts.

Mike Martin (1992) provides the strongest RoE arguments, under the assumption that our perceptions must feed into memories, thus we might have a memory of a scene for which we do not have the concepts of every object. Yet, we can acquire these concepts and then realize what our memory is about. His Richness of Experience arguments can be summarized by the following quote:

> If the memory experience can have a content that exceeds the conceptual resources of the subject at the time of perception, we have reason to think the conceptualist is applying an arbitrary restriction on the content of experience (Martin, 1992, p. 241).

To demonstrate this point he uses the example of Mary who plays a game with her twelve- and eight-faced dice, yet who does not possess the concept of the dodecahedron. Later on she gains the concepts and now can recollect that her dice playing experience involved a dodecahedron.

> The Mary example gives us a case in which (C) *[It appears to S as if p -> S possesses those concepts necessary for believing that p]* does not hold for all the ways in which things appear to her. The conceptualist view of experience therefore seems wrong: It involves an arbitrary restriction on the ways things can be experienced (Ibid., p. 244, italic material added.).

His argument is certainly novel and advances the debate, but can be questioned based upon the role of perception in forming memories. Furthermore, it treads upon issues related to what gets consciously encoded into memory and its connection to awareness. For instance one aspect of the classic Sperling (1960) experiments is that though I might attend to an entire visual array, not all of the items within my experience are encoded in memory. Even though attention might be able to modulate and increase the grain of the constituents within my memories, I find it doubtful that anyone might have such fine-grained memories of multisided dice. While this worry does not directly effect Martin's argument, since it is offered as a thought experiment without empirical support, I think if one were to look at the scientific evidence on memory formation that encoding such fine grained details of one's own experience seems quite questionable.[67] Since the role of perception in encoding memories, as well as attention and consciousness's role in memory formation, are thornier issues than I need handle here, I will leave them aside. Historically the RoE argument has depended upon the role of vision, thus it is worth considering whether olfaction provides a

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[67] As an aside, I have vivid memories of being dragged to the Metropolitan Museum of Art every spring. I strongly remember seeing a host of paintings, which I thought were painted by artist who clearly needed glassess, since they were all out of focus. This seemed rather odd to me having always traversed the renaissance and Italian painters sections first. At some stage I gained the concept of impressionism and understood that the colors and vague object boundries of impressionist art were purposeful and not a matter of simple optical dysfunction. However, I would be wary of ascribing my childhood memories the content of seeing impressionist paintings. There is certainly a sense in which I can now appreciate that what I saw back then was of a given school of artistic expression. Yet, standing in front of the same paintings these days or even thinking about my last experience a week ago the memories and experiences are far richer in content, because of my conceptual repertoire.

stronger argument for nonconceptual content, one which by-passes the afflictions of the aforementioned arguments.

3.5.3 Olfactory Richness of Experience

Given how little attention we pay to smells and how often our olfactory experiences are neglected or simply thought to be inconsequential for day-to-day life, it seems odd to claim that these experiences are nonetheless phenomenally rich in their experiential content. Yet, when one attends to their olfactory sensory and perceptual states it is apparent that they are experientially more robust then our conceptual (olfactory) repertoire should prima faice allow.

Evidence for the existence of the richness of content in olfactory experience can be derived either from pretheoretical reasoning or based upon our discriminative abilities outrunning our capacity to recognize and identify odors. There is a pretheoretical argument that can easily be given for the existence of the richness of content in olfactory experiences: if concepts are anything like language then the dearth of vocabulary regarding smells suggests that we are able to experience far more smells than we can label using it.

However, this simple reasoning is flawed. Even if there is a scarcity of olfactory concepts it does not entail that we cannot acquire or develop new concepts as our olfactory experience increases. It seems quite plausible to think that our conceptual capacities evolved together with the frequency of olfactory experiences. As one’s experiential base increases one’s conceptual olfactory capacities should follow suite and unsurprisingly, this is exactly what is found. Olfactory professionals have a greater capacity to recognize and label odors, as well as a greater ability for olfactory imagery (Gilbert et al., 1998). However, their enhanced conceptual resources do not depend upon increased linguistic abilities or labels, but on the actual number of experiences (Gilbert et al 1998). The evidence that olfactory coding and experiences are nonlinguistically formatted, nor dependent on language processing in the same way as vision, has been further substantiated with a host of further empirical evidence (Goodglass et al., 1968; see Herz, 2000, for a full review of the literature). Taken together, these studies suggest that the olfactory experience, cognition, and memory depend upon a sensory template, which can be reactivated thereby recreating the original experience.

Though this is by no means a demonstrative argument, our olfactory experiences clearly exhaust our linguistic ability to identify and recognize odorants at a given time and across time. Our ability to discriminate odorants vastly exceeds our capacity to identify or recognize the same smell (Herz, 2000). Furthermore, our ability to detect and distinguish more odors than we can recognize is evident from the negative effect verbal retrieval tasks have on odor identification, but not on discrimination (Dulay et al. 2008). Thus, if concepts are thought to be linguistic in nature, it seems that our olfactory experiences vastly exceeds our ability to conceptually capture its full content.

If olfactory states are encoded in a nonlinguistic sensory format this might be further used to argue that given that the nature of concepts is about types and not mere tokens, the sensory state's detailed particularity cannot be captured using concepts. Olfactory experiences are nonconceptual, because concepts requires abstraction from the particular in a stable and public manner that allows for recognition and identification of multiple token experiences as falling under the same type over time. However, this is not possible for olfactory representations that encode the particular in all its glory. While this argument seems enticing (and fits Intermediate-processing theory assumptions about concepts and cognitive processing well)[68], it slips into an issue over the fineness of grain of concepts making it evidence for the FoG, instead of RoE, argument.

Rather than focusing upon the detail of content that concepts can capture about an experience, a more promising idea might be to return to the format of content that concepts require. If thoughts trade in the currency of concepts, then concepts should obey the general requirements of a compositional system of thought. Concepts must obey the formal constraints of the LoT, thus olfactory experience might be richer in content not, because of a lack of linguistic labels, vocabulary, or experience, but simply because olfactory states utilize a functionally compositional format. The content of our olfactory experience is more robust than our conceptual repertoire based on a difference of what kind of compositional system is employed in each type of state.

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[68] See Chapter 4, Section 3.5.

We can experience more than we can conceptualize in olfaction, because concepts and thoughts require concatenative compositionality, while olfactory experiences are encoded in a functionally compositional format, which does not allow us to access all of the aspects of the particularity of each part of the complex experience on their own. Presented pair-wise, we can easily recognize, discriminate, and identify each of the individual constituents of a complex odor. However, once these are combined into a functionally compositional complex odor we can no longer access nor detect each component within the complex. We are presented with a rich olfactory experience, which is different from the sum of its parts. We can diachronically tease out the individual constituents and perform the decomposition function of recovering the individual components, but we can at best access four constituents at a time. Olfactory experiences veridically presented to us in the specious present outrun our conceptual repertoire. They may be decomposable, but this is a serial process that requires multiple presentations of the odor across time.

For example, I might smell a new fragrance by *L'Artisan Parfumeur* and the first experience presents me with a novel Oud odor experience, which I cannot capture in terms of my previous olfactory sensory templates or odor concepts. However, upon sniffing it across time I might be able to tease out the main components and the perfume might even develop over time. The temporal aspect of a complex smell allows for decomposition, but synchronically presented odors outrun our conceptual resources due to their formative structure.

When moving from functionally compositional sensory and perceptual states to cognitive olfactory states the decomposition of the format from one type of system to the next yields less representational content than the sum of its parts. What is powerful about this argument is that all the evidence from Sections 3-4 can now be used in support of the idea that what explains our olfactory verbal and identification deficits is simply attributed to the functionally compositional nature of the format of olfactory experiences. In conclusion, the previous sections demonstrate that olfaction employs a functionally compositional system of representations, which provides a new argument and explanation of the olfactory richness of experiential content.

Chapter 4

Stinking Theories of Consciousness.

Introduction:

We may not always notice the world of odors enveloping us, yet they provide a powerful source of experience. Our sense of smell, the anatomical structure, and functional organization of the olfactory system have profound consequences for the study of consciousness. In this chapter I show how neglecting olfaction has negatively impacted the current neuroscientific theories of consciousness to the extent that a large portion of these theories are either false or inadequate as general theories of consciousness.

A partial difficulty in studying consciousness is that everyone claims to know what it is, yet a consensus has never emerged as to the true nature of consciousness. We all claim to know what consciousness is from an expert perspective of a subject of experience. Compounding this difficulty, theorists often start with background assumptions about the nature of consciousness and the methodology best suited for studying such a conception. Practically this translates into the problem that each theorist's conception of consciousness must be noted before beginning an analysis of consciousness.

I will not propose a new taxonomy of consciousness, rather for my purposes it will be best to stipulate that there are three different kinds of states that we commonly think about as conscious: waking consciousness, conscious awareness, and phenomenal consciousness. Waking consciousness might be determined merely by physiological levels of arousal and is ascribed to a creature depending upon whether it is awake or asleep and responsive to its environment. The next kinds of state that we commonly think about as conscious is awareness, consciousness of, transitive consciousness, or access consciousness. Though entire theories are built upon the fine nuances between the definitions of such states, the common denominator is that we are sometimes aware of our experiences, we are aware that we are undergoing experiences, or we are conscious of being conscious. The last notion of consciousness is that of phenomenal or qualitative consciousness: some (if not all) of our experiences have a qualitative character for the subject undergoing the experiences. To say that something is qualitatively conscious is to say no more than that there is some qualitative aspect for the organism to undergo the experience.[69,70]

Since there are at least these three different conceptions of consciousness at play within the study of consciousness, this chapter will carefully highlight what kind is at play in each theory, but leave aside discussing phenomenal consciousness until the next chapter. The methodology will be to group theories according to their shared failures with their claimed necessary conditions for consciousness. The focus will be upon the implications that the olfactory system

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[69] The relationship between this type of consciousness and the previous ones is a contentious debate that will not broached until the final concluding chapter.

[70] The simplest understanding of qualitative consciousness is that from our own perspective we can notice that our experiences are different. There's something that is like to have a hot cup of chocolate on a cold winter's day or to hear Mahler's Symphony No. 1 being played by the New York Philharmonic on the Great Lawn on a hot summers evening at dusk, and that these experiences differ in some aspect of the experience.

and our sense of smell brings to bear for the necessary conditions claimed bythe neuroscientific theories of consciousness.

The general structure of each section is to state each theory's conception of consciousness, their research strategy, methodological assumptions, the evidence supporting their theory, and the necessary conditions they claim are required for consciousness. After the overview of each theory, the consequences of neglecting olfaction will be set out, possible replies on their behalf will be offered, followed by a brief conclusion regarding the status of their claimed necessary conditions of consciousness given the nature of olfaction. The theories of consciousness covered are: Merker's Centrencephalic theory, Lamme's Neurobiological Theory, Intermediate-processing theories (IPT) including Jackendoff's, Prinz's Attended Intermediate-Level Representations (AIR) theory, Mandik's Allocentric-Egocentric Interface (AEI) theory, Crick and Koch's Neurobiological Specificity Theory, The Global Workspace Theories of Baars, and Dehaene, and Tononi & Edelman's Information Integration Theory.

4.1 Subcortical Consciousness:
Merker's Centrencephalic theory of consciousness.

The Centrencephalic theory (Merker, 2007) claims that consciousness can arise without the cortex and corticothalamic loops. Resuscitating Penfield and Jasper's idea that the midbrain reticular formation is supracoritcal in terms of function and control, Merker argues that the thalamus and corticothalamic relays are not required for consciousness. Merker is purposefully obtuse in defining consciousness. Since his theory concerns the necessary conditions of having experiences, which should be carefully contrasted with the necessary condition of being aware that one is undergoing an experience, it is most charitably treated as a theory of waking consciousness. His lack of definitional clarity is due to a very permissive notion of consciousness as whatever it is that makes experience possible. By his own admissions he is only seeking the enabling conditions of consciousness based upon its constituent states. This is best brought out by his working assumption that the functional role of consciousness is to guide behavior, which he thinks can be facilitated in the absence of awareness.[71] Thus, his methodology is to assume that the putative functional role of consciousness arose from the evolution of the visual system[72] and our ability to navigate the environment to fulfill our homeostatic needs.

Merker's background assumption regarding evolutionary function becomes apparent, when he defines 'consciousness' in accordance with the purpose it serves for the organism. It is in this vein that he claims that the brain evolved around the visual system whose teleofunction is to select targets that will realize our homeostatic goals. Accordingly, the human cortex and thalamic connections

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[71] It might be worried that his theory applies to awareness in addition to waking consciousness for the reason that any mental state that guides behavior is traditionally thought to have a content that is available for rational or inferential process. However, all he is minimally claiming is that some states occur without awareness, yet can play a functional role in guiding behavior. His claim regarding functional role and behavior amounts to nothing more than the common claim that sometimes unconscious processes guide our actions.

[72] We can analyze the function of consciousness as predominantly allowing for our capacity to navigate our environment to fulfil homeostatic needs and that we may trace this as predominantly due to the evolution of the visual system.

evolved for the visual system, yet it is still possible to have target selection that does not involve the cortex. It is difficult to assess his claimed phylogenetic development of the brain without a complete evolutionary story regarding the development and selection pressures upon the brain. Given the current state of evolutionary biology, his claims regarding the phylogenetic development of the human brain are not fully justified.

The assertion that the cortex's structure was evolutionarily sculpted in accordance with the development of the visual system seems empirically unmotivated and unsubstantiated. Though I am skeptical of his overall assumption that the structure of the cortex was determined by the development of the visual system, it is worth noting that the specificity of brain areas for the visual system and the coercion of greater cortical tissue for vision is supported by recent work on the genetics of olfactory system. While Buck and Axel's (1991)[73] work regarding the genetic basis of olfactory receptors showed that mice have one-thousand genes for producing olfactory receptors, only a portion of which generate olfactory receptors. Depending on the species the number of pseudo-genes could range from 10-60%. One of the interesting findings using comparative genetics in animal psychology is that species with tri-chromatic vision have a proportionately higher percentage of pseudo-genes (Gilad et al., 2004). The hypothesized explanation of this is that as visual acuity increases the utility of olfactory acuity decreases. Alternatively, olfactory acuity may be sacrificed for vision given constraints on the amount of tissue available to the

[73] See Chapter 1, Section 3.3 for further details.

organism based on caloric consumption and space. While this line of evidence does not fully support Merker's general assumption that the entire cortex developed to accommodate the visual system, it suggests how our olfactory abilities may have been shaped by our limited cortical resources being devoted to vision.

Another contentious aspect of the centrecephalic proposal is that the visual system is primarily responsible for object tracking and goal setting, in light of action planning, to acquire the object of desire. There is evidence of the olfactory system's capacity to track objects across distances depending upon the concentration level and the presentation to the different nostrils at different times (Porter et al., 2005, 2007). When our olfactory tracking abilities are combined with olfaction's primary role in detecting social relations (predator, family member), food sources, and possible mates, as noted in the introductory chapter, Merker's claimed centrality of the visual system seems dubious.

Merker provides modern evidence for Penfield and Jasper's original theory regarding cortical control, who argued that the midbrain reticular formation was supracortical in terms of both function and control. Evidence for their claim derives from surgical procedures performed on patients with epilepsy in which the removal of brain tissue was required to alleviate their symptoms. Based on their work with 750 patients who were awake and responsive during the surgical treatment, so as to ensure that the key areas underlying conscious control and cognition were not affected, Penfield and Jasper were impressed by how much cortical tissue could be removed without a patient losing consciousness. Their neurosurgical findings provide support for the Centrencephalic conclusion that the cortex is not necessary for consciousness or cognitive activity generally, but rather that the midbrain and its extension (including the nonspecific thalamus encompassing the midline, intralaminar, and reticular nuclei) are responsible for cognition.[74]

According to this incarnation of the centrecephalic proposal, while the cortex is not necessary for all forms of cognition and consciousness, some degree of cortical mediation is still required. Merker's own stance on the requirement of cortical mediation is explicit that consciousness itself need not be mediated by any cortical connections and can occur independently in the midbrain. To make this audacious move and the original theory even more minimal, Penfield and Jasper's approach is updated using Thompson's subcortical general learning system, the Sprague effect, midbrain target selection, and ancephalic children.

Thompson's (1993) subcortical general learning system contradicts our common thinking that the cortex and conscious awareness are required to learn about and navigate our environment. Thompson's work shows that animals are

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[74] Merker's centrencephalic proposal might be criticized, because Penfield and Jasper's research concerned epileptic patients who were awake and reporting on their conscious experience during surgery. However, his theory concerns the mere preconditions of having an experience whether or not one is aware of undergoing any experience. Thus, it might be argued that he is conflating waking consciousness and awareness. Nonetheless, if the cortex is not required for even the later kind consciousness this certainly adds further credence to the centrencephalic proposal.

able to learn even with substantive cortical lesions. Subcortical areas might be considered more important than cortical areas when considering a systems level analysis of neural function. Thompson's work provides further support for Penfield and Jasper's proposal that "certain upper brainstem systems in receipt of convergent cortical projections occupy a superordinate position" (Merker, 2007, p. 66).

Continuing the theme of considering the midbrain supracortical, the Sprague effect concerns individuals with cortical damage who have lost some visual abilities, yet upon further damage to the connections between cortical areas and subcortical tissue several visual abilities reemerge. Their restored visual capacity is limited to the ability to orient and approach locations of moving visual stimuli in space, and visual pattern discrimination does not recover after midbrain intervention. The Sprague effect supports Merker's claim that just thinking in terms of cortical deficiencies inflates the functional necessity of the cortex. Cortical deficiencies on their own need not necessitate deficiencies of consciousness, but the cortex's connection to neighboring areas explains how cortical deficiencies impact upon midbrain proficiencies that are responsible for consciousness.

Further support for the Centrecephalic proposal can be gleaned from our abilities for target selection, goal setting, and action planning, which demonstrate the supracortical function of the caliculus in the control process (Carello & Krauzlis, 2004; McPeek & Keller, 2004). Also, the colliculus sums up and decides from the possible actions available to an organism which to execute (Allport, 1987; Brooks, 1994; Dean & Redgrave, 1984; Isa & Kobayashi, 2004; McFarland & Sibly, 1975; Tyrrell, 1993). Evidence for the colliculus performing a functionally higher role than the cortex in target selection is supported by collicular lesion studies with macaques that showed a great deal of compromise in their sophistication and scope of target selection. (Albano & Wurtz ,1978; Casagrande & Diamond, 1974; Denny-Brown, 1962; Goodale & Murison, 1975; Merker, 1980; Mort et al., 1980; Schiller et al., 1979; Schiller & Lee, 1994; Schneider, 1967).

The most fascinating part of Merker's theory is his discussion of children with the medical condition of Anencephaly:

> Anencephaly is the medical term for a condition in which the cerebral hemispheres either fail to develop for genetic developmental reasons or are massively compromised by trauma of a physical, vascular, toxic, hypoxic-ischemic, or infectious nature at some stage of their development (Merker, 2007, p. 78).

Most cases of Anencephaly occur in children who are missing the vast majority of their cortex. According to medical practitioners these children fall within the definition of being brain-dead. However, observations of them in home settings shows that these individuals have experiences that seem to have a qualitative character.[75] They might not possess awareness of their experiences, but they appear to have preferences for different kinds of experiences. What he suggests

[75] The assumption that these children undergo qualitative or phenomenal conscious states might seem contentious to some, but is perfectly in keeping with Block's conception of p-consciousness, Rosenthal's thin phenomenality, and olfactory phenomenal consciousness. For a further discussion of this matter please see Chapter 5, Section 2-3.

is that these individuals have qualitative consciousness without having a cortex i.e. experiences of some nature, but they do not possess an awareness of these experiences. Thus, Anencephaly provides reason to conclude that a precondition of consciousness need not be the cortex or corticothalamic loops.[76]

The problem with using these cases as criteria of consciousness is not that they might not teach us about the sufficient underlying neural conditions that are a prerequisite for consciousness, but with the nature of consciousness that these children are claimed to have. I wonder whether these children really have the kind of consciousness that we intend to study. It is quite clear that they attain waking consciousness and do not possess awareness, but Merker's evidence for their attainment of qualitative consciousness is far from demonstrative. A critical flaw of the centrencephalic proposal is that it is unclear whether it is a theory of consciousness or merely a theory of the preconditions necessary for waking consciousness.

Anencephaly and our subcortical learning system support the midbrain as a precondition for waking consciousness, but I think few would doubt that the midbrain including the reticular formation of the thalamus is not necessary for waking consciousness. Lesion studies[77] have shown that damaging the reticular formation of the thalamus causes a lack of waking consciousness. So what is

[76] Merker's claim that phenomenal consciousness can occur in the absence of awareness is a contentious claim, since this allows for nonconscious phenomenal experience. However, I think that his evidence does support this claim, but will not argue here for the view that phenomenal consciousness is independent of awareness, as it is one of the central themes of Chapter Five.
[77] For a good discussion of the role of these areas in waking consciousness see Baars (1988, 1997).

Merker adding that is novel? His greatest contribution to consciousness studies is the description of anencephalic children's likes and dislikes. Anencephaly suggests the possibility that individuals may have phenomenal consciousness or qualitative aspects of experience even in the absence of awareness, such that awareness is neither necessary for nor identical to qualitative consciousness.

But what about olfaction? One of the key findings of my exposition of the anatomical connections of the olfactory system is that our experience of odors does not require the thalamus nor corticothalamic loops, since neural connections projects directly from the olfactory bulb to the cortex.[78] The unique anatomy of the olfactory system provides an immediate counterexample to Merker's entire proposal that consciousness need not involve the cortex and corticothalamic loops. While the last half of his claim that corticothalamic loops are not necessary for consciousness is true,[79] the olfactory system's direct projection to the cortex without thalamic connections suggests that at least for olfaction the cortex is required for conscious awareness.

Merker's approach is incorrect as a general theory of all types of consciousness, yet it provides a springboard for launching an attack upon the overvaluation of the cortex and the stranglehold that the notions of access consciousness and transitive consciousness have upon theorizing about consciousness. Prevailing orthodoxy is to begin by explaining the datum of conscious awareness from which an understanding of qualitative consciousness

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[78] Chapter 1, Sections 3.4-3.6.
[79] For a full discussion of, and evidence for, this point see Section 4 of this chapter.

is then derived. Merker's approach sets out the initial conditions to argue for a bottom-up approach in which waking consciousness is a necessary condition for phenomenal consciousness, which then forms a constitutive condition of conscious awareness.

4.2 Lamme's Neurobiological Theory of Consciousness

Lamme (2004, 2006a, 2006b) seeks to explain the nature of conscious experience in terms of neuroscience by arguing that the only way to successfully define consciousness is through the use of neuroscientific approaches and concepts. He thinks we can circumvent the problems of reportability by changing the conceptual framework that we use to talk about our experiences. Commonly we think of conscious states as those that we can report being in, however, Lamme counters that using reportability as the sole criterion for consciousness has the consequence that the entire right hemisphere of the cortex could not be considered part of the neural correlates of consciousness. Language and reportability cannot be the sole criterion for ascertaining if a state is conscious unless we disallow the entire right hemisphere from having consciousness merely because it does not have access to language centers.

Lamme distinguishes between awareness and attention in the visual system, scientifically cleaving the two cognitive functions from each other, so as to allow a conscious experience of a visual entity even when we are not attending to the object. Neuroscientifically we can separate attention from awareness such that attention is responsible for reportability, so that nonetheless we might be aware of far more states than we can report, which suggests an understanding of consciousness that moves away from our folk psychological conception. While the separation of these two cognitive faculties or functions might be suggestive of Lamme's approach falling within the parameters of conscious awareness, it is quite clear that he identifies awareness with access-consciousness (a-consciousness), and states that are conscious but not attended to with Block's notion of phenomenal consciousness (p-consciousness).[80]

Block (1996) claims that the concept of consciousness is not a cluster concept containing lots of different kinds of relevantly similar concepts, but a mongrel containing different kinds of states that nonetheless share the same term. The variegated nature of consciousness allows Block to distinguish between phenomenal consciousness and access consciousness (1993, 1996, 2001, 2007, 2008, and 2009). The most charitable interpretation of this distinction that fits with Lamme's approach is that p-consciousness occurs when there is some information that is not available for reasoning, reporting, or rationally guiding action, but there is still something that it is like for the subject undergoing the experience. By contrast a-consciousness occurs when the representational content of a mental state can be used to make inferences within rational thought processes that are reportable.[81]

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[80] The definition of access and phenomenal consciousness is carefully explicated in Chapter, Section 2.

[81] See Chapter 5, Section 2-2.1 for a more detailed discussion of the best interpretation of phenomenal and access consciousness.

Lamme's (2003) background assumption is that consciousness is not functionally realized in a manner that is localizable, as opposed to Crick and Koch who think we can find one particular area or region of the brain which is responsible for conscious awareness.[82] Furthermore, consciousness must be realized based upon recurrent processes as opposed to feed-forward systems (2004, 2006b). The evidence for his theory derives from change blindness, inattentional blindness, backwards masking, and TMS studies (2006a). Change blindness (2006a) and TMS studies (2003), he claims, indicate that it is possible for us to be aware of something even though we do not or cannot attend to it.

Backwards masking and TMS studies, Lamme argues, provide reason to doubt the adequacy of feed-forward networks for conscious activity. Rather, feed-forward system (FFS) activation combined with recurrent cortical loops provide necessary and sufficient conditions for consciousness. So long as the current connections occur within parts of the cortex that are not accessible to higher cortical areas such as memory or language production, reportability is not possible, but these states could still be phenomenally conscious. Since visual awareness requires recurrent processes for consciousness, he infers that a similar structure of recurring connections must underlie phenomenal experience as well.

Lamme's theory is best analyzed in terms of two separate but constitutive claims. First, access consciousness occurs when recurrent connections sweep from the back of the brain in the visual system to the prefrontal and frontal areas

[82] For a more detailed discussion see Section 4.1 of this chapter.

of the brain. Second, recurrent connections within the extrastriate areas of the primary visual cortex are phenomenally conscious even though they are not projected to frontal areas and cannot be reported linguistically. Although both kinds of consciousness share the same underlying theoretical assumption such that a necessary condition of consciousness is that there be recurrent connective sweeps, the requisite conditions for attaining each kind of consciousness are slightly different.[83]

Lamme is wonderfully moderate in only claiming to have a theory of visual consciousness, such that its applicability to our sense of smell might be limited. However, we can still worry about the generalizability of the overarching claims that he has regarding the nature of consciousness. Attended conscious states are those states that I am conscious of and are accessible to me based upon the role of attention. But, the role of attention is not all clear when it comes to olfaction and we do not attend to most of the incoming olfactory stimuli (Sela & Sobel, 2010), yet the vast majority of olfactory stimuli have conscious effects.

Lamme asserts that attention is required for the formation of long-term memories, because mental states, which are not attended to, cannot attain long-term memory storage and be reportable. The role of attention in memory

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[83] The rest of the section focuses upon the applicability of Lamme's notion of awareness to olfaction. Lamme's approach to visual p-consciousness might apply to olfaction so long as it can be ascertained whether or not phenomenally conscious olfactory states occur without attention. Chapter 5 uses the case of blind smell, as well as that of our social interactions, choices of mates, and social preferences to indicate that there are some qualitative conscious states within the olfactory system that we do not have full access to. The argument for these being phenomenal will be developed in the next chapter using the case of affective mental disorders that occur due to olfactory deficits.

formation might be questionable based upon the olfactory systems direct projection to the hippocampus, which is traditionally implicated as the area responsible for both short- and long-term memory formation. Though these anatomical differences do not falsify his approach, olfaction's direct projection to areas of the brain responsible for memory creates a problem for his differentiation of a-consciousness from p-consciousness given that olfactory states might project directly to the hippocampus and limbic areas in a manner that is far faster than the projection to the cortex. At the very least this aspect of his approach requires further scrutiny.[84]

Lamme's theory requires further elaboration concerning what is causally responsible for generating attentional mechanisms. Within the visual system the salience of the object itself might cause us to attendto the object. However, with regards to the olfactory system, questions arise about which aspect of an olfactory object should be considered its salience and how it is identified. The most likely candidate is the level of concentration - the higher the concentration level the more intense the experience should be. However, concentration on its own will not be sufficient, because the activation pattern that will result after increasing the concentration will amplify general overall olfactory receptor neuron

[84] As it currently stands the debate regarding Proustian memories is still unsettled. Herz (2000) strongly claims that these are more vivid memories than those found in any other modality, while Gilbert (2008) maintains that the evidence is inconclusive. While the vividness and ability to elicit memories is currently under debate, Lamme's contention that attention is necessary for LTM memory encoding is questionable given the olfactory bulbs direct and unmediated connections the hippocampus.

and glomeruli activation, which can yield a change of the percept itself.[85] Odors are experienced in a different manner depending upon the level of concentration presented to the olfactory system.

Visual awareness and attention might require recurrent connections and loops between frontal and visual areas of the cortex, while recurrent processes within the visual system itself are those Lamme identifies with p-conscious states. According to this line of thought the more pronounced the object becomes in terms of its lines, edges, shading, and color the more phenomenal the states becomes. As such phenomenal consciousness involves the intermediate level of processing above area V1 in the visual cortex. The implication this has is that the object is fully bounded from the initial sensory level, which would allow for the possibility that phenomenal consciousness could arise in the olfactory bulb.

As currently proposed the olfactory system and olfactory consciousness create difficulties for Lamme's theory, but his theory is adaptable enough to encompass the aforementioned problems. Some adjustments to the constituent parts of the theory might be required for its application to the olfactory system. The only aspects of the approach that is questionable regards the intermediate levels of processing being phenomenally conscious.Since the existence of intermediate levels of processing within the olfactory system is an issue that arises in the next section concerning the levels of olfactory processing in

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[85] A detailed discussion of concentration as a property of the olfactory object and its ability to change the olfactory percept through increased neural activation can be found in Chapter 2, Section 6.5 and as well as a brief mention in Chapter 3, Section 4.2 regarding olfactory imagery.

Intermediate-Level Processes theories of Consciousness, it is best that I now turn to them.

4.3 Intermediate-Level Processing Theories of Consciousness

Intermediate-Processing Theories (IPT) of consciousness all concern the nature of conscious awareness and share the claim that consciousness arises at an intermediate level of cognitive processing. Jackendoff's (1987) Intermediate-Level Processing theory, Prinz's Attended Intermediate-Level Representations (AIR) theory (2000, 2005, 2007), and Mandik's Allocentric-Egocentric Interface (AEI) theory (2000, 2005, 2009) all agree on where consciousness occurs within the stream of cognitive representations, yet disagree on the necessary conditions for consciousness or the nature of the representational format. Jackendoff presents the initial form of the theory from a computational representational standpoint, but does not provide neuroscientific evidence for the theory. Neuroscientific evidence for the IPT is later added by Prinz's AIR theory with the added stipulation that only attentively modulated intermediate representations become conscious. Mandik's AEI theory departs from the previous theories by elaborating the perspectival requirement, as its theoretical starting point.

Since IPT theories share theoretical underpinnings, evidence, and methodology, I will summarize each theory individually and then note their differences. Having assembled the relevant theories and noted their differences, their olfactory shortcomings will be stated in terms of phenomenological concerns and neuroscientific evidence that the olfactory system is not structured anatomically or functionally in the manner the intermediate level theories of consciousness suppose. This suggests that their theories cannot adequately be generalized to olfactory consciousness. My argument is not that these theories cannot explain our consciousness of smell, as empirically the matter is unclear. Rather, as things currently stand some of their necessary conditions of consciousness are not applicable to smell. Where possible I will suggest how to adapt the theories to accommodate olfaction, but my general prognosis is that these theories need to rethink their requirements for being an intermediate representation.

4.3.1 Jackendoff's Intermediate-Level Processing theory.

According to Jackendoff's Intermediate-Level Processing theory, consciousness arises at an intermediate level of computational processing. Borrowing heavily from Marr's (1982) work on visual processing, he suggests that within the visual system consciousness arises at the level of the 2½ D sketch, while our experience of language occurs at the level of formal logical processing for language, and the level of notes for the surface of our music awareness. Jackendoff's theory proceeds in two steps: first the levels of processing are outlined (how cognition arises at these three levels is explained in terms of vision, language, and music comprehension), then our phenomenology of awareness in the different modalities is used to fix the point at which consciousness occurs within the hierarchy of processing. The inference is from the character of the representations of our introspective awareness to the level of information processing that best fits these representational characteristics.

His methodological assumption is that a computational series can generate the same distinctions within the computational processes that are found within our awareness of our experiences. He does not think that this methodology answers the mind-mind problem nor how computational processes lead to qualitative states. This makes the notion of consciousness at play within Jackendoff's theory that of conscious awareness.

Jackendoff's theory proceeds from a computational perspective to predict the level of computational processing at which consciousness occurs. To ascertain the level of representational structure at which consciousness occurs he offers four *prima facie* possibilities: first, that consciousness arises at the sensory level of processing; second, that consciousness happens at an intermediate stage between the lower and upper levels of processing; third, that consciousness arises at the central level of processing, such that there is some discrete central processing unit that gathers the representational outputs from across multiple modalities and outputs them in an unified code to higher-level representational processing[86]; finally, that consciousness only arises at the highest level of computational processing, which involves full conceptual structure.

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[19] Jackendoff's argument against this view is the simply that it does not allow concepts to be modality specific. For the full argument see Jackendoff (1987, p. 286).

Having stated these possibilities, Jackendoff argues that only the intermediate level of processing fully captures the phenomenology of our experiences. While his explanation of consciousness is meant to derive from the computational processing of mental content, our reports of the content of our awareness in different modalities act as the decisive factor and evidence for his approach. In accounting for our awareness of the content of mental states, phenomenological reports are employed to garner evidence for the conclusion that what we are aware of is not the conceptualized level of cognitive processing nor the representations at the lower sensory level, but rather representations that arise at the intermediate level, which involve a vantage point of an individual as located in space undergoing the experience. Evidence for the intermediate stage being the correct level is offered regarding the nature of our linguistic, auditory, and visual experiences.[87] However, what little he does say about our olfactory experience is simply not true.

Jackendoff asserts that taste and smell are so experientially intertwined that one cannot distinguish between the two based upon the mere content of our phenomenal experiences. Taken at face value it is unclear whether he thinks we cannot or that we do not. Since taste and smell are often conflated, we do not

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[87] For his argument regarding the form of linguistic awareness as derived from the level of phonological awareness and the tip-of-the-tongue phenomena, see Jackendoff(1987, pp. 287-292). For arguments regarding the form of musical awareness involving notes, not pitch nor cochlear encodings nor concepts as derived from contemporary classical music
involving language/verbal structures see *Ibid*. (pp.292-3). For his argument regarding the form of awareness in visual perception being 2½D sketch with viewer centered representation of visible surfaces see *Ibid*. (pp. 293-6).

distinguish between these modalities most of the time. However, that does not demonstrate that we cannot distinguish between the two once we attain a better grasp of the nature of smell. The simplest demonstration of how we can distinguish the phenomenology of the two modalities is to hold one's nose the next time one eats and consider one's experiences of taste. The nature of these sensations will be purely that of taste and they are readily distinguished from those of smell. Most things taste of cardboard without our sense of smell – that's why eating when one is suffering from nasal congestion lacks the same sensual pleasure as normal gustation. Further evidence for the phenomenal divide between these modalities is that one cannot smell salt, which is one of the primary tastes for which we possess dedicated chemoreceptors.[88]

The role of attention, which is not necessary for consciousness, plays a definitive role in focusing our awareness of the elements of our attended experience. Attention modulates the amount of detail of the constituent structure of representations that gets encoded at the intermediate level. This is extremely questionable if, as was argued in Chapter 3, odors occur in a combinatorial, but not concatenatively compositional representation format,. Additionally, the Laing effect (Chapter 3, Section 3.3) nicely shows that top-down attentive mechanisms do not enhance the details of constituent structure of compositional olfactory representations.

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[88] The taste of salt is one of the five primary tastes for which we possess chemoreceptors as explained in the Chapter 1, Section 1. Unless salt is volatized it is not possible to smell it, a problem that Céline Ellana faced in the creation of *Sel de Vetiver*, a synthetic perfume containing no salt that is meant to capture what it would be like to smell salt (for a detailed discussion, see Burr (2007, pp. 188-190)).

An alternative interpretation of Jackendoff's claim as applied to olfaction might be that the constituent structure of an odor experience together with its valence, memories of past occurrences, its associations, and emotional significance is modulated by attention. Yet, even this interpretation is questionable based on the arguments in Chapter 3 that the content of olfactory experience outruns our ability to conceptually represent its constituent structure. Thus, the formative nature of olfactory representation is not compatible with the basic tenets of Jackendoff's approach concerning attention. Furthermore, if olfactory processing is combinatorial, but not classically compositional, then Jackendoff's entire methodology of analyzing distinctions within the phenomenology of our awareness in terms of computational constituent structure distinctions is called into question.

To summarize, Jackendoff claims that consciousness arises at the intermediate-level of cognitive representational processing relative to each modality, but that the general characteristics of these representations are perspectival, modality specific, and not fully conceptualized.

4.3.2 Prinz's Attended Intermediate-level Representation (*AIR*) Theory

Prinz's (2000, 2005, 2007) theory of consciousness is modeled upon Jackendoff's, provides neuroscientific and psychological evidence to support its phenomenological argument, and gives a more substantive role to attention. According to the AIR theory, consciousness arises at an intermediate-level of processing when we attend to those states. Borrowing from Jackendoff's use of Marr's theory of vision, Prinz's arguments primarily involve the visual system and the mechanisms of visual processing. Though he admits that the details of Marr's model are outdated, Prinz maintains that the general idea of the three levels of processing is adequate in spirit to capture the levels of processing within our cognitive architecture. The first level is the primal sketch, which merely encodes the sensory constituents of an experience. Within the visual system the primal sketch represents nothing more than the lines and edges of an object independent of each other. At this level the smallest representations of the system occur. Intermediate-level processing occurs from an individual's perspective and represents objects with properties, but neither of which have yet been fully abstracted from the particularity of the percept. The higher-level processes are responsible for representational content that is categorical, at an abstract level of conceptualization, which does not represent the information from a vantage point.

Prinz echoes Jackendoff's methodology by attempting to identify the level of processing that correspond to our phenomenological reports of what we attentively claim to be conscious of. The inference is from the characteristics of the mental representations that we are aware of to the level of representation within the cognitive hierarchy at which this occurs. Methodology in hand, his arguments reflect those of Jackendoff's such that we do not experience the sensory level representations and are not conscious of our experiences in an abstract manner. Since our conscious experiences are from a vantage point, conscious experience must arise at the intermediate level of processing. Evidence for these claims is further supported by neuropsychological data confirming that consciousness does not arise at area V1 (the primary visual cortex) but rather occurs at the extrastriate area of the visual cortex.

Having ruled out the lower sensory levels, Prinz argues that consciousness cannot occur at the higher levels, because representations at these levels of processing are too abstract to match the format of our reports of conscious experience. While consciousness might not arise at these high levels, our conscious experience is certainly modulated by them, a role that Prinz attributes to attentional selection. The essential role of attentional selection in consciousness sets the AIR theory apart from the IPT since according to the former, it is a necessary condition for consciousness, while for the latter it only modulates it .

4.3.3 Mandik's Allocentric-Egocentric Interface Theory of consciousness.

Mandik's Allocentric-Egocentric Interface (AEI) theory (2000, 2005, 2009) states that consciousness arises at a stage of computational processing, between the personal and conceptual domains of representation. The distinction between these two different kinds of representations derives from the notion of a perspective as required for planning guided motor actions. Given this starting point the AEI theory clarifies the perspectival requirement that distinguishes high-level and intermediate-level representations. Using pictorial representations as a launching point, Mandik argues that all representations are either encoded from a standpoint or from a third-person perspective.

Allocentric representations are representations without a perspective, while egocentric representations derive from a perspective or vantage point. AEI theory states that consciousness arises with recurrent loops between the Allocentric and Egocentric representations, since the sensory level of incoming stimuli cannot be conscious and higher level cognitive states may only mediate what is going on at the intermediate stages. The theory is best interpreted as claiming not that consciousness is localized at an intermediate stage, but rather that it occurs as recurrent loops between Allocentric and Egocentric levels of processing. Conscious states are a hybrid of Allocentric and Egocentric representations. They are not intermediate-level representations, but an amalgamation of these two types of representations. While consciousness arises between these two levels of processing, this does not necessitate that existence of an intermediary level of processing.

Given the similarities between all three theories it is not surprising that their evidence seems to draw from the same studies. Mandik's arguments and evidence are nearly identical to those of Prinz, who in turn echoes Jackendoff. He argues that we are not conscious of all sensory states, because we are not at all aware of the retinotopic mapping of stimuli or representations within the Lateral Geniculate Nucleus (LGN). Furthermore, he argues that what we are conscious of is not the same as the representations that are found in area V1 of the visual cortex. Additionally, we are not aware of full allocentric visual representations from the frontal cortex or hippocampus. The evidence presents against the claim that low-level sensory states can be conscious is more or less identical to that cited by Prinz; while the arguments against the claim that high-level processes can be conscious are supported by appeal to the cases of blindsight and motion-induced blindsight.

While Mandik agrees that we are conscious of intermediate-level representations, his conception of a mental representation and his theory of levels differs from both the IPT and AIR theories. For this reason in the next section I compare and contrast the three theories so far discussed.

4.3.5 Summary: General requirements of all IPT theories and differences

According to all three of the theories. we are conscious of intermediate representations from a perspective or vantage point, such that they are neither abstractions nor conceptualizations of our experiences. Though they all agree on what we are conscious of, they do not agree about how consciousness arises: whether it be merely intermediate representations, intermediate representations modulated by an attentional mechanism, or mongrel representations formed by loops between top-down and bottom-up processes.

Jackendoff with his IPT theory claims that attention attenuates the detail of the constituent structure of the intermediate-level representation but does not consider it necessary for consciousness. By contrast, Prinz argues that attention is required for these representations to become conscious. AIR theory posits attentional mechanisms, which select the intermediate representations that will become conscious. While being an intermediate-level representation, according to Jackendoff, might be sufficient for being conscious, Prinz maintains that attending to these representations is also necessary. Mandik's AEI theory does not concern the role of attention; rather he claims that consciousness arises with recurrent connections between the Egocentric sensory level and the Allocentric conceptual level.

A further difference is Mandik's conceptualist framework according to which one's conceptual repertoire determines the experience one can have. Jackendoff and Prinz allow that incoming stimuli and top-down processes may modulate our conscious experience, but they do not think they are part of the essential conditions for having an experience. According to the AEI theory, a necessary condition for attending to the sensual world is that there be recurrent connections between conceptual levels and egocentric sensory levels.

4.3.6 Criticisms of IPT theories

Rather than question the adequacy of the evidence provided by Jackendoff, Prinz, and Mandik, in this section I raise doubts about the IPT's applicability to the case of olfaction based on phenomenological concerns derived from the fragrance industry, empirical studies regarding olfactory imagery,[89] and concerns derived from IPT's background assumptions regarding representational cognitive processing, hierarchy, and formative nature. The main worry is that the three levels of computational processing that IPT posits are not applicable to the case of olfaction. IPT may be perfectly adequate as a theory of vision and of the other sense modalities, but the scientific evidence and arguments upon which they are constructed do not generalize to our sense of smell.

The details of Jackendoff's arguments and evidence for IPT require further scrutiny, but *prima facie* his theory's applicability to the olfactory system is questionable based on its unique anatomical structure and functional organization. The key test for his approach is whether a hierarchical system of cognitive processing occurs within the olfactory system. For the intermediate level of processing theory to generalize there must be an intermediate level of olfactory processing at which we are perspectivally aware of a smell (which also has not been abstractly represented).

The main challenge IPT faces is the applicability of their criteria for being an intermediate-level of representation, Indeed the criteria that Jackendoff and Prinz develop (and for the most part endorsed by Mandik) derive from Marr's computational model of vision processing. An intermediate-level representation is minimally, a representation that is reportable based upon one's awareness of the state, arises from lower-level perceptual states, is modulated, attenuated, or

[89] For more information regarding olfactory imagery see Chapter 3, Section 4.2 and Chapter 5, Section 4.

selected by higher-level processes, and derived from a vantage point (relative to a perspective). Even if it is possible for Jackendoff, Prinz, or Mandik to show that these levels of processing occur within the olfactory system, the suitability of applying IPT to olfaction would still challenged if the intermediate-level representations in olfaction are not formatted in the representational manner they assume.

4.3.6.1 Anatomical and Functional Hierarchy

In Chapter 1 the key anatomical and functional differences, between the olfactory system and the systems of the other modalities, were explained and carefully explicated. These differences create the unique nature of stimuli transduction and processing within the olfactory system, as was demonstrated in Chapter 3. This, taken together with the conclusion of the Chapter 2, suggests that even the perceptual object of experience might be different between smell and the other modalities. The first line of criticism concerns whether the hierarchical structure posited by IPT can be accommodated by olfactory processing.

Based on the claimed existence of a hierarchy of levels of processing, applying IPT to the case of olfactory consciousness faces three problems. First, it's unclear whether the olfactory system is hierarchically structured and moreover in the same manner as IPT claims for the cases of vision, language, music, and motor control. If there is some manner of hierarchical structure the question is then whether the same processes are merely functionally realized in a different anatomical manner? Second, even if a retreat to functionally identical levels were successful, it is unclear whether intermediate level processing does in fact occur within the olfactory system. Lastly, the sensory transduction of odorants - occurring in a combinatorial and noncompositional manner – stands in marked contrast to Jackendoff's information processing framework, which creates problems for the role of attention, recurrent-loops, and top-down conceptual selection.

Currently it is empirically unclear if the olfactory system is organized anatomically or functionally in an identical hierarchical manner as that of the other modalities. This need not cause concern, however, since it will not get to the heart of IPT's inability to generalize to olfaction. There might be disagreements regarding the nature of the olfactory systems hierarchical structure, but I have yet to come across anyone denying that it is hierarchically organized. Savic et al*.* (2000) have nicely shown that there is some hierarchical organization, but the details of their claimed organization are questionable. Furthermore, whether or not the hierarchy is identical to that of vision, audition, or motor control is irrelevant since intermediate-level representation is meant to be modality specific. However, if the olfactory system only has two levels, an amalgamation of the primal sketch and 2 -½ D, and a hybrid of the 2- ½ D level with the 3-D representation, IPT will certainly need to be amended to accommodate olfaction. While this might show that IPT as it currently stands is inadequate as an overarching theory of consciousness it does not falsify the theory. The most essential claim of IPT is the notion of representational processing and hierarchical stages, thus the real test concerns the existence of intermediate-level representations within olfaction processing. The representational levels of processing posited by IPT are at issue with regards to the existence of intermediate-level representations that satisfy the conditions of being perspectival, a bound object, not fully conceptualized nor abstracted from the percept.

4.3.6.2 Perspectival representations

One of the essential properties of intermediate-level representations is their perspectival format, which is clearly apparent in vision occurring within a three-dimensional sensory space. Mandik nicely demonstrates how the requirement of having egocentric representations can be adapted for the cases of motor control and thermodynamic representation. However, the body centric mapping employed by Mandik is not readily apparent in olfaction especially considering that odorants are usually heterogeneously diffused across a vast area. I might catch whiffs of different smells at different concentration levels of the odorant from point to point in a three-dimensional environment, yet it is unclear if my representation of the odorant is relative to a perspective fixed by me or derived from a representation of the environment itself.

IPT might be adapted to olfaction based upon the role of sniffing and the anatomical structure of the nostrils. It was shown in the introduction how each nostril is physically distinct, which allows us to both track odorants across an environment and to differentiate between aspects of chemical stimuli such as concentration, intensity, and trajectory (Porter et al., 2005, 2007). Thus, while the notion of olfactory perspective might turn out to be different than the other modalities, intermediate processing theories can nevertheless accomodate this. While this evidence suggests that at the sensory level of representation olfactory representations are perspectival, some find it questionable with regards to phenomenological reports of olfactory experience (Lycan, 2000; Batty, 2007; Smith, 2002; Matthen, 2007). A common mistake, refuted in the Chapter 3, Section 2.1, would be to deny that olfactory experiences occurs with any spatial phenomenology. While there is scientific evidence that olfactory representations are spatially inferior to those in vision and audition (for a review of this literature, see Sela & Sobel, 2010), their meager nature should not be taken as evidence that they have no spatial aspect whatsoever.

4.3.6.3 Bound object

Another key requirement of being an intermediate representation, which is not easily translatable to the case of olfaction, is the claim that conscious experience is of a bound object. The nature of the olfactory object proves perfectly disastrous for this requirement of the IPT. If, as argued in Chapter 2, the olfactory object is the chemical structure of molecular compounds within an odor plume, , then since it is well documented that we have the ability to detect the difference between enantiomers the IPT claim that we are not conscious of experiences at the sensory level becomes difficult to plausibly maintain (Dyson, 1938; Boelens & van Gemert, 1993; Wright, 1977). Though it is true that when we sense odors we do not have access to the molecular structure of the odorant, we can still discriminate between left-handed and right-handed constructions of the same molecule. If the bound olfactory object that we are representing in our experience is a chemical structure and we are sensitive and aware of its chemical structure, then we do experience the sensory level, that is, we might be conscious of neural activation patterns within the olfactory bulb, a level that does not seem intermediate at all.[90]

4.3.6.4 Not fully conceptualized/abstracted from the particular

A further underlying tenet of both Prinz's AIR theory and Mandik's AEI theory is that we do not experience the high-level representation. For phenomenological reasons this claim might be questionable when considering complex odors. When aware of a complex odor, I experience a complex entity, which, as has been argued in Chapter 3, is not fully decomposable into its constituent structure (Laing, 1998; Livermore & Laing, 1998). This aspect of olfactory experience stands in marked contrast to complex visual objects. When

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[90] If the olfactory bulb is equated with the thalamus this might suggest that it is partially an intermediary stage of processing, but it will be argued in section 4.5 of this chapter that such an equation does not work.

viewing a Necker cube the direction of the lines may be relative to the viewer and seem indeterminate, but one can clearly see the lines and decompose its complex shape into its composite images. The Laing effect demonstrates that we can identify, at most, four component odorants within a complex odor, but usually we treat complex odors as their own types (e.g. spaghetti sauce smells like spaghetti sauce).

Our experience of a complex odor is abstracted from its components. This being said when it comes to simple odors, like those generated by synthetic molecules, they seem to occur in a manner that is completely unabstracted from their particularity. Currently, it is unclear if an olfactory representation can occur as an abstraction from its own particularity. If the arguments of Chapter 3 are correct then the olfactory systems represent the olfactory object in a nonconceptual fashion, such that the experiential contents are always richer than our conceptual resources. Furthermore, evidence from olfactory imagery suggests that the initial sensory state is inherent to any representation of the content of olfactory experience, thus whenever one thinks about, remembers, or imagines a smell one activates the cortical areas responsible for the encoding of olfactory sensory stimuli.[91]

Perfume chemists claim to be able to introspectively access the smell of a chemical odor, while imaginatively combining individual odorants. If their reports are taken at face value then just thinking about the formula of the perfume gives them an experience of what it will smell like. However, they readily admit that the

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[91] See Chapter 5, Section 4.

experience of introspecting a formula is not as robust as actually smelling the chemical complex. The robustness of the incoming experience compared to introspectively accessing it seems to further support the claim made in the previous chapter that the richness of olfactory experience outruns our conceptual repertoire. The phenomenom of olfactory imagery further supports this line of thought and shows that olfactory imagery states reactivate the initial nonconceptual and qualitatively conscious sensory and cortical areas in order to elicit the imagined olfactory experience. Taken together these pieces of evidence seem to count against Mandik's conceptualist framework.

4.3.6.5 Attentional Modulation

The role of attention within Jackendoff's theory is not essential to his theory, but it deserves further scrutiny. Attentional mechanisms function to attenuate the fine-grained detail of the constituent structure of intermediate representation. However, if the arguments in the Chapter 3 are correct then the nature of olfactory processing is different to that of vision and audition, because it occurs in a combinatorial format at the sensory level through to higher cognitive levels, which in turn underlies the nonconceptual content of our olfactory representations. Even upon conceptualization at the higher levels of cognitive possessing we lose some of the richness of the original olfactory experience. If this is the case then attention cannot generate more fine-grained representations than those already available at the sensory level. While this aspect of

Jackendoff's theory is questionable, it can be adapted to a related claim that attention generates stronger links between the representations and long-term memory. However, if there is no constituent structure within the molecular representations of the olfactory system there can be no attentional attenuation.[92]

4.3.6.6 Attentional Selection

What separates Prinz's model from Mandik and Jackendoff is the necessary role of attention in selecting the intermediate-level representation that becomes conscious. The role of attention for smell is not that well researched, but it is arguably the case that one can have a conscious experience of a smell even when it is subliminally presented. Support for this claim can be derived from the phenomenon of blind smell in which subjects are able to detect the presence of an odor, one highly correlated with their confidence ratings, but cannot report on whether or not they are aware of the odor. Research on the selections of mates and social preferences also demonstrates the role that qualitative states without awareness can have on our behaviour. . Though this evidence does not negatively impact Prinz's own theory of consciousness it does raise a further issueregarding the relationship between conscious awareness and qualitative consciousness. In Chapter Five, alongside further arguments regarding olfactory deficits and their role in causing affective disorders, I argue that blind smell

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[92] Laing's finding that we can identify, at the most, four components within a complex odorant might be brought to bear here as these experiments were conducted while the subject was consciously attending to the odorant and had access to the molecular components. Even with all of the resources cognitively and physical before them, attention could not increase this individuation beyond four components.

subjects have qualitative states despite the absence of conscious awareness and that, at least for our sense of smell, qualitative consciousness is independent from but necessary for conscious awareness.

4.3.6.7 Recurrent loops

One of the key differences that separates the AEI theory of consciousness from other intermediate-processing theories is the requirement that there be top-down attentional modulation: we are only conscious of intermediate-level representations when they are modulated by incoming stimuli and top-down processes. There is no doubt that the incoming stimuli level representations modulate our experiences of smells. Nonetheless the top-down component is unclear. Given the arguments of the previous chapter that the richness of experience outruns our conceptual repertoire, the claim that top-down conceptual processing is necessary seems questionable.

Nonetheless Wilson and Stevenson's (2006) argument that all learning of olfactory objects occurs against a background context of odors, thereby requiring top-down processes for odorant fixation, might be used as evidence that some manner of top-down modulation is required.[93] However, aside from the case of olfactory learning, there are no other known top-down effects within the olfactory system since most studies are conducted using anesthetized animals. In lieu of

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[93] I am wary of using Wilson and Stevenson's theory for the reasons outlined in Chapter 2. Additionally, since they are concerned with learning rather than consciousness further complex cognitive processes will presumably be involved. At the very least some type of re-identification criteria would be required while all that is required for olfactory consciousness is the mere detection of an odor.

further study, Mandik's requirement of recurrent loops should be left open as an empirical matter.

I am pessimistic that the reciprocal links between such levels of processing will be similar to Mandik's allocentric-egocentric mechanisms of representation as these are closely modeled upon stimuli transduction through the thalamus to the sensory-motor sulci of the cortex. My worry that the model does not in fact carry over to olfaction relies upon the fact that the other modalities access the homunculus that contains a sensory-motor representation of our body while olfaction does not. Although Mandik does not explicitly argue that this underlies the two levels of representations, but I am hard-pressed to figure out how else the brain could represent three-dimensional egocentric states without such a map.

4.4 One of these things does not belong:

Hierarchical approaches involving the thalamus and thalamic relays

The anatomical structure of the olfactory system presents a problem for current neuroscientific theories of consciousness, which state that a thalamic relay is, or corticothalamic loops are, a necessary condition for consciousness. A thalamic relay might be necessary for consciously analyzing odorants (Plailly et al., 2007), but it is not required for consciously discriminating between odorants (Price & Slotnick, 1983; Price, Slotnick, & Revial, 1991; Slotnick & Schoonover, 1992; Zatorre & Jones-Gotman, 1991),thus, providing reason to doubt Crick's

(1984, 1994) theory (Smythies, 1997), Crick & Koch's (1990, 1998, & 2005) theory (Shepherd, 2007), Koch's neurobiological theory (2004), Global Workspace Theories (Baars, 1988, 1997, 2003; Dehaene et al., 2001, 2003, 2004, 2006), and the Information Integration Theory of Consciousness (Tononi & Edelman, 1998; Tononi, 2004).

It is generally accepted that the thalamus is not required for olfactory consciousness, thereby making olfaction drastically different than all other modalities and falsifying the putative necessary condition that consciousness requires thalamic connections or corticothalamic loops. Aside from a small group of fibers going to the mediodorsal thalamus (Ongur & Price, 2000), the olfactory system projects directly to the cortex without thalamic connections or corticothalamic loops. Furthermore, lesion studies of the dorsomedial thalamus implicate the role of thalamic connections in the olfactory system as required merely for complex behavioral planning and motor integration (Price & Slotnick, 1983; Slotnick & Shoonover, 1991). Thus, a quick anatomical perusal demonstrates that the thalamus is not essential for olfactory consciousness

The lack of evidence that there are thalamic relays, connections, or loops involved in olfactory consciousness brings into doubt three major groups of neuroscientific theories of consciousness: Crick and Koch's framework for the specificity of the NCC, The Global Workspace Theories (GWT) of Baars and Dehaene, and Tononi and Edelman's Information Integration Theory (IIT). The mere anatomical structure of the olfactory system demonstrates that these theories cannot give an adequate and general account of consciousness.

4.4.1 Crick and Koch: Neurobiological Specificity of NCC

The driving methodological assumption behind Crick and Koch's framework of consciousness is that we should initially examine whether specific areas of the brain or neural circuits underlie consciousness, before operating according to the alternative assumption that consciousness is distributed across the entire brain. The thalamus, with its central location and connections, serves as a good starting point for such specificity. The underlying idea behind the posited involvement of the thalamus is that it acts as a mechanism for attentionally binding visual information and can create strong reverbratory connections with the cortex.

Crick (1984) implicates that the thalamus and the nucleus reticularis play the role of his hypothesized searchlight of consciousness, which is suggested by the thalamus's topographical maps of the sensory modalities and cortical loops and evidence that the reticular nucleus plays a role in unifying our perceptual experiences. , Crick thus claims that the thalamus, and in particular the reticular nucleus are necessary parts of the neural realization of consciousness. In his later work, Crick (1994) maintains the instrumental role of the thalamus as the conductor that produces consciousness. However, he is careful to note that the theory only regards the NCC of visual awareness. Furthermore, he rejects the intralaminar nuclei and the reticular nucleus of the thalamus as the key to consciousness, replacing these with the lateral geniculate nucleus (LGN) since this area of the thalamus is required for visual consciousness. Crick is quite careful to admit that his claims regarding thalamic connections do not apply to olfaction (Crick, 1984). Nonetheless he assumes that the theory of visual consciousness will generalize across all the modalities. The assurance that these differences need not worry us is seen throughout to his collaboration with Koch (Crick & Koch 1990, 1998, 2005), as well as in Koch (2004).

Crick and Koch's (1990, 1998, 2003, 2005; Koch 2004) general strategy is to generate a framework for understanding consciousness. One of their key assumptions is based on the visual system such that coalitions of neurons must fire together in circuits to generate enough activation to bind sensory information into a conscious percept. This implicates the thalamaus as the seat of attention, since it is necessary for consciously attending to a bound unified perceptual experience. Aside, from the general claim that the thalamus is a necessary condition of conscious awareness (Crick & Koch, 1998, 2003, 2005) they also claim as necessary conditions the reticular nucleus (Crick & Koch, 1990), the pulvinar (Crick & Koch, 1990), the LGN (Koch, 2004), and the intralaminar nuclei (Koch, 2004). Given the specificity of their claimed NCC, and the central role of the thalamus therein to bind information attentively, the lack of a thalamic connection within the olfactory system creates real trouble for the claim that this approach generalizes as a theory of consciousness for the other modalities.

Furthermore, if a functionally equivalent neural analogue of the thalamus cannot be found for olfaction this will show definitively that Crick and Koch's framework truly is only a theory of visual consciousness.

4.4.2 Global Workspace Theories of Consciousness

The anatomy of the olfactory system has the least impact on the Global Workspace Theory (GWT) of consciousness according to which consciousness is functionally realized by a global workspace system (GWS) that is distributed throughout the brain. Nonetheless, as a neuroscientific theory of consciousness it cannot remain neutral on the neural realization necessary for global broadcasting. Although the mere lack of thalamic relays within the olfactory system is not decisive proof against GWT as a plausible neurofunctionalist theory of consciousness, I demonstrate in Section 4.5 that there is no functional equivalent to the thalamus in olfaction, thereby bringing into question whether the GWT can even be functionally generalized to the olfactory system.

Baars' original model built upon the idea that information must be integrated from across the different sensory systems and have access to working memory to become conscious. The integrative property of consciousness is utilized as evidence in favor of there being a global workspace in which information from across the different sensory modalities is combined to form a unified conscious percept. Baars (1988) is explicit in identifying the thalamus as a necessary element in GWS interconnectivity and suggests the Extended-Reticular Thalamic Activation System as a possible workspace realization.

Baars' more recent work still implicates the thalamus as a necessary precondition for waking consciousness in terms of the intralaminar nuclei (1997) and the role of the thalamus as a general requirement for consciousness based on a contrastive analysis with other kinds of conscious states (2003). However, these areas are neutral and irrelevant with respect to the issues, for the same reason that the most charitable interpretation of the Centrecephalic approach was found to be innocuous and trivial. His current version of the GWT takes the guise of a metaphor of 'the theater of consciousness', whose applicabilition to olfaction is unclear. Luckily, he is still explicit in endorsing the thalamus as playing a necessary part in the realization of the global workspace, based on its centrality within the brain and its interconnections to the different sensory systems, cortex, working memory, and motor systems. Baars leaves open the possibility of other functional implementations of the global workspace within the olfactory system, however, given a lack of any suggestions of what these might consist in the olfactory system's anatomical structure remains a serious problem for his theory.

Dehaene's version of the GWT (2001, 2003, 2004, 2006) is indirectly influenced by Crick and Koch's framework via Baars' version.. The neural realization of consciousness is difficult to ascertain in Dehaene's account, since it is not offered as a theory of the NCC themselves, but rather long-distance neural connections and bi-directional connectivity, and their connection to memory, motor, and language areas, as essential requirements that the neural circuitry responsible for such a global workspace must satisfy (Dehaene & Naccache, 2001). While this is not enough to implicate his GWT in the anatomical crimes of the other theories, Dehaene et al. (2006) suggest a role for the thalamus in this regard while Dehaene et al. (2003) states that pyramidal neurons distributed across cortical and thalamic regions may be responsible for realizing conscious states.

The actual requirements of the GWT model require a role for the thalamus as a necessary condition for consciousness. Thus, the olfactory system's anatomical connectivity does not meet this general constraint and I would argue that the only option left to them is to retreat to a functionally equivalent model for the olfactory system. Ultimately, if the GWT is merely generating a functionalist account of consciousness in terms of information processing then any problems discovered with the IIT will equally afflict the GWT.

4.4.3 Information Integration Theory of Consciousness

The Information Integration Theory (IIT) seeks to account for consciousness in terms of the information processing internal to a system. The IIT was proposed by Tononi and Edelman (1998) and elaborated by Tononi (2004). Its key claim is the dynamic core hypothesis, which states that the neural correlates of consciousness are realized by a process of dynamic integration between neural states. Evidence for the IIT derives from what Tonono and Edelman claim are two underlying properties of consciousness: the integration, or unification, of information (i.e. each conscious experience has some manner of unified content to it) and differentiation (i.e. our conscious experience can rapidly change between drastically different percepts). These key properties are used to verify the neural processes required to realize informational states capable of generating information integration and differentiation. Tononi and Edelman identify the dynamic core with the recurrent interaction between the anterior and posterior areas of the thalamus and claim that it is required to generate information states that can have the properties of integration and diffferentiation. While Tononi (2004) does not completely reject this earlier idea, he now only endorses the view that the thalamocortical system is essential for consciousness. The IIT is the most explicit theory with regards to its endorsement of the thalamus as a necessary condition for consciousness. Thus its untruth as a general theory of consciousness is even more apparent given the unique anatomical structure of the olfactory system. The IIT may work as a theory of the other modalities, but the anatomical structure of the olfactory system simply cannot be accomodated for by their approach.

4.4.4 The role of the thalamus in olfaction

Though the anatomy of the olfactory systems and lesion studies of the thalamic relay in olfactory consciousness, by Price and Slotnick (1983) and

Slotnick and Shoonover (1991), provide evidence in favor of the traditional view that the thalamus is not required for olfactory consciousness, Plailly et al. (2008) argue that the olfactory system may be similar to the other modalities in requiring thalamic connections. Taken at face value their results vindicate the aforementioned scientific theories of consciousness based on the conclusion that a thalamic relay is required to consciously analyze smells. However, their study only reveals that attending to odors increases the connectivity of the olfactory medial pathway, only showing that it is involved with consciously sniffing.

The experimental task in Plailly et al.'s study was a simple detection task consisting of attending to the presence or absence of an odor in one condition and a tone in the second condition. Subjects were instructed to be attentive and detect the presence or absence of the target. The tone task was used as a baseline to judge the effects of the overall connectivity of the dorsomedial thalamic connections in the olfactory task. The results indicated increased connectivity of the dorsal medial thalamic pathway, when (as they put it) "we consciously analyze smells" (Plailly et al., 2008, p. 5257).

Given the experimental design there are multiple problems with their conclusions. The most trifling problem is that Plailly et al. overstate their results, which is evident from the fact that the experiment is a mere detection task from which no inference regarding the analysis of smells can reasonably be made. Properly stated the results indicate that thalamic connectivity is increased when attempting to detect the presence of odors. Yet, this conclusion is also unwarranted because the experimental design itself required active sniffing as part of the task. Subjects were instructed to actively sniff for three seconds as cued by a green fixation screen, which allows for an alternative explanation of their data: the increase in the connectivity of the thalamic pathway is more likely caused by consciously sniffing, which requires convergence of motor areas. What their evidence points to is that consciously sniffing odors requires thalamic connections. However, they have not shown that detecting an odor in normal respiratory activity is not possible without a thalamus or an increase in thalamic connectivity.

The role of the medial dorsal thalamus role in olfactory cognitive processing and consciousness requires further study. Yet, current evidence regarding the anatomical structure of the olfactory system demonstrates that thalamic relays and corticothalamic loops are not required for our conscious smell experiences. Thus, Crick and Koch's Framework, The GWT of Baars and Dehaene, as well as the ITT of Tononi and Edelman are either false or inadequate as general theories of consciousness, since none of them can account for the anomalous anatomy of the olfactory system.

4.4.5 A Functionally Equivalent analogue to the thalamus in olfaction

The functional organization of the olfactory system further aggravates the problem for the neuroscientific approaches discussed here by demonstrating that they cannot replace the necessity of a thalamic connection with that the claim that there is nevertheless a functionally equivalent part of the olfactory system. Since the GWT and IIT are neurofunctional accounts of consciousness, Crick and Koch can retreat to their theory only with regards to visual consciousness. It is thus worth exploring whether these theories can account for the role they give to the thalamus, in terms of some functionally equivalent part of the olfactory system. The functional role attributed to the thalamus is to bind information, as a common workspace, or to integrate information cross-modally.

Since these theories are looking for an intermediate-level structure between the cortex and receptor cells of each modalities, one suggestion would be to view the olfactory bulb as functionally equivalent to the thalamus. Using research on the functional encoding of odorants in the olfactory bulb, I argue in this section that the functional organization of the olfactory bulb shows that it is not functionally equivalent as might be claimed.

Kay and Sherman (2006), using the intermediate stage of processing approach, argue that the olfactory bulb is functionally equivalent to the thalamus, that is, it plays the same role in the olfactory system as the thalamus in visual system. Their argument depends upon the following three areas of comparisons between the olfactory bulb and the LGN of the thalamus: the intermediate-level of perceptual processing, informational bottlenecking, and the similarity of structural circuitry.

The first comparison is that both structures are anatomically situated at an intermediate stage of processing between the receptor cells and the cortex.

However, this comparison is silent regarding whether each structure is functionally equivalent aside from the ideas that since vision has three stages projecting to the cortex, so might the olfactory system (depending upon whether the olfactory bulb is considered a receptor site similar to the ganglion cells in the retina or the LGN in the visual pathway).

The second similarity Kay and Sherman note is that both the olfactory bulb and LGN serve as a bottleneck within the informational stream reaching the cortex, thus allowing a further functional similarity. The bottleneck metaphor is best unpacked as the claim that both structures focus incoming stimuli by decreasing the amount of information projected from the receptor sites to the cortical areas. But this grossly underestimates the function of glomureli and mitral cells within the olfactory bulb, as nothing more than relays. Closely connected to this means of comparison is the presumption that both structures receive cortical feedback and amplification, something that is true of all receptor sites in our sensory systems.

Lastly, Kay and Sherman use the structural similarity of the sensory input circuitry as comparison, utilizing the fact that both consist of mitral and tufted cells. Generally, understanding structural organization facilitates a better understanding of function, but in this situation assessing the actual workings of the olfactory bulb at a less cursory level is important. However, before detailing a functional description of the olfactory bulb, it is worth noting some further problems with Kay and Sherman's theory.

Neural activation patterns are quite different between the olfactory bulb and the thalamus. The OB fires slowly compared to the neural firing patterns in the visual stream. The OB firing patterns are selectively sensitive to the presence of odors and types of odors present within the olfactory epithelium, showing that at the level of firing patterns, the structures are not analogous. Furthermore, Kay and Sherman only compare the LGN to the OB. This might help if all areas within the thalamus do in fact function in the same manner as the LGN, but whether this is so is far from clear. Even if the OB is functionally equivalent to the LGN, this will only be of help to Crick's (1994) theory and perhaps Koch's (2004) neurobiological approach. Kay and Sherman's functional equivalence between the LGN and olfactory bulb will most certainly not resuscitate the GWT, the IIT, nor any other theory according to which the general functional role of the thalamus is to bind information cross-modally.

The functional disconnect is further supported by the fact there is no cross-over of information in the OB, while the LGN integrates ipsilateral projections. Given all of these problems it is quite reassuring that Kay and Sherman admit ignorance regarding the role of mitral cells within the human olfactory bulb, which could be rectified using the work of Friedrich and Laurent (2001) on zebra fish as animal models for OB function in humans.[94]

Based on the convergence of olfactory receptor cells firing rates overtime and, in particular, the convergence of firing patterns within the odor-coding

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[94] For further details on combinatorial olfactory stimuli transduction, see Chapter 3, Section 3.

assemblies of mitral cells in the olfactory bulb of zebra fish, Friedrich and Laurent suggest that the olfactory bulb might encode odorants in a combinatorial manner such that there is not a discrete representation of each aspect of the encoded stimuli, but rather that the representation of the stimuli is holistically encoded in the firing pattern of the glomureli and mitral cells across the entire olfactory bulb. They nicely highlight this key difference between the functional organization of the olfactory system and all other sensory systems, in terms of the variable of time. Given the slow transduction speed of the olfactory system, as compared to vision, time can be used as a computational variable in encoding the presence of an odor across olfactory bulbs within an individual circuit. This phenomena of distributed representations temporally across a circuit is unlike the other modalities and particularly different from the stimuli transduction which occurs from the retina to the LGN. The olfactory bulb encodes stimuli in a manner unlike any other sensory system, thus blocking the move of functionally equating the OB with the thalamus.

Since I have only surveyed one possible candidate for functional equivalence advocates of the neuroscientific theories of consciousness discussed here might reply that I have not demonstrated their falsity. However, I know of no other claimed functional equivalences between the thalamus and the parts of the olfactory system. Thus, I think the burden of proof lies with them and I have no intention of doing their work, because I am pessimistic of a positive outcome. The functional organization of the olfactory system and its encoding mechanisms, from the receptor sites to the cortex, is simply different than that of the other modalities. As we have seen in Chapter 3, the olfactory system transduces and encodes stimuli in a combinatorial and functionally compositional fashion. Olfaction is different than all the other modalities and attempting to fit olfactory consciousness into the other models of consciousness is an ill-advised research strategy.

Since an account of qualitative consciousness is not forthcoming in terms of any of the aforementioned neurobiological approaches, other than to wave their hands at global properties of the central nervous system, in the final chapter I suggest how a theory of qualitative consciousness might be more forthcoming given the nature of the olfactory system and the intrinsic qualitative character of the olfactory object.

Chapter 5

The New Game In-Town:
Olfactory Cognition and Consciousness

For each of us there's a moment of discovery
We turn a page, we raise a hand
And just then in the flash of a synapse
We learn that life is elemental
And this knowledge changes everything
We look around and see the grandness of the scheme
Sodium bonding with chlorine
Carbon bonding with oxygen
Hydrogen bonding with oxygen
We see all things connected
We see life unfold
And in the dazzling brilliance of this knowledge
We may overlook the element not listed on the chart
Its importance so obvious Its presence is simply understood
The missing element is the human element
And when we add it to the equation
The chemistry changes
Every reaction is different
Potassium looks to bond with potential
Metals behave with hardened resolve
And hydrogen and oxygen form desire
The human element is the element of change
It gives us our footing to stand fearlessly
And face the future
It is a way of seeing that gives us a way of touching
Issues, ambitions, lives
The human element
Nothing is more fundamental
Nothing more elemental

- Dow Chemicals "The Human Element."

5.1 Kinds of Consciousness

The Human element certainly changes the equation, but its addition to the periodic table serves only to generate an even more profound question. How does the qualitative character of our experience arise from the mere interaction of elemental entities? If everything is elemental, including the human element, where does the phenomenal element come from? How is the qualitative character of experience realized by molecules?

As the most elemental sensory modality, olfaction holds the key to a fundamental new understanding of consciousness and the qualitative character of experience. Olfaction provides a new explanation of the qualitative character of consciousness, which builds upon the findings that the olfactory object is the chemical structure of molecular compounds, that olfactory experiences are nonconceptual, and contemporary neurobiological theories of consciousness are inadequate. In this section I argue that the qualitative character of consciousness arises from sensory states, which are necessary for awareness and which occur in a nonconceptual format.

Before playing the new game in-town, this chapter unfolds in seven sections. The first few sections introduce the background debate regarding the nature of phenomenal consciousness and its relation to conscious awareness. Instead of an historically exhaustive account of phenomenal consciousness, I survey Block's and Rosenthal's theores so as to situate my own approach between these poles regarding what it means to claim that there is a kind of consciousness that corresponds to there being something that it is like for someone to undergo an experience.[95] Following a short exposition of the debate between Block and Rosenthal regarding phenomenal consciousness, I offer a new way of thinking about phenomenal consciousness with empirical evidence that shows olfactory phenomenal consciousness can occur without conscious

[95] The expression 'what-it-is-likeness for someone to undergo an experience' seems to presuppose some agent.
However, I will not get entagled in issues regarding the metaphysical nature of the self. Elucidating olfactory phenomenal consciousness need not trespass in metaphysical lands and I shall do my best to avoid beging any questions as may pertain to the self.

awareness and that whenever we are aware of the presence of an olfactory object or experience, our olfactory states always have a qualitative character. Olfactory phenomenal consciousness might occur without awareness, but it is required for conscious awareness. In Section 5, I will carefully set out why olfactory phenomenal consciousness provides a counterexample to the leading theories of phenomenal consciousness, thereby showing how the competition is culled by olfactory consciousness.

As mentioned in Chapter 4,[96] there might be many kinds of consciousness, so a short clarification of the terminology used in this chapter seems merited. Pre-theoretically one might refer to consciousness in terms of being awake, there being something qualitative about an experience, or being aware of something or of being in a certain state. I shall refer to the first kind of consciousness as waking consciousness, since it centers around distinguishing between being asleep or awake. This might be determined by something as simple as physiological measures of arousal in the Pons and Brainstem. For the purposes here, I set this notion aside in Chapter 4 and there it shall stay.[97]

The second kind of consciousness is extremely difficult to define. When someone claims that their experiences has a certain quality to them or some fuzzy feel goodness, they could mean quite a few things which may involve many further vexing issues. The qualitative character of consciousness might amount to nothing more than there being something subjective about being in a given

[96] See the introductory section of Chapter 4.
[97] See the discussion of Merker's Centrencephalic theory in Chapter 4, Section 1.

state or that there is some qualitative character of the experience. However, a further issue arises for either interpretation: for whom? For the creature undergoing the experience, for me as some sort of sentient being, or for my brain states? Also, maybe this state is nothing more then having some peripheral awareness of the content of the experience, thus making it not a new kind of consciousness but rather a subkind of how we are aware of the content of our experience. For instance, in the course of thinkingI may stroke my chin thereby come to attending to my skin sensations. I may come to notice that I have had an itch and some discomfort in my leg for quite a while now. This raises the further question of whether or not there one can have an experience that has qualitative character without one being aware of it. Can one undergo an experience and yet not be aware that it is happening to or in them? My discussion of olfactory phenomenal consciousness will touch on some of these issues, but each one is worthy of a dissertation of their own. Throughout this chapter I shall use the expression 'olfactory phenomenal consciousness' to signify that an experience has a qualitative character of, and need not involve the subjective awareness that one is undergoing this experience.

Being conscious of something or being aware signifies that one is conscious in a way that allows for a subjective report of undergoing the experience or of being in the relevant state. For my purposes I shall use (conscious) awareness, to pick out that state in which the subject is conscious of being in a state S with content p (they are conscious of undergoing experience E that is of, or about, object x). 'Awareness', I shall stipulate can be understood separately from phenomenal consciousness, such that organism has olfactory phenomenal consciousness when there is something that it is like for it to undergo experience E which is distinguishable from undergoing experience E*, and moreover that the subject need not be conscious of being in state S (i.e. undergoing E) nor of state S's content p.

5.2 Phenomenal and Access Consciousness

There have been many interesting conceptions of consciousness, but in what follows the primary concern will be phenomenal consciousness and how it might differ from awareness. Of the many definitions of consciousness few have been as influential in consciousness studies as Block's notions of access and phenomenal consciousness.[98] Since the nature of these kinds of consciousness and what distinguishes them is of critical importance for my impending claims about olfactory phenomenal consciousness and awareness, this section progress in the following steps. First, the definitions of a-consciousness and p-consciousness are stated. Second, a difficulty in interpreting these two kinds of consciousness is discussed. Third, the evidence offered in favor of these kinds of states and their double dissociations reviewed.

Block (1995a) is responsible for the claim that the concept of consciousness is not a cluster concept containing different kinds of relevantly

[98] Henceforth I shall use 'a-consciousness' and 'p-consciousness' in keeping with current terminological conventions.

similar concepts but a mongrel containing different kinds of states. The two states that Block is keen to distinguish are access-consciousness and phenomenal-consciousness (1993, 1995a, 2001, 2007, 2008, 2009). However, the difference between these kinds of conscious states is difficult to assess. One manner of distinguishing between a-consciousness and p-consciousness might be along the lines, suggested in the introductory section of Chapter 4, that we are aware of being in some states, whilst others merely have a qualitative character. Naturally, this suggests equating a-consciousness with awareness, but this would be a mistake since by Block's own standards a blindsight patient might possess a-consciousness, yet does not show awareness of the stimulus itself (Block, 1996). Given that these states do not cleanly line up with the conceptions used so far it is best to see if definitional clarity can be had.

Access-consciousness is best understood in information processing terms and might be summarized as a property or mode of any cognitive state whose informational (representational) content can be used in generating behavior or inferential reasoning. Another way of putting this is that a state is a-conscious so long as its contents are inferentially promiscuous (1993). While one might have access to the content of these states one need not be subjectively aware that one has access to this information. A straight-forward definition of a-consciousness is;

> A perceptual state is access-conscious roughly speaking if its content – what is represented by the perceptual state – is processed via that information-processing function, that is, if its content gets to the Executive

> System, whereby it can be used to control reasoning and behavior (Block, 1993, p. 164).

Thus, we might characterize an access-conscious state as a cognitive state whose content can be utilized in cognitive reasoning and the guidance of behavior.

A subject that has phenomenal-consciousness is one that has experiences. Intuitively there is a sense of ‘consciousness’ that corresponds just to having an experience. However, attempting to define this kind of consciousness proves far more elusive than the phenomenology itself of our subjective conscious experiences. Block (1995a) is quite happy to admit that he cannot offer a non-circular reductive definition of p-consciousness. The closest approximation he offersis that a subject has p-consciousness when he has an experience or is in a conscious state that has experiential properties: “P-conscious properties include experiential properties of sensations, feelings, and perceptions, but I would also include thoughts, wants, and emotions” (Ibid., p. 166). However, Block’s conception of p-consciousness also suggests another interpretation such that there is something that it is like to undergo the experience, which might correspond to the claim that some conscious experiences have an experiential or qualitative aspect. However, the difficultly in understanding the concept of p-consciousness with any clarity fails to dissuade most researchers who from assuming there is some distinction between the two kinds of consciousness.

The difficulty with the concepts of a-consciousness and p-consciousness is not that they are unintelligible, since to some extent they map onto a commonsense distinction that we make between types of qualitative states, but that at other times Block applies these concepts in a way that is best understood only in the terminology of information processing theory. Semantics and definitional clarify aside, these states are sometimes differentiated and identified according to their representational content as an information processing issue (Block, 1996, 2007, 2008), while at other times he ostensitvely defines a p-conscious state as one that has qualitative properties (Block, 1993, 1995a). Thus, it might be complained that at times the concept of p-consciousness does not pick out anything qualitative, while at other times it does so wholly in terms of qualitative properties that are seemingly unrelated to access consciousness, which is demarcated within an flow of informational processing rubric.

At times Block writes of the properties of phenomenally conscious states as including “experiential properties of sensations, feelings, and perceptions” (Block, 1995a, p. 164). However, Block (1993) explains the difference between a-conscious and p-conscious states in information processing terms. He slips into using information processing terminology when he claims that a state is merely p-conscious when it contains information that is not available for reasoning, reporting, or rationally guiding action, there is still something that it is like for the subject undergoing the experience. By contrast, a mental state is a-conscious when its representational contentcan be used by the subject to make inferences (i.e. reason), which are also reportable. Phenomenal consciousness is difficult to explain, because it could be a qualitative character of an experience or that there is some informational content of some states that are not fully accessible which we are nonetheless aware of in some other sense.

The difficulty in interpreting Block is simply that he could be claiming there are two kinds of conscious state, a-conscious states and p-conscious states, which are individuated accordingto a mental state's content, either in terms of its availability to information processes (e.g. reasoning) or by whether it has qualitative properties (sensational aspects of an experience) properties which are simply not captured by the concept of access consciousness. The distinction is unnecessarily obfuscated by his claim that a clear definition of p-consciousness need not be forthcoming and asking for one would be profane.[99] Still, when empirical evidence is being used to support the distinction between a-consciousness and p-consciousness, the question whether it is meant to capture some qualitative difference between the two kinds of states or some representational difference becomes pressing. It will be noted in the course of discussing Block's claim that double dissociation studies are evidence for distinguishing p-consciousness from a-consciousnesswhich interpretation the evidence supports.

Block (2007, 2008) clearly uses the information processing interpretation when discussing empirical evidence for p-consciousness based on the overflow

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[99] Somewhat seriously, we are told by way of Louis Armstrong that "If you got to ask, you ain't never gonna get to know." (Block, 1980).

of information from phenomenal modules and accessibility. Though he does not employ any claims involving a-consciousness it is nonetheless similar to his earlier claim (Block, 1996) that the key difference between a-consciousness and p-consciousness is the representational character of information stored within and between the relevant modules.[100]

Aside from definitional differentiation, Block argues that a-consciousness and p-consciousness are not identical, since they do not always co-occur. Based upon the cases of blindsight and superblindsight[101], he maintains that we can have one without the other-. Blindsight (in its most minimal form) is a well-documented phenomena whereby subjects, suffering from some brain trauma, are considered blind in a specific visual field. Yet when cued these subjects are able to guess at a rate above chance whether something is in that visual area. His interpretation of these cases is that they have access to some information contained within the state, yet since subjectively they have no experience of the stimuli (they report that they cannot see anything), the state is thereby not phenomenally conscious. However, this evidence is far from conclusive since the reports of blindsighters have to be cued and superblindsighters exist only in imagination land[102] making the first dissociation questionable.

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[100] A-consciousness is system-relative since it is a functional informational processing notion, while the content of a p-conscious state is determined within the module.
[101] Superblindsight is the hypothetical case of a blindsight patient who has been trained to self-cue to the existence of visual objects thereby allowing them to perform tasks and navigate the environment as if they were sighted despite their blind fields.
[102] A place best left to *South Park* for further exploration. For further details, please consult the TV series *South Park*, Season 11, Episode 10.

Reverse Anton's Syndrome (Hartmann et al., 1991), of there is only one documented case, might be considered an real life example of superblindisight (Block, 1995a, 1997).The subject claimed to be blind yet was still able to perform visual tasks using information gleaned from the claimed blind areas. However, as Byrne (2011) points out the subject was only able to perform these task with a 51% success rate, which is really at chance. Additionally, the subject oddly used audio and tactile terminology to describe his visual phenomenology in a way that calls into question whether his case is a valid data point for theorizing about consciousness. Reverse Anton's Syndrome is best put aside as an interesting case study that is unsuited for any general inferences regarding the nature of consciousness.

Evidence for p-consciousness without a-consciousness is offered by Block with the unconvincing example of the experience of pain during dream states, unconscious Freudian mental states (Block, 1993), as well as empirical evidence supporting a difference in both the informational content and the processes within the dorsal and ventral streams of the thalamus (Block, 2001).[103] Block (2001, 2007, 2008) derives further evidence for p-consciousness without a-consciousness from change blindness and memory tasks. When our working memory store is insufficient to capture all of the visual information that we receive

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[103] It is tempting to run a reductio argument on his position by pointing out that the only connection olfaction has with the thalamus occurs in the dorsal stream, which by his own admission would entail that olfactory states are not a-conscious, thereby yielding the rather absurd conclusion that we never have access to and cannot report our olfactory states. However, it would be more charitable to interpret him as limiting his claim regarding the dorsal and ventral pathways to visual consciousness since the research he draws from derives from Mel Goodale's (1996, 1997) work on the visual system.

and experience, the amount of phenomenal information overflows our ability to access it). As noted above this clearly shows the difference between the kinds of conscious states should be cashed out in terms of their information processing properties and not any phenomenal properties that are intrinsic to the p-conscious states. Additionally, Block (2008) offers the example of GK the blindsight patient, whose Fusiform Facial Area (FFA) shows the same activation in the nondominate lobe as it does on the dominate side. Block claims that while GK cannot access the information, we nonetheless should infer from the strength of activation invariance across lobe sides that his experience of faces is the same in each. Perhaps, but then it is deeply mystifying why retinal or thalamic activation might not be phenomenal as well (Papineau, 2007; Prinz, 2007a). Perhaps we cannot report these states, but there is still something that it is like to be in them.

What I hope to show when discussing olfaction is that this seemingly absurd conclusion is exactly what we should expect for olfaction. Olfactory phenomenal consciousness provides a nice counterpoint to the data derived from vision science, because it can occur in the absence of awareness even at the sensory level, one cannot be aware of a smell without the co-occurrence of a qualitative olfactory experience. The reactivation of olfactory sensory states that are phenomenally conscious seems constitutively necessary for being aware of an olfactory experience. Olfactory phenomenal consciousness is independent from, but necessary for, olfactory awareness, contrary to Block's claimed double dissociation.

5.2.1 Thin and Thick Phenomenality and HOT Consciousness

David Rosenthal (2002, 2007, 2009, 2010) has argued that Block's notion of phenomenal consciousness is ambiguous, both descriptively and in terms of the evidence offered in support of p-consciousness in the absence of a-consciousness. The distinction is intended to capture an intuitive difference between states that we can report or are aware of and those that simply have a qualitative character. However, Block's notion of phenomenal consciousness, or the what-it-is-likeness (WiiL), of an experience is ambiguous between at least two kinds of phenomenal states.

In contemporary philosophy of mind the idea of WiiL can be traced back to Thomas Nagel's (1974) influential paper on our inability to imagine or represent what it would be like to be a bat given their ability for perceiving the environment using echolocation. Nagel's precise usage of the phrase requires that there is a WiiL for the creature undergoing the experience. The notion of a phenomenal character of experience from a subjective point of view is inherent to the concept of WiiL.

However, Block's definition of phenomenal consciousness might be interpreted in one of two ways as referring to: states that have a qualitative character for the subject and which are conscious though not reportable or not fully accessible ; or to statesthat have a qualitative characterthough which the subject is in no way conscious of being in. These two different kinds of phenomenal states correspond to Rosenthal's (2002, 2007, 2009) distinction between thick and thin phenomenality:

> One kind consists in the subjective occurrence of mental qualities, while the other kind consists just in the occurrence of qualitative character without there also being anything it is like for one to have that qualitative character. Let's call the first kind thick phenomenality and the second thin phenomenality. Thick phenomenality is just thin phenomenality together with there being something that it is like for one to have that thin phenomenality. (Rosenthal, 2002, p. 657)

The first kind of phenomenality corresponds to Nagel's WiiL, while the second seems to correspond to that supported by Block's evidence for phenomenal consciousness from subliminal vision and extinction studies. Disambiguating these two kinds of phenomenality nicely sets up Rosenthal's claim in the case of thin phenomenality that qualitative states can occur in the absence of subjective awareness.

Quality Space Theory (QST) (Rosenthal, 2007, 2009, 2010) is proposed as an explanation of how qualitative states could occur in the absence of any conscious awareness. Using perceptual role theory to motivate the claim that mental qualities can exist in the absence of awareness, Rosenthal argues for Quality Space Theory;

> On a perceptual-role theory, mental qualities are the properties in virtue of which we make perceptual discriminations. So independent of anything that consciousness tells us, if an individual's perceiving involves such discriminations, that individual is in mental states that have mental qualities that pertain to those discriminations. Perceiving provides a third-

> person way of determining what mental qualities occur, independent of the first-person access that consciousness delivers. (Rosenthal, 2010, p.6)

Mental qualities, he argues, can be identified and individuated according to the perceptual qualities that a creature can discern. Qualitative mental states are derived from a creature's discriminative abilities to distinguish between physically perceptible properties of the world such that mental qualities exist within a holistic matrix or quality space that is homomorphic to the external discernable qualities. These states have thin phenomenality, since they possess a qualitative character. However, there is nothing that it is like for subject to be in them in the absence of a HOT that makes the subject conscious of being in these qualitative states.

Quality Space Theory is proposed as an account of how mental qualities might be identified and individuated using a third-personal scientific method without recourse to phenomenological first-person reports. As a theory it is independent of any theory of how we become conscious of these qualitative conscious states (how thin consciousness yields thick consciousness). However, by supplementing QST with HOT theory, Rosenthal provides a comprehensive account of how conscious experiences can have a qualitative character. In keeping with his general theory of consciousness, one is aware of undergoing an experience with a qualitative character, when one has a HOT that represents the lower order state within the homomorphic matrix of quality spaces. According to Rosenthal (2007, 2010), the higher-order state might not be conscious, but how it represents the qualitative first-order states determines the nature of the mental quality for us (its qualitative character)). The higher-order states determine the qualitative character that one is aware of in subjective experience.[104] Also, it is quite possible to have conscious states that do not have any qualitative character, since they do not represent that experience as such (Rosenthal, 2009). Even though he allows that the quality space is not conceptual and does not have the same structure as that of intentional states, I argue in the next two sections that these two claims, regarding the top-down determination of the phenomenality of the qualitative state, are questionable given the nature of olfactory phenomenal consciousness.

5.2.2 Olfactory Phenomenal Consciousness

Olfactory qualitative consciousness shows that there is a middle position that can be taken between that of Block's p-consciousness and Rosenthal's thin phenomenal qualitative states. It might seem contentious that there are states that have a qualitative character in the absence of our awareness of being in these states. However, I think QST goes some way towards showing that mental qualitative states could be identified and individuated in the absence of awareness. That being said, thin phenomenal consciousness is too anorexic. Yet, thick phenomenality of the kind I think Block's distinction draws us towards is

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[104] "What a qualitative state is like for one is a matter of how one is conscious of it, and hence of how one represents that state to oneself. And that's a matter, in turn, of how the HOT one has about the state characterizes it. One's HOT about a qualitative state determines what it's like for one to be in that state – what it's like qualitatively"(p.193).

too subjectively bloated. The WiiL of experience, in the sense outlined by Nagel and employed by Block, accords too large a role to the subjective aspect. What I would like to suggest is that there might be a third intermediate option – olfactory phenomenal consciousness.

Olfactory phenomenal conscious states have a qualitative character for the subject undergoing the experience even in the absence of full awareness that one is undergoing these experiences. Phenomenal consciousness in olfaction is fatter than the thin notion, since it requires that the subject is currently undergoing some kind of qualitative experience but cannot fully report this. Yet this need not require a thick conception of a subject undergoing these experience. These states are subjective without implicating any thick conception ofa subject. Olfactory phenomenal conscious states are states of a subject that have a qualitative character

and which influence his behavior even while he is unaware of being in these states.[105] By analogy they are like an itch that one is not aware of; there is a sense in which there is some peripheral awareness that something uncomfortable is occurring and a general feeling of irritation, but there is no awareness that one's left big toe is horribly itchy.

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[105] To an extent the concept of olfactory phenomenality is in keeping with Prinz's (2007b) concept of phenomenal consciousness in the sense that while all consciousness is perceptually driven, an explanation of the subjectivity of phenomenal consciousness does not require any robust metaphysical claims regarding the subject, since the subject having subjectivity consists in nothing more than the organism being in that state.

5.3. Olfactory Consciousness

The necessity of cortical connections without thalamic relays for our conscious sense of smell provides the beginnings of an approach for studying olfactory phenomenal consciousness as a necessary condition for conscious awareness. Since the neurobiological theories surveyed in Chapter 4 are at best only adequate as theories of visual consciousness, this section will serve as an argument for the beginnings of olfaction's emergence in the arena of consciousness. Olfactory consciousness provides evidence that olfactory sensory states are phenomenally consciousness and necessary for our conscious awareness of olfactory experiences.

5.3.1 Olfactory sensory states are phenomenally conscious

Olfactory sensory states are such that they have a qualitative character even if the subjects themselves are unaware of being in them. While some might call these 'qualia', 'phenomenal consciousness', or 'unconscious qualitative mental states', I however shall simply refer to this phenomena of there being something that it is like for the subject undergoing the experience as 'olfactory phenomenal consciousness'. Evidence that olfactory sensory states have a qualitatively character in the absence of awareness derives from research on blind smell (Schwartz, 1994, 2000; Sobel, 1999), mate selection (reviewed in Wilson & Stevenson, 2006), the selection of social preference for social interaction and acquaintances (Li et al., 2007), as well as the role of olfactory deficits in causing affective disorders.

5.3.2 Blind Smell

The existence of blindsight is a well-documented phenomena that has played a role in shaping theories of consciousness as these states modulate the subject‘s behavior even though they are not aware of being in them. Blind smell is not nearly as well-studied and documented, but Schwartz (1994, 2000) and Sobel (1999) have shown that analogous states are available in healthy human subjects for olfaction. This research provides evidence that normal people undergo qualitative states that guide their behavior, yet are unaware of being in them.

Schwartz's (1994, 2000) discovery of blind smell involved a detection task. The subjects had two vials placed in their hands, one containing an odorous solution, the other not. They were instructed to sniff each vial and judge which onecontained the odorous compound. In addition to monitoring their cortical activity using EEG, the subjects were also required to report on the perceived concentration of the odor and their confidence in their own judgment, using a ten-point scale. Initial results showed increased cortical activity during these tasks, which was thoroughly expected and uninteresting. However, upon closer inspection they discovered a large subgroup of sensitive subjects who were able to detect the presence of an odor with 68% accuracy. These subjects also displayed an increased confidence rating when they correctly detected the presence of an odor, however, they were unaware of the presence of an odor as all trials used subliminal odor concentrations. Since the self-reports demonstrate that they were unaware of the presence of an odor, their confidence rating on hits showed a direct linear relation, suggesting they are undergoing some experience of which they are unaware. From these results Schwartz concludes that the sensitive subjects possessed a level of conscious awareness even when they are not conscious of undergoing this experience. These findings support the claim that olfactory sensory states have a qualitative character even if subjects themselves do not report awareness of them.

Sobel's (1999) evidence is not nearly as conclusive as Schwartz's.[106] Sobel's experimental design involved a detection task of odor vs. no odor, while placed within a full body fMRI machine. The subjects were instructed to sniff at given intervals and then report on the presence or absence of an odor. The odor trials consisted of two subliminal levels of odor concentration. The results indicate that detection increases with the level of odor concentration, showing an increase in brain activity in those areas responsible for smell even when the subjects deny

[106] Sobel's study might not be evidence for blind smell, but it is of additional interest since the thalamus was active showing a dose-dependent response across the trials. The activation of the thalamus in this study cannot simply be attributed to the role of sniffing, because of the dose-dependent relation of activation. The implications of this, they duly note, supports the necessity of thalamic relays even for olfactory consciousness. However, they admit that the results are far from conclusive, based as they are on the use of a compound that might be the human equivalent of pheromones. Since the effect of the vomeronasal organ was not controlled for, it is possible that this might be responsible for the robust thalamic activation. (Human pheromones and the vomeronasal organ are discussed in the Chapter, Section 3.) Furthermore, they are careful to note that their recording of specific activation in the thalamus might be an artifact of drainage effects from the internal cerebral vein.

undergoing any olfactory experience. The evidence for blind smell is inconclusive, since they used a subliminal odor without any measures of subjective feedback. Sobel's results are suggestive of there being some level of unconscious olfactory processing, but they do not demonstrate that these states are qualitative.

5.3.3 Mate Selection (I love you, because you smell nice.)

Evidence for the qualitative character of olfactory sensory states can also be gleaned from research on mate selection. Further research on human olfactory mate selection is required, but the initial data indicates that we select partners based on their smell (reviewed in Wilson & Stevenson, 2006). We might not notice it, but our reason for preferring significant others might be that their immune systems smells good to us.

Using olfactory cues we select sexual mates based on the synergy of our combined immune systems for producing offspring with an even stronger hybrid system. If we mate with a partner whose genetic human leukocyte antigen (HLA) system is the converse of our own this generates offspring with a more robust hybrid immune system. Thus, it would be adaptive to be able to detect the structure of a possible mate's HLA.

The evidence that we select mates based upon HLA compatibility, since we tend to avoid mates with HLA haplotypes identical to our own is derived from Ober et al.'s (1997) study of Hutterite mate choice. Previous studies examining

HLA mate choice were inconclusive, since they were conducted in heterogeneous populations in which the confounding effects of ethnic or racial self-preference could not be discounted. The Hutterite population served as a nice control, since it is a small homogenous population with easily traceable genetic lineages. By looking at the HLA haplotype matches between spouse's, they concluded that less of an overlap existed than would otherwise be expected if the selection processes were random (as compared to a computer simulation that controlled for HLA haplotype matches). Thus, they concluded that major histocompatibility complex (MHC) based mate choice is operant even in humans. Furthermore, they suggest that the mechanism for HLA detection and MHC structural comparison might be mediated by the olfactory system. The olfactory system is quite capable of such chemical structural analysis and comparison. However, two further steps are required to establish that olfaction is the causal mechanism responsible for HLA mate selection and that these states are phenomenally conscious.

First, it assumed that the causal mechanism for HLA detection is identical to the mechanism responsible for MHC detection and recognition in animal models. In mice and rats it has been demonstrated that MHC recognition is accomplished by the olfactory system (Yamazaki et al*.,* 1979; Yamaguchi et al*.,* 1981; Ehman, et *al.,* 2001). Further research has also shown that mice, rats, and humans can distinguish using olfaction between the urinary scents of rodent urine derived from different MHC strains of mice (Beauchamp et al*.,* 1985).

Taken together these studies show that mammals certainly employ MHC-based mate selection and that the human olfactory system is sensitive to these same chemicals. When these findings regarding our olfactory sensitivity are combined with the aforementioned research on Hutterite mate selection, strong evidence emerges that we engage in HLA-based mate selection as mediated by olfactory cues in the same manner as other mammals.

Second, it must be established that HLA mate selection employs olfactory phenomenal conscious states in the absence of awareness based upon hedonic judgments of the odor of male body odor and sweat. Using twoday old sweaty t-shirts of men, experimenters determined that females judged a t-shirt's odor most pleasant when it was derived from a man whose HLA system differed from their own (Wedekind et al*.,* 1995; Jacob et al., 2002). What is interesting about both these studies is that no, one, male body odor was universally agreed to be pleasant smelling, which differed across females depending upon the dissimilarities of the donor's HLA with their own. The major difference between these studies is that Wedekind's study shows that the more dissimilar the HLA, the stronger the hedonic rating; while Jacob's evidence points to their being some level of HLA overlap implicated in the hedonic rating of the sweaty odor. Nevertheless, both studies clearly implicate the olfactory system as a possible means for selecting mates based on their immune profile and that a subject's olfactory states have a qualitative character as established by their hedonic value.

Though we are unaware of doing so, we select mates based on their converse genetic HLA system. The biochemical mechanisms responsible for this mate selection are located in the olfactory system in rodents We are also capable of distinguishing these chemical structures. Furthermore, humans find the sweaty odor of complementary mates more pleasant than those with a similar HLA system. Therefore, it is possible that we select sexual mates based upon the qualitative character of our olfactory states even in the absence of awareness. Literally, one might love another, because their immune system smells nice.

5.3.3 Social Acquaintance Selection

Further evidence that olfactory sensory states have a qualitative character in the absence of awareness can be derived from research on the effects olfaction has in guiding social interaction and preferences. Subliminally pleasant and noxious odors can modulate our ratings of preferences and likeability of social acquaintances (Li et al*.,* 2007). While it is quite uncontroversial that supraliminal smells modulate our mood and affective responses towards someone (Herz & Schooler, 2002; Jacob et al., 2002), this study showed that the hedonic value of an odorant subliminally modulates social preference. Using a simple odor detection task (pleasant, unpleasant, neutral, and control) combined with a subjective rating of the likeability of pictures of faces, Li et al*.* (2007) demonstrated that pleasant and unpleasant odors presented subliminally both had a physiological effect and modulated the subject's affective response towards the pictured faces. It was shown that unpleasant odorants caused the subject to rate the face as being less likable, while pleasant odorants had the opposite effect. Additionally, the effect only occurred with subliminal odorants and quickly disappeared if the subject was aware of the smell. The causal efficacy of these states is thus implicated in our selection of social acquaintances. I might like you, because you smell nice or at least familiar.[107]

Olfactory sensory states have a qualitatively richer content of experience than one would suppose based on folk psychology. Subliminal odorants play a causal role in social acquaintance selection, such that it is quite possible that even if one is unaware of undergoing an olfactory experience, given olfaction's direct connection to the limbic areas (Gotfried, 2006), it nonetheless certainly has an affective component and perhaps also a qualitative character.

3.4 Anosmia - Argument from Absence

A severely unethical, but clearly conclusive, experiment could be performed to test my claim that olfactory phenomenal consciousness arises at the sensory level of olfactory processing in the absence of awareness. The experiment would be to sever the olfactory tract's connections in healthy humans

[107] It would not be at all surprising if we select our social groups based on their smell, given that those that smell most familiar to us will be the most comfortable to be surrounded by. Social groups usually have a unique odor by which they can be identified. An interesting study substantiating this point was done with elephants, who can distinguish the odorants of different clans in their surroundings (Bates et al., 2007). Since one group usually consists of poachers, while the other poses no harm, recognizing and avoiding the former group is of great ecological value to these elephants.

to see if they could have olfactory phenomenally conscious states. Though this experiment is unfeasible there is other data from olfactory pathologies that accomplishes the procedure for us. Combined with what I shall refer to as an 'Argument from Absence', these deficits should establish that it is not possible to have olfactory qualitative consciousness without olfactory sensory states.

Anosmia is the most common disorder of olfactory pathology in which individuals lose their sense of smell. In some cases anosmia is due to the presence of a psychological disorder, but the vast majority of them are due to damage to the Olfactory Bulb either due to infection or head trauma. The most interesting cases for testing my claim are those of anosomia, caused by head trauma which has severed the olfactory tract. In addition to their inability to perceive olfactory objects, anosomic individuals also experience a decrease in their hedonic quality of life (Miwa et al*.,* 2001), which in turn is often causally implicated in the further development of depression (Deems, et al., 1991). We are not aware of our olfactory experiences most of the time, but they imbue our lives with a qualitative character of experience, which is most striking in their absence.

To summarize, the Argument from Absence is that the absence of olfactory sensory states are causally implicated in lower quality of life scores and depression. Hence, these states are responsible for generating olfactory phenomenal consciousness even in the absence of awareness. The argument certainly does not prove that olfactory sensory states have a qualitative character, but the evidence certainly is suggestive.

5.4 Olfactory phenomenal consciousness is necessary for olfactory awareness

Even while we are unaware of it, a world of odors continually envelops us exerting a profound influence on our behavior and the qualitative character of our everyday experiences. These smells contribute to the quality of our life and, as argued above, have a qualitative character such that it is possible for one to have a phenomenally conscious olfactory experience, but not be aware that one is undergoing the experience. What is even more astounding and controversial is that it is not possible for one to be aware of an olfactory experience without it having a qualitative character. Evidence for the claim might be derived from first-person reports and the reader's own awareness of olfactory experiences. Introspecting, remembering, or imagining an odor tokens some manner of qualitative olfactory experience. Just thinking about the smell of the fresh cut grass on the great lawn in July, or the smell of honeysuckle on sheep's meadow, elicits an olfactory experience for me. However, using first-person reports of phenomenology might be methodologically questionable. Besides from biasing us to only consider experiences that we are aware of as having a qualitative character, the veracity of olfactory first-person reports might be doubted given how little we attend to our experience of odors (Sela & Sobel, 2010).

Veridical odor perception certainly establishes my claim, but it is not a good test case. Situations of perceiving olfactory objects, when one is aware of a smell, will activate a sensory state, which according to the last section is phenomenally conscious, thereby making one aware of an olfactory quality. In these situations there is certainly a what-it-is-likeness for the subject undergoing the olfactory experience. Anytime we are aware of perceiving an olfactory object the conscious state has a qualitative character, since qualitative sensory states are elicited as part of creating the perceptual state. Since using first-person phenomenological reports is methodologically questionable and perceptual states will always have a qualitative character, olfactory imagery will serve as the test case for my claim that all states of olfactory awareness are phenomenally conscious.

Olfactory imagery demonstrates that all olfactory states that we are aware of being in are qualitative. Methodologically my claim cannot be tested using mere detection or discrimination tasks, since whenever the subject reports the presence of an odor, while undergoing a qualitative experience of the smell, he is aware of smelling something. A better test would be to see whether olfactory phenomenal consciousness occurs when introspecting or imagining previous olfactory experiences. Olfactory imagery concerns exactly this issue and provides affirmative evidence. While the phenomena is badly named and often ill conceived as an issue regarding the representational format of cognitive states (Kosslyn, 2003; Kosslyn et al., 2003; Pylyshyn, 2003), it demonstrate that we can elicit a qualitative experience of a smell in the absence of an olfactory stimulus (reviewed in Stevenson et al., 2005). Experimentally it has been shown that subjects can re-elicit the qualitative experience of smelling something in the absence of an olfactory object. Merely introspecting or imagining a smell elicits a qualitative experience of smelling an odor in the subject. Even in the absence of olfactory stimuli, when we are aware of an olfactory experience it is phenomenally conscious.

Even more fascinating is that olfactory imagery states mimic those of ordinary olfactory experiences in three ways. First, they mimic ordinary olfactory experiences in terms of odor mixing experiments (Algom & Cain, 1991), suggesting that even our olfactory cognitive states employ a nonconceptually formatted system of representation.[108] Odor mixing experiments yield the interesting results that, when two similar odorants are combined to yield a configural compound, the resulting complex's odor is different to those of its constituents parts; while odorants that are dissimilar yield elemental compounds in which the odors of the constituents are clearly discernable. However, by simply changing the concentrations of the constituents one can shift an elemental compound to a configural compound. What is of interest in olfactory imagery is that if one is asked to imagine the mixture of two odors and report the olfactory quality of the compound, the reports will mimic those given when smelling the actual odor. Given the argument from Chapter 3 that olfactory perception occurs in a nonconceptual medium and the identical results in these cognitive tasks I

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[108] See Chapter 3, Sections 3-4.

conclude that cognitive olfactory states occur in the same nonconceptual medium.

Second, our sniffing patterns during olfactory imagery mimic those of normal olfactory perception, indicating that we need to reactivate the olfactory epithelium and bulb (sensory states) to be able to remember or imagine odors (Bensafi et al., 2003). When thinking about an olfactory object and imagining what it smelled like, subjects are unaware that they sniff in patterns reminiscent of veridical perception. Given that olfactory sensory states give rise to phenomenal consciousness in the absence of awareness, then if one wants to think about the quality of an olfactory object, a simple way of accomplishing this would be to reactivate or simulate the qualitative state that one is trying to think about.

Lastly, the same cortical areas responsible for ordinary olfactory perception are activated in olfactory imagery (Bensafi et al., 2007). The same cortical areas that are active in veridical perception of an olfactory object are activated in remembering or imagining odors. The combination of these results creates quite an amazing conclusion.

Olfactory imagery provides evidence that the cognitive states in which we are aware of olfactory states have a qualitative character to them even when the olfactory object is not present. Since the sniffing patterns are similar between both types of experiences it is arguably the case that in order to re-elicit an olfactory qualitative experience one must once again manipulate the olfactory epithelium and bulb (the low level sensory states) , whichthen recreates the experience by re-activating the olfactory cortex (Rinck et al., 2009). To think about a smell, one must literally token the initial sensory and perceptual states.

The nonconceptual format of olfactory phenomenally conscious sensory states provides a novel and far-ranging conclusion. As discussed in Chapter 3, regarding olfactory imagery and olfactory memory encoding, olfactory experts are better at imaginatively recreating olfactory experiences (Gilbert, 1998). The olfactory expert's heightened ability is not derived from the use of any verbal or conceptual resources, but merely from a greater exposure to olfactory stimuli. Having a larger repertoire of previously activated olfactory sensory states allows for greater olfactory cognitive abilities. Moreover, Herz (2000) has shown that olfactory memory encoding is not verbally mediated. Neither linguistic tags nor an increased number of linguistic labels have an effect upon our abilitiesto encode olfactory experiences in memory and recollect past odor experiences. This research provides further reasons for thinking that our olfactory cognitive states are not linguistically nor conceptually mediated.

Our conscious awareness of an olfactory experience in the absence of direct stimulation is not determined by how the state is conceptually or linguistically represented in imagination or memory, rather it depends upon the reactivation of sensory and cortical areas. The reactivation of nonconceptually formatted sensory and cortical states is required for our conscious awareness of smells. Olfactory conscious awareness is driven by bottom-up processing even in the case of cognitive states such as remembering or imagining olfactory experiences. Combining this line of evidence with the arguments of Chapter 3 yields the far-ranging conclusion that olfactory consciousness is always qualitative, driven by the elicitation of the initial sensory states, and occurs in a nonconceptual format that is not mediated by our linguistic abilities or conceptual resources.

5.5 Olfactory phenomenal consciousness and awareness: The damage done

The nature of olfactory consciousness for both phenomenal consciousness and awareness has far-ranging consequences for both Block's distinction between phenomenal and access consciousness, and Rosenthal's Quality Space Theory when combined with his HOT theory. This section culls the competition using the findings of this chapter on olfactory phenomenal consciousness and awareness. Olfactory consciousness provides reasons for doubting Block's claim of a double dissociation between phenomenal consciousness and access consciousness, and Rosenthal's claims that Higher-Order Thoughts can occur without having a qualitative character and that the HOT determines the qualitative character of the conscious experience.

5.5.1 Phenomenal consciousness without awareness

It was argued in Section 3 of this chapter that olfactory phenomenal consciousness occurs in the absence of awareness, which is perfectly in keeping with Block's double dissociation between p-consciousness and a-consciousness, as well as Rosenthal's thin phenomenality. According to these theories, it is uncontroversial that a conscious state can have a qualitative character in the absence of awareness. Everything that has been surveyed about olfaction seems to support this claim. Olfaction provides an intermediate notion of phenomenal consciousness and a theory of the level of processing at which these states arise, as well as a theory of the representational format of these conscious states.Within the olfactory system phenomenal consciousness occurs at the sensory leveland the content of the relevant states is encoded in a nonconceptual format of representation. Nonconceptual phenomenal consciousness is compatible with the representational medium of Block's p-consciousness and Rosenthal's homomorphic matrix of quality spaces. The content of the states of Block's phenomenal consciousness is not available for reasoning, reporting, or rationally guiding action, but there is still something that it is like for the subject undergoing the experience (Block, 1996, p. 164). Also, Rosenthal allows that mental qualities occur in a format that is not the same as that of conceptual content nor similar to the representational format of intentional states (Rosenthal, 2007, p. 207). Therefore, the format and occurrence in the absence of awareness of olfactory phenomenal consciousness is compatible with both Block's and Rosenthal's treatment of phenomenal consciousness.

5.5.2 Olfactory awareness is phenomenally conscious

The second line of evidence that all states of olfactory awareness are phenomenally conscious causes problems for both theories. Whenever someone has olfactory awareness either by way of perception or some cognitive state, these states always have a qualitatively character of experience for the subject undergoing them. Thus, it is not possible to have olfactory awareness without olfactory phenomenal consciousness. Olfactory awareness without olfactory phenomenal consciousness certainly falsifies Block's double dissociation between p-consciousness and a-consciousness. P-consciousness without a-consciousness is possible, but it is not possible to have a-consciousness in olfaction without p-consciousness.

While nothing about olfactory awareness causes problem for Quality Space Theory, it certainly causes trouble when combined with HOT theory, since according to Rosenthal (2009) one can have a conscious HOT that lacks any qualitative character, which according to the evidence from olfactory perception and imagery is simply not possible for olfactory awareness. The fact that all olfactory states that we are aware of being in always have a qualitative character is not a critical problem to Higher-Order Thought theorists, since they could retreat to the weaker claim that a HOT without a qualitative character is a theoretical possibility, which given the anatomical and functional organization of the olfactory system simply cannot occur in olfaction.

A more difficult problem that arises with combining QST with HOT theory is the claim that the manner in which the HOT represents the mental quality of the first-order state within the quality space determines how we experience its qualitative character (Rosenthal, 2007, 2010). The HOT top-down determination of the qualitative character is incongruent with what occurs in olfaction. The nature of the olfactory object as encoded by the initial sensory states determines the qualitative character of olfactory experiences, and our conscious awareness of undergoing olfactory experience requires the bottom up re-activation of these same sensory states. For olfaction it is not how the state is represented, but the actual state itself that both encodes the qualitative character of the experience determines its qualitative character. However, Rosenthal (2011) might only be offering a theoretical explanation of what it is for subjects to report on what their conscious experiences are like for them such that he HOT state does not change the actual qualitative character of the first-order state that it is about, rather how the subject experiences the quality as determined by the higher-order state. Retreating in this way certainly accommodates olfactory consciousness. However, how the HOT determines the quality of the subjective experience of the first-order state might be an issue. Background knowledge and contextual cues might partially shape one's experience of an odorant. Yet these do not change the olfactory quality, since this is determined by the olfactory object in conjunction with the qualitative sensory states. Cognitive states might change the valence or hedonic value of my olfactory experience, but not what it smells like. Thus, olfactory awareness provides reason to doubt Block's and Rosenthal's claims regarding the occurrence of awareness without phenomenal or qualitative consciousness.

5.6 Qualitative consciousness and Awareness employ different formats

The formative nonconceptual content of phenomenally conscious olfactory sensory states, which can occur in the absence of awareness, supplies a superior explanation of the distinction between phenomenal consciousness and access consciousness. The difference between these states is simply due to an incompatibility in their representational formats of content. Presumably if a-consciousness is to play a role within rational and inferential cognitive processes then it must be formatted in accordance with some kind of LoT, which as argued in Chapter 3 requires concatenative compositionality.[109] However, phenomenal consciousness in olfaction arises at the sensory level and is representationally formatted in a combinatorial, and functionally compositional, fashion. Phenomenal conscious states might not be fully reportable not because of how they are broadcast or where they are encoded, but because of how they are encoded. Thus, a possible explanation of why these kinds of conscious states

[109] Interpreting the distinction between these kinds of consciousness as an issue of representation format might not in fact be available to Block, and moreover is questionable given his own inferential role theory of semantics. However, I think it is a viable alternative interpretation of his own distinction, which provides an interesting explanation of why phenomenality might overflow accessibility.

behave as they do is their representational format. The full content of phenomenally conscious states is not available in conscious awareness due to its representational format occurring in a nonconceptual manner, whose experiential content exceeds our conceptual repertoire (as demonstrated by the Richness of Experience argument, Chapter 3, Section 5).

Block does not consider alternative proposal that what underlies accessibility is the format of the representational content of each kind of state. Rather, the opposition that Block (2008) argues against is confusingly labeled "inattentional blindness" which asserts that the richness of perceptual features is not encoded whatsoever and that is why they're not accessible (O'Regan and Noë, 2001). However, it has been shown that the sensory level of incoming information within the olfactory system encodes the full richness of the olfactory object in a combinatorial manner that when conceptualized does not allow access to the component or molecular parts of the original sensory information.

Considering the distinction as an issue of representational format offers a better explanation of the difference between phenomenal consciousness and access consciousness, because it explains why the states are not fully accessible, as well as why they are qualitatively conscious. They are not fully accessible in olfaction due to the nonconceptual representational format of phenomenal sensory states, which are qualitative in themselves due to the nature of the olfactory object and stimuli transduction in the olfactory system. The twofold explanatory power of this interpretation of the difference between phenomenal consciousness and awareness generates a reason for preferring my explanation of Block's distinction.

Block's (1996, p. 177) only reply to this kind of interpretation is that the difference of experiences from different modalities is due to a difference in the phenomenology of each modality but not based on the representational content (). However, as shown in Chapter 3 the difference does concern the format of the representations. Taken together with the arguments in the initial sections of this chapter, this further supports the claim that phenomenal consciousness and conscious awareness is partially determined by the format of the content of their representational states and not the claim that it is due to some mythical mental oil that greases the wheels of consciousness. Moreover, rethinking the difference between phenomenal consciousness and awareness as a formative issue provides interesting ramifications for the explanatory gap and the phenomenal concept strategy.[110]

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[110] Olfactory consciousness subverts the epistemic and metaphysical versions of the gap by showing how we cannot predict the qualitative character of olfactory experiences using third-personal descriptive concepts and how we can predict the epistemic gap based on the biological nature of ORN genetic encoding. What the phenomenal-concept strategy has going for it is the experience thesis, but what it gets horribly wrong is the attemptto plug an experiential gap with a conceptual entity of any variety. Olfactory qualitative consciousness and conscious awareness requires an experience thesis, since to know what the quality is, one must undergo the experience such that even thinking about the experience retokens the initial sensory state, which occur in a nonconceptual format.

7. The Phenomenal Element –
Olfactory nonconceptual phenomenal consciousness

The olfactory system's anatomical, and functionally unique, nature makes it ideally situated to make novel predictions about phenomenal consciousness and its relation to conscious awareness. The beginning of this chapter proceeded to show how olfactory consciousness is special because phenomenal consciousness occurs in the absence of awareness, yet all states of olfactory awareness have a qualitative character.

Combining all of the findings within this chapter warrants the conclusion that olfactory consciousness is derived from our interactions with the basic elements of reality.; its qualitative character derives from the nature of chemical reality such that the nature of olfactory experiences cannot be predicted based on concepts, because one's olfactory experiences are nonconceptually formatted. Thus, all olfactory sensory states are nonconceptual qualitative states. Furthermore, whenever one introspects, thinks about, remembers, or is directly aware of an olfactory experience these states contain an olfactory quality, which necessarily requires the reactivation of the original sensory areas. However, given how this conclusion was arrived atm it is best to review the findings of the previous chapters.

The olfactory object was identified in Chapter 2 with the chemical structure of molecular compounds or mixtures. The qualitative character of an olfactory experience is derived from the chemical structure of elemental entities. Olfaction allows us to sense some of the most basic building blocks of the universe – Matter smells.

The representational content of our olfactory experiential and cognitive states was documented in Chapter 3, where I argued that these states occur in a functionally compositional format. The formative nature of olfactory content provided a new interpretation of nonconceptual content, as merely an issue of the representation format employed by combinatorial systems. The difference between conceptual and nonconceptual content was dissolved into an issue concerning whether or not cognitive and experiential content must occur within a system of representations that employs concatenative compositionality, thereby making it conceptual (as LoT theorists suppose). Equally, if some far weaker notion of compositionality were to be employed by a system then these representational states would no longer count as conceptual.

Formative nonconceptual content provided new evidence for the Richness of Experience Argument. The reason that our experiential content outruns our conceptual repertoire is not due to a lack of concepts or linguistic abilities. Rather, the experiential content of sensory and perceptual states is richer than what our conceptual repertoire can capture, because of an incompatibility between the representational formats. Additionally, this formative difference was employed to offer an alternative interpretation of the difference between awareness and phenomenal consciousness.

Nearly all neurobiological theories derive from empirical evidence gleaned from vision science, so it is unsurprising that their theories either cannot account for olfaction or need to be adapted to account for olfaction's unique anatomical structures, functional organization, and stimuli encoding. The inadequacies of generalizing the current neurobiological theories of consciousness to account for olfaction were discussed in Chapter 4. One of the ramifications of the findings of Chapters 3 and 4 is that olfaction generates different empirical evidence for debates regarding the nature of mental content and consciousness, which militates in favor of modality specific approaches to these topics. My theory of nonconceptual phenomenal consciousness as a necessary condition for awareness in olfaction might generalize as an overall theory of consciousness, but a more neutral approach might be warranted. Theories of consciousness and content should be generated relative to the modality under consideration. If we are attempting to give arguments to the best explanation of some phenomena that might be relative to the modality under consideration then a more permissive approach that allows for the plurality of content and consciousness is preferable.

Methodologically it makes more sense to explore how consciousness and perceptual cognition arises in each modality separately, rather than tyrannizing these research areas by simply assuming that the findings of one modality will generalize across to others. Each modality deserves independent study, followed by researching the mechanism of integration and cross-modal interaction, such that a general theory of consciousness and cognition is produced by a bottom-up methodology. What I propose without further argument is the Mixed Modal Account (MMA) of consciousness. Consciousness is best treated as a many-headed beast requiring different lines of attack each with their own specialized tools.

Olfaction's fundamental and elemental nature provides a new understanding of consciousness and the qualitative nature of our experiences. While the quality of smell is inherent to a chemical object, we can only know what it smells like and gain access to this experience through having an olfactory experience of the object. We cannot predict what something smells like just by mapping its chemical structure or understanding it conceptually, since based on their nonconceptual format our conceptual states cannot fully access olfactory sensory states. Nevertheless, once the issue of primary olfactory transduction has been resolved and we have smelled the object, we can predict what kind of an experience a person is having by combining our knowledge of the genetic basis of olfactory receptor genesis together with a determination of the olfactory object using chemistry.[111]

Aside from providing reason to doubt conceptual inferences regarding our olfactory qualitative states from mere descriptive concepts, the chemical nature of the olfactory object calls into question the reduction of qualitative consciousness to physical objects. Given that chemistry and its molecular

[111] If we can ascertain that a subject has the same ORNs as normal people and that the olfactory object's quality is documented based on previous experiences, then so long as the chemical structure and receptors are the same, we should be able to predict what olfactory experience a subject is having.

structures are epistemically autonomous with respect to physics (Scerri & McIntyre, 1997), we cannot give a purely physicalist account of the phenomenal nature of olfactory consciousness. The nature of our olfactory phenomenal consciousness predicts an epistemic explanatory gap, while suggesting that the qualitative character of our olfactory experiences derives from elemental structures. In conclusion, nothing is more fundamental, for our understanding of mental content and consciousness than olfaction, because no other perceptual modality is more elemental. Olfaction places us in direct contact with an inherently qualitative aspect of reality. Everything and everyone smells.

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