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PERCEPTUAL STABILITY IN OLFACTORY EXPERIENCES

Master's Thesis in Philosophy

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"Whilst part of what we perceive comes through our senses from the object before us, another part (and it may be the larger part) always comes out of our own head" (James 1890: 103).

Introduction

Olfaction refers to our sense of smell and the act or process of smelling. Often olfaction is seen as very subjective, much more subjective than our sense of vision. Reasons for this are varying experiences and different preferences people have for odorous substances. Perfumes are a good indication of this, as humans differ considerably in their conception of a good scent. This conception is also influenced by the emotional impact of an odor. It is not easy to stay neutral on a smell, as we experience strong affective waves of pleasantness or unpleasantness when smelling and might also be transported back to memories when being triggered by an odor.

A consequence of these differences is that people might find it difficult to agree on the smell of an odor and what is important when smelling. The uncertainty revolves especially around the worry that we are not perceiving the world as it is but are also projecting ourselves to our experiences, as is alluded to in the 1890 quote from philosopher and psychologist William James on the previous page.

To address this and other related worries, this thesis explores the question of whether one can give an account of verification in olfaction that would allow for experience-related variations between people. But before introducing this question properly, let us describe the basics of olfaction in a little more detail.

What is olfactory perception and what are olfactory experiences?

Olfactory perception refers simply to a process, in which we perceive via the nose and mind. We are able to detect small invisible particles of odorous substances from the air with receptors in our noses. This information then travels from the receptors into parts of our brain, which produce for us the perception of odors. In this sense the particles in the air cause and stimulate our olfactory experiences.

For example, under normal circumstances, when I smell an apple, I encounter and detect odor molecules that come from the apple. Once detected, these molecules act as stimuli for the olfactory system, ultimately causing my 'apple-y' olfactory experience. Some of the stimuli, might be more meaningful to me than others and produce a bodily sensation, such as the salivation of the tongue in anticipation of eating the apple. In general, there are considerably many olfactory stimuli around us, but not all are distinguished and become significant for us. Still,

a rough estimate is that humans can distinguish over 1 trillion olfactory stimuli (Bushdid et al. 2014), but this capacity varies between people and also reduces as we age.

Odors become significant to us when we direct attention towards them, instead of simply ignoring them. When we are consciously smelling, for instance, the apple, we can think of a description of our experience, such as the notes that we are picking up from the apple or what the experience reminds us of. We might also wonder if this scent is similar to other apples that have previously been smelled.

It could also happen that we are uncertain about a smell, for instance in the case we do not know what it is or where we may have encountered it before. In these instances, we may start to question our olfactory experience. We might wonder if we are misperceiving a scent, especially if other people start describing their experience and this differs from ours. We may also start to investigate what the smell is and whether we are perceiving it correctly. In other words, we try to verify that the experience is veridical.

However, when it comes to verifying our olfactory experiences, the situation is complicated in ways that, at least, verifying visual experiences is not. Indeed, these complications are such that it becomes questionable whether humans have at all the capabilities to verify that odors are what we perceive them to be.

Problem Statement

As is already briefly alluded to above, there are skeptical worries about the possibility of verifying olfactory experiences. This raises questions whether our experience of an odor is veridical at all i.e. we are perceiving the smell as it actually is. In this thesis, I shall reject these skeptical worries by identifying the core elements of a satisfactory account of olfactory verification. To start, though, it is important to introduce the problem, and doing so will also help us to identify what I suggest are the three desiderata of any satisfactory account olfactory verification.

The main problem that we are facing when considering olfactory verification is that there is more inter- and intrapersonal variation in the kinds of experiences that occur than what is easily accommodated by standard models of veridicality and verification that we might associate with vision. And we are unsure what to do with

this, besides blaming subjectivity and differences in preferences. For instance, when a mug is seen similarly by multiple people, this is evidence that their perceptual experience is veridical, just because veridical visual experiences do not seem to be subject to interpersonal variation. To take a well-known example from olfaction, however, cilantro results in experiences of soap for some people, while for others it results in experiences of fresh herbs. Yet, it is not obvious that we could say that either one of these experiences is an inappropriate response to the presence of the cilantro (or the odor molecules that correspond to its presence). A normal feature of olfaction seems to be, thus, that two people can have quite different experiences of the same object while there is no dysfunction in the olfactory system. Indeed, it is tempting to suggest that there can be such variation in the experience without there being a mistake on either person's part – or, in other words, it can be the case that two people have veridical experiences of the same object, even when those experiences are quite different. The possibility that there can be such variation in veridical olfactory experiences, then, suggests that, if we were to give a satisfactory account of olfactory verification, it would be quite different from, at least, an account of visual verification. Thus, we already have our first desideratum. That is, any satisfactory account of olfactory verification must explain how there can be two or more veridical experiences of the same object.

The above worries relate especially to ordinary independent attempts to verify our experiences, in which a person by themselves assesses whether the experience is correct. These are for instance by thinking and talking about the experience, or by getting closer to the smell and experiencing it from different perspectives. It is possible to contrast this type of ordinary verification to scientific verification, in which the invisible odor particles are analyzed using scientific experiments. While this method could give us knowledge about the presence of odorous chemicals in the environment, it does not tell us how the chemicals will be experienced. And we are especially interested in knowing whether the experience with its manifold characteristics, also emotive and memory-related, is correct. Therefore, a second desideratum for a satisfactory account of olfactory verification would be that it must allow for verification in an ordinary non-scientific way.

However, once we permit that something can be perceived differently and can be ordinarily verified, the worry arises that we might be forced to allow that any

olfactory experience can count as veridical in any situation. Such an anything-goes account of olfaction, however, seems even less preferable than a skeptical one. If a non-skeptical account of olfaction is to be convincing then, it must explain how there can be limitations on the kinds of experiences that are appropriate in a given situation. The third desideratum is thus that a satisfactory account must introduce a limiting factor for the olfactory experience that ensures that the experience will not be 'anything at all'. In other words, what is needed is a satisfactory account of 'perceptual stability' in olfaction.

To put these things together, what a theory of olfactory verification requires is an account that allows that there can be two veridical experiences of the same object, that these can be independently verified, and a satisfactory account of perceptual stability. This thesis is concerned with olfactory verification. More specifically, I shall consider the question of what olfactory perceptual stability involves. In this light, I shall argue that the phenomenon of perceptual stability is different in olfaction compared to vision. Where perceptual stability in the case of vision is most obviously, and most commonly, explained by what we can call the perceptual constancy model, this model fails to explain olfactory perceptual stability. Instead, I introduce a more general notion of stability, according to which stable perceptual experiences in olfaction share two core characteristics: appropriateness and consistency of experience.

Understanding the nature of olfactory perceptual stability is important for multiple reasons. First, it gives a better understanding of the functioning of olfaction as a sense modality. Philosophical papers illuminating olfaction have become increasingly popular in recent years (e.g. Barwich 2020, Keller and Young 2022) and issues around the olfactory object, representation, and olfactory illusions are at the forefront of the debate. This thesis thus fits into the recent literature stream and the ongoing discussions.

Second, it challenges current theories in perceptual constancy, which are dominantly vision-centric and do not fit the particularities of olfaction. Instead, a more general account of perceptual stability is proposed, and two characteristics are drafted.

And third, this thesis gives insight and possibilities for future research on how experience-related aspects can be integrated into theories of perceptual veridicality and verification.

Definitions and terminology

Before moving on to the thesis, I shall briefly introduce the key terminology and then provide a summary of the thesis chapters.

An **odorant** is any substance that yields a distinctive smell and can most likely result in an olfactory experience for someone. It can be added to substances, such as to gas, for safety purposes (Merriam-Webster 2023a).

The term **odor** is used beside the terms smell or scent to refer to the smell itself, which is given off by different sources. It is usually attached to a descriptor, such as a potential source object, e.g. the rose odor, coffee odor, melon odor, or a characteristic, e.g. pungent odor, homey odor, fragrant odor. The term **general odor** is used here for our abstracted 'ideal' type odor of something, such as what I believe the substance 'coffee' should smell like, while the specific odor refers to particular instances when the odor of coffee has been smelled before.

The **source object** of the olfactory experience is the object that we attribute as the source of the odor, for instance, an orange, a cup of brewed coffee, or a rose. When talking about our experience, also in verification attempts, we typically speak of ordinary source objects, as we do not have sufficient knowledge of the actual odor molecules. Often, these are also visually depicted objects, as we tend to rely heavily on our sense of vision.

Odorous substances consist of **odor molecules**. These are particles that are able to reach a human's olfactory receptors (see below) and in doing so, at least in part, cause an olfactory experience. However, there are conditions as to when molecules can be odorous, and not everyone can pick up odor molecules similarly. Typically: "*molecules that are volatile enough, not too volatile, and also hydrophobic enough [not dissolving in water] are generally odorous*" (Barakat 2023). Odor molecules are the main components of olfactory stimuli (see next).

Besides the odor molecules, **olfactory stimuli** also include all the substances, including bacteria and other chemicals or micro-organisms, which

stimulate and impact the receptor ends and result in an olfactory experience for the perceiver. These stimuli can be called **distal stimuli** when the stimuli are at a distance as a property of an object, whereas they are called **proximal stimuli** when they are impacting the receptor, e.g. from the eye, directly (Sekuler 1999). If not otherwise mentioned, 'olfactory stimuli' in the thesis refer to the distal stimuli.

The **olfactory experience** is the perceptual experience that occurs when inhaling olfactory stimuli. The experience has a phenomenal character, which describes what it is like for the subject to have the experience (Siegel 2021). The experience can also convey information to us, e.g. 'that there is a substance present in the environment that I have previously encountered', 'that there is a substance present in the environment which I have previously found pleasant', or 'that the pasta contains parmesan'.

The **olfactory receptor** is a nerve ending, consisting of proteins that bind odor molecules. These receptors get stimulated by odor molecules through matching shapes: "*It is thought that stimulation occurs when a molecule with a particular shape fits into a corresponding "pocket" in the receptor molecule, rather as a key fits into a lock*" (Bernays and Chapman 2019). There is however not a linear relationship between odor molecules and receptors, as one odor molecule can stimulate many different receptors and multiple molecules can be picked up by a single receptor. The receptors extend to a neural structure in the front of the brain called the **olfactory bulb**, where information about an odor is processed and sent further to the amygdala, in which our brain processes memory and emotional responses (Chapman and Bernays 2010).

The **olfactory cortex** is the area of the cerebral cortex (i.e. brain) concerned with the sense of smell. It receives information from the olfactory bulb (see above). According to the Merriam-Webster dictionary, the olfactory cortex is: *"probably concerned with the subjective evaluation of olfactory stimuli"* (Merriam Webster 2023b).

Veridicality refers to truth and the degree to which perception accurately represents reality (Siegel 2021). For an experience to be veridical it must satisfy certain **accuracy conditions**, i.e. conditions under which the experience is not a misperception. However, it may be that the accuracy conditions differ for different

senses (e.g. vision, olfaction…). Moreover, although it is generally considered that at least some conditions will relate to objects and properties, there is disagreement about what the accuracy conditions are for any of the different sense modalities.

Objects are unified wholes that we are able to perceive. They are differentiated from **properties**, which are constituents or components of objects (Rettler and Bailey 2023). The **odor object** is a debated concept, as it is sometimes used to describe source objects, i.e. coffee, rose, while at other times it relates to the actual odor molecules. In this thesis, the term odor object is used to describe the odor molecules (stimulus of the olfactory experience). In addition, the term **psychological construct** of an odor (Wilson and Stevenson 2006) is also used and refers to the single perceptual object that we create of an odor.

Olfactory **verification** refers to one's capacity to confirm that one's olfactory experience is veridical (Stevenson 2011:1888). This can happen by thinking about the experience and trying to identify or place the odor, for instance by searching for likely source objects. This also includes the attempts to confirm one's assumptions through interpersonal verification. The term **interpersonal verification** is used when attempting to triangulate the olfactory experience by talking about it with other people.

Perceptual stability is a general term to indicate the non-arbitrariness of perceptual experiences, meaning a limiting factor that gives predictability to our olfactory experiences. In this thesis, it will be understood as consistency between several perceptual experiences.

Perceptual constancy is the: *"constancy of the perceptual response despite changes in the proximal stimulus"* (Sekuler 1999). This means that the distal stimulus is represented as having the same constant properties, despite changes in the proximal stimulus. This results in the perspectival invariance of objects and recognizable **features**. Features refer here to distinct qualities of objects.

Summary of chapters

Chapter 1 introduces what I call the standard account of veridicality and verification typical for our sense of vision and shows how this account does not fit olfaction, as experience-related aspects are not sufficiently considered. The chapter

provides the motivation for the thesis by situating the phenomenon of perceptual stability into the wider context of olfactory verification.

Chapter 2 describes the phenomenon of perceptual stability in olfaction and shows how the perceptual constancy model does not fit an account of olfactory perceptual stability through example cases and argumentation. In addition, the chapter identifies further considerations that we need to consider when trying to account for perceptual stability. These emerge when we consider cases about our everyday olfactory experiences.

Chapter 3 introduces a positive view of perceptual stability that I call the template-matching model. On this model, experience has a key role to play in shaping olfactory experiences i.e. through familiarity and the synthesis of co-occurring features into single perceptual objects. Implications of the template-matching model are postulated for olfactory verification and its objections are discussed.

Chapter 1 Standard view of veridicality and verification challenges

Typically, unified wholes that exist in the external world are called objects. When we are perceiving, we are organizing the perceptual world into individuated objects, which then display certain properties (Millar 2019). For instance, chairs, tables, and cabinets are such objects. They display properties such as woodenness, durability, and symmetry. Presuming that radical skeptical views are false, then we can presume that objects are most often represented from the external world accurately and others perceive them similarly to you. To take a visual experience, for example, if there is consensus among a group of people that the thing they are all looking at is a chair, the best explanation of this (under normal circumstances) will be that the people in question are all having a veridical experience of a chair.

When we want to assess whether our perceptual experience of something is correct, i.e. veridical, we typically want to ascertain that we can perceive an object in the world as it is. The most obvious way to do so would then be to identify an object in the world and then check whether the object under scrutiny really has the ascribed characteristics or properties that we believe it has (Siegel 2021). When it comes to seeing, an appealingly intuitive model of how this process would go is the following:

1. You have a visual experience of an object
2. The experience is veridical if the properties of the object that causes the experience are represented accurately
3. You can assess the veridicality by examining the object and its properties from another perspective

Let's call this the 'standard model of verification'. On this model, if the object under scrutiny has the relevant properties, then the account is veridical, otherwise, it is non-veridical. For instance, if I see a yellow panda on this model, we could assess whether the panda's hide really has yellowness to it in order to assess whether my experience was veridical. We can do this for example by going closer to the panda, by asking other people or the panda caretaker about their experience, or by touching the hide to make sure that there is no additional substance (i.e. paint) that would have colored the panda. If the panda's hide does not have yellowness to it, my experience was non-veridical.

Non-veridicality can furthermore be differentiated into illusions and hallucinations. Illusions would be those non-veridical cases, in which there is an object in the world, but due to some circumstance, I saw the object incorrectly and got the property wrong. The panda would have been black and white all along, but unbeknownst to me, the glass in the zoo enclosure was tinted in a way that black and white appear as yellow. In result, my perceptual experience of the panda was incorrect. Hallucinations are non-veridical perceptual experiences in which there is no object there that corresponds to the perceptual experience. For example, this would be the case if there was never a panda there to begin with and I created the experience by myself out of thin air (as in dreams). Crucially, non-veridical visual experiences cannot be successfully verified since, by definition, these are not accurate representations of the objects in the world.

1.1 Applying the standard account of veridicality and problems with the odor object

In this section, we will apply the standard account of veridicality to olfaction and are introduced to the assumptions we would have regarding the odor object, which typically plays a central role in the comparability between olfactory experiences. We discuss problems around the odor object and settle that the odor molecules are what cause the olfactory experience.

If we apply the above standard model of veridicality to olfaction, we could assume the following. There are individuated objects in the olfactory world, which have certain properties. These objects would be for instance natural or synthetic smells such as a rose, a perfume, or a bar of soap. To have a veridical olfactory experience would mean that the smell impression that you have of an object is accurate, i.e. that what you are smelling is how that object actually smells like. For example, suppose I am standing in a room, and I have the pleasant sensation of smelling freshly baked apple cookies. According to the standard model applied to olfaction, my olfactory experience is veridical when the sensory experience is caused by an objective state of the environment and my experience accurately represents that state (Stevenson 2011:1893). Thus, on the standard model applied to olfaction, if I am smelling apple cookies and my olfactory experience is veridical, then there must be apple cookies in my immediate vicinity.

From the standard view of veridicality, we have learned that in order to verify our experience, we should define the object of our sensory experience and examine its properties. This could mean that we would be committed to figuring out what the odor object is and what its properties are. This would be something like trying to define what the apple cookies smell like and then confirming that (i) there are apple cookies in the vicinity and (ii) that those cookies have the smell property attributed to them.

However, what makes olfaction complicated in terms of the odor object is that when we are smelling apple cookies, we are not smelling a substance called 'apple cookies' per se, but rather a mixture of odor molecules that interact with microorganisms and bacteria in our surroundings (Keller 2022, Young 2016, Barwich 2019). This makes it confusing to know what the actual object is that we should be examining. In the case of coffee, for example, there are several hundred chemicals that individually do not smell like coffee, but only together as a mixture produce the typical odor (Barwich 2019). For the smell of rain, the resulting smell is caused by a molecule 'geosmin' inside the earth when rainfall interacts with it. We are thus presented with a scent cloud of geosmin molecules, which we then associate with the source object of rain (Keller 2022). Furthermore, odor molecules are complex, not stable, and a change of just one atom can completely alter the overall conception of the resulting scent (Barwich 2019:4).

In this thesis, I will initially presume that the odor objects are the actual odor molecules that cause the olfactory experience. This seems suitable, as different visual source objects can have different smells, e.g. different apple cookie scents, and we want a more precise understanding of which stimuli result in what kind of experience for the perceiver. On this presumption, a veridical olfactory experience occurs only when the odor molecules are actually present. For example, if I smell 'rain' and that olfactory experience is veridical, then there must be molecules of geosmin in the vicinity. Importantly, my experience can be veridical, even if it is currently not raining. What this means, though, is that, if we accept the presumption that the odor objects are odor molecules, then, the standard account as presented above cannot be the correct account of olfaction.

There are some options for how the object causing the olfactory experience can be understood. On the one hand, there are critical views from authors such as

Barwich (2019) and Batty (2010) which argue that 'olfactory objects' are not actual objects as they do not fulfill criteria on issues such as perceptual constancy, stimulus representation, and [spatial] figure-ground segregation (Barwich 2019)[1]. They can at best be seen as some form of content that is targeted 'at' the perceiver (Batty 2010), but what this means concretely is somewhat unclear. On the other hand, authors such as Wilson and Stevenson (2006) and Young (2016), seem to suggest that the odor molecules are the actual odor objects. The difficulty with this approach is that in language, and interpersonal verification attempts, we speak of the source objects that emit the odor, not of the invisible odor molecules. We are not saying: "*I am smelling geosmin*!" But instead, we say: "*I am smelling rain*". In this sense, it becomes difficult to recognize the odor molecules as the unified 'wholes' (i.e. objects) of our experience, as we cannot see them with our eyes. For a further overview of different positions regarding object-based approaches to olfaction see Millar's summary (2019:4284).

Next, we will be introduced to the question if only odor molecules determine our olfactory experiences, or if there are other considerations as well, and the implications this has for veridicality.

1.2 Olfactory veridicality when accommodating for molecules and experience

In the above, we discussed difficulties relating to the odor object and settled on the notion that the odor molecule is what's important for determining the olfactory experience. However, we have yet to establish if it is only the structural features of odor molecules that determine our experience, or if other considerations should be included as well. Whether or not there are other considerations, and what those considerations are (if there are any), will have implications for what counts as a veridical olfactory experience and, thus too, implications for what it means to verify an olfactory experience. To determine this, we will discuss the Youngian (2016) as well as Stevenson and Wilson's view (2006) and their implications for veridicality, these views being different perspectives on the position that odor molecules are what count for the olfactory experience.

The first view I want to consider is Young's Molecular Structure Theory of olfaction by Young (2016). This model states that: *"every olfactory quality can be*

[1] I will discuss the issues around perceptual constancy in Chapter 2 of this thesis.

accounted for in terms of the molecular structure of chemical compounds within the odor plume [i.e. gaseous feather-like entity permeating our nostril]" (2016:527). This means that we are in fact inhaling chemicals and that the differences in the chemical composition of odor molecules result in different olfactory experiences.

Veridicality would then mean that there is only one accurate representation of odor molecules and that differences in olfactory experiences can be traced back to minuscule changes in olfactory stimuli. The task of verification would be then to figure out whether your olfactory experience accurately corresponds to the odor molecules and their properties. This reflects the standard view of veridicality and verification, with the exception that the means to verify our experience is using scientific experiments and not ordinary triangulation of our experience, e.g. talking and comparing the experience with that of other people, as in vision.

Under Young's view, verification becomes a scientific endeavor of experimenting with chemical compositions of odors in a laboratory environment with carefully designed experiments that could map out what kind of percepts arise from different chemical compositions of odor molecules. This seems undesirable for an account of verification, as we want an understanding of verification in which an ordinary person can assess the veridicality of one's experience, or at least have an indication of how likely the experience is to be veridical. Having to make a scientific experiment every time you want to verify your olfactory experience seems unfeasible for daily life and for guiding our behavior in the world.

For this reason, the Youngian model (2016) does not meet our second desideratum as an account of verification in which the ordinary person is able to independently verify one's experience without scientific experiments. It does so precisely because it is attached to too demanding expectations about the structural features of odor molecules, in which the individual perceivers do not play a role.

Interestingly, there are especially cases of intrapersonal variation that suggests that the Youngian model is either wrong or incomplete. For instance, a well-understood variation is of cilantro, which can smell and taste intensely like soap to some people, rather than fresh herbs, due to a genetic mutation at the olfactory receptor OR6A2 (Eriksson et al. 2012). Intuitively, however, it seems that

it would be a mistake to say that either experience is more accurate than the other. Yet, the Youngian model struggles to accommodate this intuition, just because, on that model, the nature of the odor molecules determines the conditions of veridicality. So, if the odor molecules are the same in both instances, then, one experience must be more accurate than the other. Because of these kinds of findings, it is argued that individual or genetic differences influence our receptivity to odor molecules (Barwich 2020) and should therefore be considered besides structural features of stimuli. A satisfactory account of veridicality should therefore allow that there can be two experiences of the same object, i.e. an odor molecule, that are different, yet both veridical. This would be a position, in which the emerging olfactory experience is not fully determined by structural features of the olfactory stimuli, but also determined by internal aspects of the perceiver.

We will thus consider another view, called here the experience-dependent view. This view is especially represented in Wilson and Stevenson's book *Learning to Smell: Olfactory Perception from Neurobiology to Behavior* (2006). In this book, odors are being treated as experience-dependent psychological constructions (Wilson and Stevenson 2006:8), that are learned. This view holds that there are two components to the odor object (i) the molecules (ii) a psychological construct, in which different odor molecules are combined to match our ordinary language of smells.[2]

Nevertheless here, we want to understand what this view means in terms of veridicality and verification. For an account of veridicality, it means that it is still the presence of odor molecules that create the olfactory experience, but that these might not always be perceived similarly. In this, there are two options, of which the first seems to be the case.[3] Either odor molecules cause the experience but do not themselves fully determine veridicality. This would mean that whether an experience is veridical is going to be a matter of the kind of odor molecules that are in play and internal experience-related aspects. Or second, odor molecules cause the experience but don't have any role to play in determining veridicality. If this is the case, then whether an experience is veridical is only a matter of internal considerations.

[2] We will further look at this in Chapter 3.
[3] Will be discussed in Chapter 2.

On either kind of account, though, once we allow that internal factors or experience have a role in determining the conditions of veridicality, problems arise as to whether it is possible to ever verify an olfactory experience. I discuss these problems in the next section.

1.3 Three worries about verification, together represent a problem of stability

Stevenson has prepared a summary of the numerous verification issues in olfaction in his paper Olfactory illusions: Where are they? (2011). He is very pessimistic about our ability to verify our olfactory experience to the extent that we *may* not even be able to notice if we are experiencing a smell correctly, or if we are in fact experiencing an olfactory illusion. Three problems will be discussed below.

The first point relates to challenges regarding the olfactory object and how the same odor molecule can lead to different percepts. As has been identified already in the first desideratum, it is possible for people to have different experiences of the same object with no obvious explanation of how one or the other has gone wrong. Moreover, this kind of interpersonal variation is characteristic of olfaction and is influenced by a wide range of factors that contribute to its variation, e.g. gender, cognitive ability, and genetic differences in people (see also Barwich 2019). All of these can lead to vastly different olfactory experiences caused by odorants. One person might smell a fishy smell in the kitchen and attribute this to fish, while another attributes the smell to cleanliness and a particular brand of detergent. The verification challenge then is to determine if both of these percepts are veridical, if only one, or neither. Moreover, not only is olfaction subject to interpersonal variation, but it is also subject to intrapersonal variation. For example, the exact same perfume can smell differently on different days.[4]

Not having a similarity of experience is particularly challenging for verification attempts as we typically rely upon the testimony of others to triangulate our sensory experience as veridical (instead of searching for chemicals). I might ask: *"Do you also see a red object in front of you, or am I dreaming?"* If the other person(s) also sees this object, I feel more certain that my experience is correct. However, if this is not possible in olfaction and I smell fish, while you smell

[4] Intra-personal variation is a perplexing situation. We will discuss a case in Chapter 2.

detergent, it becomes very uncertain if we are even smelling the same thing, as our percepts differ so much. The easiest option then is to just suspend judgment and dismiss both experiences as incorrect.

A further problem arising from the inter- and intra-individual variation is a practical one, as the odor molecules are invisible, making it difficult to confirm our olfactory experience by other means (Stevenson 2011:1894). This refers especially to the use of our other senses to verify the existence of the odor chemicals or molecules, as we are not able to see or hear them and also do not live in a sterile laboratory environment. If a clean kitchen smells fishy, we might find ourselves at a loss if we were to verify whether there really is a fishy smell in the kitchen or not.

The second challenge of verification of olfactory experiences is people's lack of basic knowledge about the olfactory sensory system and the limited language we have for different odors. Most people do not have a well-developed vocabulary of different odors, making it difficult to use their sense of smell to make accurate identifications. It is much easier to use the names of source objects to indicate the odor and rely more on the information gained through the sense of vision.

This is a hurdle for olfactory verification, as it might happen that two people are talking about the same odor and also have the same or similar percepts, but just because they use different terms for expressing their experience (or rely on different visual cues) the two people might find it difficult to compare their olfactory experiences. Not having accurate names for describing the experience can lead to confusion both in interpersonal verification (i.e. are we talking about the same thing?) as well as independently (prone to making mistakes such as attributing the scent wrongly or remembering it wrong).[5]

Thirdly, olfaction seems to be prone to change blindness, a phenomenon in which the perceiver is unable to detect even a quite significant stimulus change from one situation to another (Stevenson 2011:1894-1895). This is a problem because people normally have high confidence that they are able to know what is happening around them, which is here not the case. Not being able to notice changes

[5] In addition, this phenomenon is also magnified by aspects related to attention and emotions, as the emotional salience towards particular odors varies between people, making some odors attention-grabbing for some and indifferent to others. These further exacerbate language and naming differences between people.

undermines the perceivers' ability to make claims about the veridicality of their experience. Change blindness is especially observed when there are conflicting visual cues around, which distract the perceiver from noticing the change in stimulus, as well as in cases when the stimulus change occurs over multiple days (Stevenson 2011). This could mean that humans might not be able to pick up on quality shifts in stimuli but perceive (or want to perceive) the stimuli as unchanging.

Stevenson (2011) paints a very skeptical picture about our ability to verify our olfactory experiences. We have olfactory experiences, but they vary considerably between people. We also do not have the tools to verify our experience, as talking about our experience might give us unsatisfactory results. Nevertheless, if we want to presume that having such a skeptic outlook on olfactory verification is misguided, we could think about what the main expectation is regarding veridicality that we have but which does not seem to apply or causes problems for olfaction.

In my view, this is the fear that something is going wrong when the olfactory stimuli get transmitted and shaped into our olfactory experiences. Either the stimuli result in different percepts for different people, or we do not notice when the stimuli change from one situation to another. This means that how we get stimulated by olfactory stimuli is not as straightforward as what we are used to from our sense of vision and the standard account of veridicality. The signals from olfactory stimuli seem to get interfered with or modified by our emotions, past memories, the language we use, and so forth, but nonetheless, this still does not seem to be a problem for the normal functioning of our olfactory sense.

But if such variation in olfactory experiences seems to be normal in olfaction, *and* we want to reject skepticism about olfactory verification, then, the question arises 'How much variation should be permitted?' After all, for example, whilst it may seem in the original cilantro case that neither experience is more appropriate than the other, there will surely be many experiences that would not be appropriate. For instance, if one of the pair smelled 'roast turkey', that would clearly be inappropriate. There needs to be some limiting factor, with respect to which not just any olfactory experience could be veridical in a given set of circumstances. We will look at perceptual stability as a limiting factor, something that gives predictability to our olfactory experiences.

In the next chapter, I shall consider whether perceptual stability in olfaction can be accounted for on what we call 'the perceptual constancy' model. What I will suggest is that, while a perceptual constancy model of perceptual stability might be appealing when considering the other senses, it fails as an account of olfactory perceptual stability.

Chapter 2 Does the perceptual constancy model explain perceptual stability in olfaction?

In this chapter, I will first describe the phenomenon of perceptual stability in olfaction (from here onwards just 'perceptual stability' unless otherwise specified), based on a take from the odor recognition model by Wilson and Stevenson (2006). I will then introduce what seems to be an appealing model of perceptual stability in the case of the other senses (especially in vision), i.e. a model that refers to the concept of perceptual constancy. Afterward, I use example cases from Barwich (2019) and Herz and Clef (2001) to show how this perceptual stability is not fulfilled by perceptual constancy in olfaction. Lastly, I discuss some limitations upon a satisfactory account of perceptual stability that emerge from these cases.

2.1 What is perceptual stability in olfaction?

When we are smelling a familiar smell, let's say coffee, there is a similarity of those instances which ensures that we are perceiving coffee. Even if the encounter with coffee slightly varies or is different (i.e. experiencing a Mocca, or Vietnamese coffee instead of your regular coffee), the percept of coffee does not change to the extent that we are not able to recognize it as coffee anymore. The fact that we have an idea of what something should smell like, such as with coffee, and that we can recognize even small variations to how it should smell, suggests that there is some form of perceptual stability in olfaction available, which ensures that our conception of an odor does not change from one day to another. Understanding what this perceptual stability in olfaction is and what it entails is what I am interested in.

I base my take on perceptual stability on Wilson and Stevenson's account of the odor recognition model (2006). These two authors discuss that: *"the synthesis of multiple (potentially hundreds) volatile molecules into a single perceptual object can enhance perceptual stability if newly sampled odors are compared with previously stored odor object templates"* (2006:7). Perceptual stability is here an outcome of a process when new odor information is compared with previously stored odor object templates successfully. In order to do this, we lump the new odor information into a single percept, instead of analyzing the individual features separately. The outcome is a seemingly stable account of what an odor smells like.

For instance, perceptual stability could be gained about the scent of a rose. This would occur, for instance, if having several successful encounters with rose odors, the individual has a perceptual model of what a rose smells like. Once this model is in place, the individual confirms (subjectively) or disconfirms that a new olfactory experience is/isn't 'rose' partly via comparison of the experience to that model. If the experience is confirmed, then it matches prior experiences; if it is disconfirmed, there is some significant discrepancy between the new experience and prior experiences.

If it is disconfirmed, then the individual can either change or modify the idea of what a rose smells like, along the lines of: *"In some instances, the rose smell can actually be quite grassy or pungent, but I still recognize it to be the rose-smell, although a bit different"*. If the rose smell is not adjusted, then the individual can attribute the difference to a mistake in perceiving the smell (i.e. a non-veridical experience). For instance, there could have been conflicting smells about, so that the substance (e.g. a scented candle) that was supposed to give off a rose smell, actually gave off more of a vanilla smell. In these cases, the individual does not feel motivated to change their conception of a rose smell, as they have some ground for believing that they do not have to.

So, perceptual stability relates to having consistency in one's idea of what something should smell like. The figure on the next page is an illustration of this process. The personal idea of what something should smell like is called here the *general* odor. The term is taken from Condillac's *Treatise of the Sensations* ([1756], 2013) and is differentiated from the *specific* odor.

While the specific odor is a result of one particular instance of smelling, the general odor is not attached to any particular instance of smelling, rather it emerges as a totality of the encounters with the odorant. A prerequisite for this is that we are able to abstract enough information from our encounters with olfactory stimuli to form general odors (Condillac 2014), such as of the smell of rose, or the smell of a mandarin. In other literature, e.g. in Millar 2019, the term odor identity is also used.

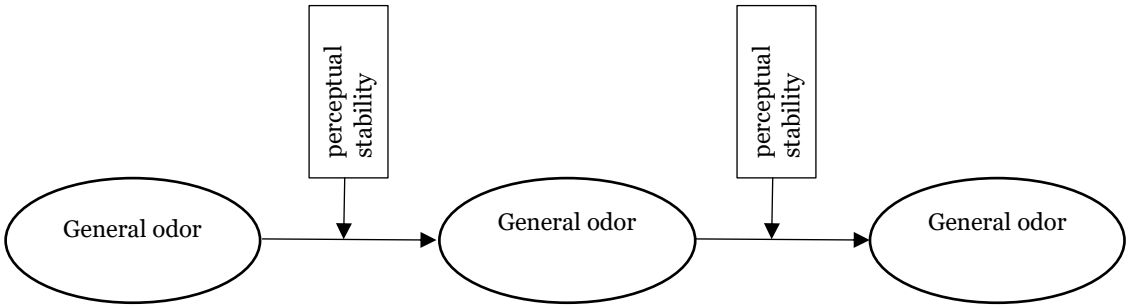

Figure 1: General odor and perceptual stability

To recap, we are looking for an account of perceptual stability in olfaction that enables us to employ object recognition capacities and to arrange olfactory information into unified wholes i.e. general odors, even if some physical features of stimuli are vague or partially perceivable. One – and perhaps the most intuitive – way that we might do this is by appealing to the idea of 'perceptual constancy'. I will discuss this approach in the next section.

2.2 Perceptual stability as perceptual constancy

At least with respect to vision, perhaps the most intuitive model for perceptual stability is what we might call 'the perceptual constancy' model. Perceptual constancy is defined by the Britannica Encyclopedia as: *"the tendency of animals and humans to see familiar objects as having standard shape, size, colour, or location regardless of changes in the angle of perspective, distance, or lighting"* (2020). This means that we as humans have a psychological constancy mechanism, which allows us to see objects as viewpoint independent.

This psychological constancy mechanism ensures that we are able to perceive invariant features in objects. A used example is that of a coin (see e.g. Sekuler 1999). The distal stimulus to our experience would be the 'actual coin object', i.e. metal round thing with a picture or number of sorts. When perceiving this coin, we are able to perceive features of roundness, smallness, etc. We are also able to perceive these features, even if we keep changing the position of the coin or are bringing it closer to us. This is explained by the perceptual constancy mechanism and how we respond to proximal stimuli.

While the distal stimuli of the 5-cent coin remain the same, we can rotate the coin in such ways that the proximal stimuli, or the signal that reaches our retina and brain, varies. For instance, when we rotate the coin 90 degrees, we see a less

conclusive angle on the coin, yet we can still recognize the shape to be a coin. The fact that we can still see these features as unvarying and in consequence recognize the shape to be a coin, means that we have a working perceptual constancy mechanism.

An interesting notion is also, that the perceptual constancy model provides perspectival invariance, which includes the interpersonal layer. Our apparatus for perceiving, at least visual stimulus, is built in such a way that different people can interpret these features similarly to each other and can agree on the actual features of an object.

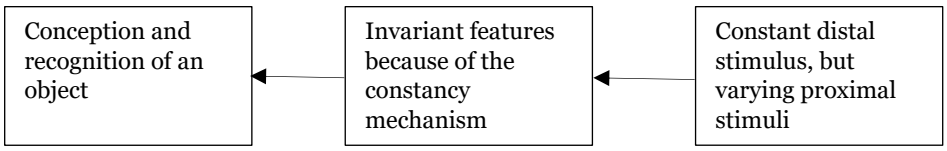

Figure 2. Perceptual stability by perceptual constancy

So, thanks to the perceptual constancy model we can have stable conceptions of objects, as their features remain invariant, even though the proximal stimulus may change. This is summarized in the figure above. This makes it easier to form our conception of objects, as it does not take many instances to learn to recognize an object, such as the 5-cent coin, as we are able to interpret features without much ambiguity. An implication of this is, that if we have a functioning perceptual constancy model, we should not expect such variation in features and experiences as is described in desiderata one of this thesis. Let's get to this next.

2.3 Why the perceptual constancy model does not fit

If we have perceptual constancy, we are able to recognize a distal stimulus (in the form of an object) even if there is a variation in proximal stimuli, as was explained above. A consequence of this for interpersonal verification is, that if we are perceiving things similarly, we can easily discuss and agree on the features of different objects. In her paper Critique of Olfactory Objects (2019), Barwich doubts whether there is perceptual constancy in olfaction.

In this section, we will look at three examples, two intrapersonal accounts from Barwich (2019) and one empirical study by Herz and Clef (2001), in which the distal stimulus stays the same, but our experience changes. These examples show

how there is no perspectival invariance in olfaction, this being a reason to doubt whether the perceptual constancy model can provide olfaction with an account of perceptual stability.

The first reason why Barwich (2019) doubts perceptual constancy in olfaction is that there seems to be selective adaptation in olfaction, meaning that prolonged exposure to an odor alters one's perception of its quality. When we encounter a smell for a prolonged period, we become desensitized towards it and have difficulties in perceiving it at all. This has a functional role to fulfill, as from an evolutionary perspective it is more important for humans to notice significant changes or signals in olfactory stimuli, rather than to get a very accurate understanding of all the stimuli around us. So, for instance, we are not able to notice the typical smells that are around us in the home, but we notice smoke or other intrusive smells very quickly. In this way, we are able to pick out a particularly interesting smell, a potential signal of danger, against a very busy background of olfactory stimuli.

Selective adaptation is a case, where the distal stimulus of the experience stays the same, but our experience changes to the point that we interpret the situation differently. For instance, we could think that nothing is there in the room, even though the distal stimulus still is. If we reflect back to the perceptual constancy model, we could assume that the proximal stimulus in the experience is changing, e.g. some of the proximal stimuli could be blocked by the receptors, resulting in inactive stimulation. However, in opposition to the coin example in which we still had a constant perception of the coin, we do not have this in olfaction. There is simply no presence of the distal stimuli observed. We do not have an invariance of features or of the object, as nothing is perceived anymore. So unless olfaction cannot somehow nullify our proximal stimulation completely (and in consequence the distal stimuli), the perceptual constancy model does not seem applicable to olfaction.

The second reason and the more astounding case why Barwich (2019) doubts the perceptual constancy in olfaction is because the context of exposure can change the phenomenological experience drastically. In the last chapter, we have already discussed the example of cilantro, in which different people have different olfactory experiences of the same cilantro odorant. However, there are also experiments that

show that the same person can have different phenomenological experiences of the same distal stimulus. This for instance, is if there is a different conceptual tag, e.g. in the form of semantic association, attached to the experience. Barwich presents this puzzling case:

> In a presentation at Columbia University in 2017, the master perfumer Christophe Laudamiel distributed smelling strips scented with sulfurol to an audience. People smelling it at first were uncertain regarding its quality. It smelled somewhat organic, perhaps a little meaty or sweaty, but also of something else. Laudamiel proceeded to show an image of warm milk. The audience murmured in agreement. Of course, it smelled like warm milk! Laudamiel continued by showing another image, this time of ham. The audience was startled. The strip with sulfurol suddenly smelled like ham. Laudamiel repeated his demonstration, alternating between the images of warm milk and ham. The perceptual switch continued to occur with the alternating images (2019:7).

This is again a case in which the distal stimulus stayed constant (and perhaps even the proximal stimuli stayed the same), but our experience changed markedly. The experience was influenced by factors related to the verbal semantic association.

So, why did the experience change so much? When we google sulfurol we get a description of a synthetic aroma chemical with: *"milky, fatty, cooked, beef juice perfume nuances"* (CreatingPerfumes 2023). This shows that the olfactory stimulus is multifaceted and depending on other surrounding stimuli, such as visual cues, we might experience varying olfactory experiences. Perhaps a rare specialist could identify this substance as sulfurol, but a normal person would most likely guess that this is warm milk or ham, a source object that is common to the daily life of many.

This means that when we use our experience to trace it back to a source for the experience, we do not trace it back to sulfurol, but rather to sources that fit with the description of milky, fatty, etc. And of those, there might be multiple. In this sense, our perception of the stimulus sulfurol does not lead to perceptual constancy, as the 'sulfurol' does not lead to an invariance of perspective but can actually even be perceived as completely different things and as having different properties with varying emotions and expectations attached to it.

Now, we could object and postulate that the olfactory experience was non-veridical and that the changing verbal semantic association interfered with the actual stimulus input of sulfurol. However, I don't think this is wise if we want to understand olfaction better. Instead, we want to assume that this is not the case and

that the perceivers had in both cases veridical experiences of sulfurol. This is because this type of olfactory experience does not seem unusual and seems to be a characteristic feature of olfaction.

The key point here is that what Barwich is describing is a normal and significant feature of olfaction. And, reflecting parts of the previous chapter, assuming we are not skeptics about olfactory verification, any satisfactory account of perceptual stability should be sensitive to this feature. This was also identified in desiderata one of this thesis, in which we already made assumptions about the inter- and intra-personal variation which seems to be the case in olfaction. This variation was observed in this case (and can also be seen in the next one), grounding our desiderata one and showing that the perceptual constancy model cannot account for the variation which is characteristic of olfaction.

The third case also shows the influence of verbal labeling on the perception of odors. A case from 2001 by Herz and Clef found that the stimulus remains invariant, but the context alters the perception (much like in the sulfurol experiment above). In the experiment, the authors (2001) administered different substances to participants and recorded their reactions. For instance, they gave the substance 'isovaleric acid' to the participants with the labels vomit and parmesan cheese separately and got very different ratings on how the participants experienced the odor and what kind of pleasantness they ascribed to it. Surprisingly, 83% of participants judged that they had been smelling two separate odors, when in fact it was the same stimulus all along.

In our examination of the suitability of the perceptual constancy model, we can again say that our processing of olfactory stimuli does not provide perceptual constancy, as in this case, participants cannot even notice that they are smelling the same thing in two different instances. This too shows the unsuitability of the perceptual constancy model, as in that model the invariance of features leads to the easy recognition of source objects, which is not the case in olfaction. As these are normal and characteristic features of olfaction that the perceptual constancy model cannot explain, it cannot serve as our account of perceptual stability.

Having shown from consideration of these cases that the perceptual constancy model fails as an account of perceptual stability, in the next section I highlight the positive features of perceptual stability that these cases highlight.

2.4 The actual effect of olfactory stimuli on perceptual stability

After having seen in the previous section that there is no perceptual constancy in olfaction, we might wonder what the role of olfactory stimuli at all is and if there are limiting factors to our experiences that we can abstract from these cases. Two aspects are here discussed: the odor molecules which determine a range for our experience, as well as the anchoring effect of familiarity.

To start with, an observation of the above Laudamiel case is that the stimulus sulfurol does seem to have some role to play in determining the nature of our experience. The sulfurol had multiple properties that were perceivable and depending on the combination with something else, here verbal label, changed the olfactory experience. The properties were milky, fatty, cooked, and beef juice nuances, which can be seen as providing a limiting range for the experience and the potential source objects. In this sense, the odor molecules pose some limitations towards what the experience should be.

This is important to note, as in the chapter on veridicality, we wondered if odor molecules have at all a role to play in the veridicality of the experience, besides causation. And here it would seem that it indeed does. We can thus assume that odor molecules provide limitations for the experience and the potential source objects in the form of a range.

The above seems like a good insight that we should keep in mind for our account of perceptual stability, yet we might wonder if there are still others that need to be considered. I would like to include the role of familiarity that was raised in the study by Herz and Clef (2001). Participants were less susceptible to the verbal labeling manipulation, depending on the experiential familiarity with the odor and the amount of anchoring that had happened. An example was the perception of wintergreen (methyl salicylate). People that grew up in the USA, experienced an exclusively pleasant mint candy smell, while people from the UK experienced a medicinal odor with highly negative odor ratings.

This effect of familiarity is important for us because we are interested in perceptual stability and the factors that seem to make the olfactory experience less arbitrary, especially if we do not have perceptual constancy. Familiarity seems to anchor the experience somehow. The person from the USA perceived only mint candy, while the person from the UK perceived only medicine. This could mean that familiarity plays a role for understanding which experience is more likely to occur and therefore is relevant for our account of perceptual stability.

In this section, we discovered a possible range that the actual olfactory stimuli influence and were furthermore made aware of the role of familiarity that seems important for perceptual stability. Herz and Clef sum up: "*Therefore, both what one is primed to think of an odor as being as well as one's standard for experience play an important role in the manipulation of perception for certain odors*" (2001:389). With these two characteristics in mind, we transition to the next chapter. In there, I consider a second model of perceptual stability. Let's call this the 'template-matching model'. As I shall argue, the template-matching model of perceptual stability can account for these two characteristics.

Chapter 3 Perceptual stability in the experience-dependent view

In the last chapter, we saw that the perceptual constancy model is not sensitive to the variation which is normal in olfaction and therefore cannot be a model of perceptual stability in olfaction. In this chapter, I want to introduce what I call the 'template-matching' model of perceptual stability. I shall argue that by giving a role to experience, this model is sensitive to the variation that is a feature of olfaction, and, at the same time, it can ground a satisfactory conception of perceptual stability in olfaction. Following that, I shall finish the chapter by exploring some of the implications that accepting the template-matching model would have on how we should conceive verification in olfaction.

Before describing the model, let's recap what we expect from perceptual stability in the context of olfaction. We expect that it could help us rule out the olfactory experiences that are completely unrelated while, at the same time, being sensitive to the kind of variation that is characteristic for olfaction. This relates to two aspects. First some limitations of what kind of olfactory experiences seem appropriate when having an olfactory experience. For instance, it would be absurd if someone were to smell the perfume of Chanel No. 5 and have an olfactory experience of milk, but it would be completely appropriate to have experiences of flowers, fresh laundry, or even mosquito spray. In the last chapter with the case of sulfurol (Barwich 2019), we learned that there is most likely a range of appropriate experiences that could correspond to a particular odor molecule or a combination of odor molecules. In this chapter, I take that as a starting point for the account of perceptual stability that I develop on the basis of the template-matching model.

The second thing that we saw was that perceptual stability in olfaction must include a certain degree of consistency when experiencing an odorant on multiple occasions. So, when the same person smells the same perfume on multiple occasions, we would not want the olfactory experience to vary to the extent that it hinders the recognition that it is still the same perfume. So, there would need to be some form of similarity in sets of olfactory experiences, that would allow for at least odor recognition. On this, the case of Herz and Clef (2001) showcased the importance of familiarity and the kinds of experiences a person has had with an odorant. As I shall argue in this chapter, the template-matching model can

satisfactorily explain how our olfactory experiences can have this kind of consistency.

Having recapped the considerations that any satisfactory account of perceptual stability must take into account, we can move on to the template-matching model of olfaction. In the next section, I shall describe this model, in section 3.2, I shall explain how the template-matching model can ground a satisfactory account of perceptual stability.

3.1 Experience shapes odor perception in at least two ways

In this section, I describe the template-matching model. This is a model that heavily relies on Wilson and Stevenson's influence of experience and templates on odor perception, but also utilizes the idea of matching odor molecules to previous encounters with an odor molecule from Keller (2022)[6]. First, I shall describe what Wilson and Stevenson (2006) mean by a 'template'. Then, I shall explain how, on this model, experience influences odor perception in two ways. This will be important to how the template-matching model can account for perceptual stability.

In their book, Wilson and Stevenson (2006) explain that in olfaction we have stored templates of odors in our olfactory cortex. These templates consist of patterns of receptor input from olfactory stimuli. These templates allow individuals to compare and contrast their template of an odor against variable arrays of olfactory stimuli. If there is sufficient overlap between these patterns, then the individual recognizes the olfactory stimuli and can assert that, e.g. this smells like coffee, or this wintergreen substance smells like mint candy.

Wilson and Stevenson (2006:33) continue that experience influences odor perception in at least two ways. First, odorant features change or improve with experience. This means that familiar features are more fully or precisely encoded, making them easier for us to process and recognize. Odor coding here just means

[6] I want to include here that Keller's paper (2022) on The Accuracy Conditions of Olfactory Perception, talks about how odor molecules are matched to previous instances when an odor has been perceived before, and how this could be an account for accuracy conditions in olfaction. This thinking inspired me to include a matching function between the odor molecule and the odor templates, as they are described by Wilson and Stevenson (2006).

filling one's template of an odor. For instance, when you are an avid coffee drinker, you might have many different subcategories of what 'coffee' can smell like and you are able to perceive subtle nuances by being able to process more information from the same stimulus than somebody who only has a less encoded template of 'coffee'.

This is a potential explanation for last chapter's observation about the impact of familiarity. Familiarity made the participants in Herz and Clef's experiment (2001) less susceptible to verbal labeling manipulation and made participants perceive 'wintergreen' more consistently as one kind (i.e. either mint candy or cough medicine). This would then mean that the participants had a 'filled' template, of e.g. the odor mint-candy, which they were able to match and retrieve when smelling the wintergreen substances.

Secondly, experience shapes odor coding by synthesizing co-occurring features into odor objects (N.B. here understood as the psychological construct) (Wilson and Stevenson 2006:33-34). The odorant features that happen at the same time will be associated with each other and a representation of that feature combination will be stored. For instance, perfumes are such created odor objects. The distinct smell of the Chanel No. 5 perfume has persisted over decades, with multiple variations and iterations having taken place. Yet, the recognizability of the perfume has remained.

When perceiving odors, we compare whole patterns of stimuli against our available templates, this being a reason why co-occurring features cannot easily be separated from each other. Wilson and Stevenson call it even the task of memory-based processing: "*to learn which features should be grouped (associated) together to form a perceptual object. Once this associative learning has occurred and perceptual odor objects are formed, discrimination, recognition, and figure-ground separation of those objects from other objects and background are enhanced"* (2006:33).

This means that when we are perceiving, we are automatically lumping co-occurring information into unified wholes, i.e. perceptual objects. In effect, when a part of the code or pattern, which came from the wintergreen substance, is matched with our template, then the source which has previously been perceived in

connection with this pattern (either mint candy or cough medicine) will come to mind too.

Now, let's move on to how the template-matching model explains perceptual stability in olfaction.

3.2 Template-matching and the two characteristics of perceptual stability

We identified earlier that perceptual stability in olfaction relates to two characteristics: appropriateness of experience as well as some form of consistency in sets of experiences. Let's have a look at how the template-matching model explains these.

The appropriateness of the experience can be understood as a successful match of patterns between an odor molecule and a person's template of an odor. We can apply this example also to our case of sulfurol. This means that when there is sufficient overlap between the stimuli coming from sulfurol and the template that a person has for instance on milk, the experience is appropriate. This is shown in the figure below.

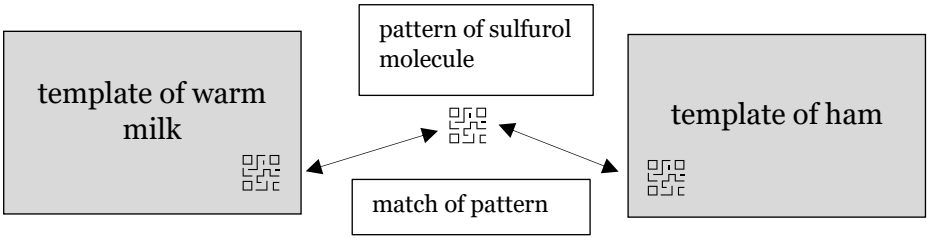

Figure 3: Demonstration of matches in pattern between sulfurol and either warm milk or ham

According to the template-matching model, when people smell the stimuli of sulfurol, they automatically scan the templates that they have available to test if there is a suitable match to the present pattern in olfactory stimuli. As we see in the above illustration, sulfurol has qualities or patterns that allow it to be associated with both warm milk and ham. So when people smell the stimuli of sulfurol and match it with either warm milk or ham, the experience is appropriate.

However, a key consideration in olfaction is, that a perfect fit between the stimulus input and template is not required. People have differently filled templates of odors, and some might only have rudimentary information on sulfurol. This would be for instance that instead of the complete pattern of the above sulfurol, a

person only has the outline of the pattern with some markings in the middle. Nevertheless, we are still able to recognize 'warm milk' even from just a rudimentary sub-pattern of olfactory stimuli when the sub-pattern matches against our templates (see also Batty 2014:6). Even from a partial match we get the experience of 'warm milk', and not just the 'partial experience' of warm milk.

The above is peculiar and can again be contrasted to how things would work in vision. In olfaction, we automatically perceive either ham or warm milk when experiencing sulfurol, as those are the available templates that we have. In vision however, if we contrast the above to a puzzle, we are actually perceiving only the corner of the puzzle and can imagine the rest through our imaginative ability. The addition that is brought to us by our imagination (i.e. that it is ham or milk) is however something like a hallucination. In olfaction, on the other hand, we do not perceive the right corner (i.e. pattern of sulfurol) but only the big picture of either ham or warm milk. This happens because we automatically synthesize co-occurring features into perceivable wholes, and do not have a good capability to dissect the olfactory experience into smaller pieces.

A consequence of this is that we could have an unclear imprint of sulfurol in our template of 'warm milk', yet we could still experience warm milk when there is a match in pattern available. This makes it a worry that the rudimentary imprint which matches the sulfurol pattern to perhaps 40% could also match completely different sources to perhaps 15%, resulting in unrelated experiences for us. A consolation to this worry is the suspicion that patterns in nature are rather sophisticated and unique, making it unlikely to have too much overlap between them. And even if there are, these could be identified, providing another interesting research stream in olfaction.

A further worry or objection to the above explanation on appropriateness is that this template-matching model of perceptual stability is just the perceptual constancy model in disguise. The only addition that we would need to make is that only 'filled' templates of odors can provide perceptual constancy.

However, what makes this difficult is that there is not really something like a perfectly 'filled' template, rather these are continuously changing containers that record our experiences with odors. In this sense, even if one were to have a

sufficiently 'filled' template, there would still be no guarantee of being able to perceive distal stimuli in a constant fashion. Moreover, limiting our model to only experts with 'filled' templates, ignores the normal ordinary functioning of olfaction, that we had identified in desiderata two. Therefore, we could at this point, as there is no further conclusive research on the patterns of olfactory stimuli, dismiss this objection.

Now, let's move on to the second characteristic: consistency between sets of olfactory experiences. When it comes to these, our explanation and thinking are a bit more speculative. Ideally, people would always be prompted of the same template when smelling a particular stimulus, but the sulfurol example showed that this is not the case. The person did not have experiences of just warm milk or just ham but of both.

In the template-matching view, the experience that is more likely to occur is path-dependent to the person's prior odor experiences and what kinds of templates this has created. This happens, because as we are continuously comparing the new available stimulus input with our already existing templates, we are reinforcing patterns and making some more established than others. These are also easier for us to retrieve. In this sense, the sulfurol was not an integral part of the perceptual object of warm milk, which would have automatically made the experience of just 'warm milk' and not of anything else.

The person arrives at this type of judgment, by comparing this experience of 'warm milk' to previous experiences of warm milk. When for instance, we are building our conception of what warm milk smells like, we start with no patterns and in forming them, we are filling out our personal template of 'warm milk'. Most experiences are accepted, and further shape our template of the odor, while some are dismissed because they do not seem to fit into our overall set of experiences with the warm milk odor.

So perceptual stability in olfaction does not refer to a type of consistency, in which all the experiences are the same, but they are similar enough to be linked to each other. We can think of this as wanting to flag the instance that really should not fit into our set, even though it shares similar patterns. On the next page is an illustration of instances when we think we are smelling warm milk. The first three

seem sufficiently similar to each other, but the last one does not, even though it shares a distinct pattern that confounded our judgment at first. The first three could be allowed experiences and influence our overall template of the warm milk odor for future instances, but the last one could be dismissed as unsuitable.

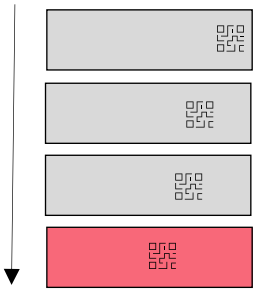

Figure 4: Illustration to demonstrate three cases of similarity and one of dissimilarity in the warm milk odor set

For the sulfurol example, this would mean that the pattern of sulfurol was available in the experiment, but that the surrounding information (other stimuli which would further indicate milk or ham) was not present. In consequence, the people, who are not used to just smelling pure sulfurol, were not able to make a judgment, as crucial information – which would have indicated that the experience is consistent with other instances of smelling warm milk or ham – was missing.

In the template-matching view, perceptual stability in olfaction can thus be understood as some form of path-dependency between multiple instances when the odor has been perceived before, thus influencing the overall availability and quality of templates. In addition, pattern-matching ensures that the similarity between olfactory experiences can be discovered.

3.3 Templates provide perceptual stability and get coded with experience

As we have seen in the above section, these templates are important for what we pick out or see as important when interpreting the available olfactory stimuli. When making an evaluation of what something smells like, according to the template-matching model, we go through different templates that we have, and when there is a sufficient overlap between two patterns, we recognize the olfactory stimuli as being familiar.

Recognizing something to be familiar does however not automatically mean that we can name the source object from the situation when we have encountered

the stimuli before. There are several authors who have written how humans seem to have very good discrimination capabilities (Bushdid et al. 2014), but an underdeveloped ability to name or identify the odorant (e.g. Young 2019, Stevenson 2011). Nevertheless, the more familiar the patterns are, the higher the likelihood that the odorant can eventually be identified.

The availability of templates and their encoding is linked to which kind of association or experience the perceiver will have when encountering olfactory stimuli. First, the amount and quality to which the templates are coded determine how much of the olfactory stimuli the perceiver is able to recognize. And second, the co-occurring stimuli that happened while the perceiver has encountered the stimuli before will influence the overall template with which the odorant will be associated with. This was easily observed in the wintergreen example, in which the pattern of the wintergreen matched with one person's template of mint candy, while for another person it matched with the template of a particular kind of medicine.

In this sense, the perceptual experiences people have when encountering stimuli (once there is a level of familiarity available) are not arbitrary but are path-dependent to the person's prior odor experiences and what kinds of templates this has created. We end up with different odor maps in our head, which enable us to decipher and quickly organize olfactory stimuli.

If we were to object to this model and say that it is dangerous to allow 'internal components' and path-dependency to matter in the veridicality of experiences, we could proceed as follows. If the above model would be true, then we run into the danger that we should allow a Covid-infected person, whose sense of olfaction has been temporarily or permanently changed to the effect that the person now has seemingly stable experiences that everything (i.e. all meat-substances) tastes and smells like chicken, that this person now has veridical experiences.

To go against this claim, we could say that the second characteristic of perceptual stability (i.e. consistency) urges the person to analyze the current odor to one's overall consistency of odor experiences. If the person has experienced, let's say beef before, and dismisses that this should smell like chicken, then the person themselves does not allow this experience to count as veridical. However, this would be different if the person has simply no prior odor experiences to reflect back to.

Then we might have to say that this person is *experiencing* veridical experiences. The reason is that the perceiver's perceptual apparatus is modified, or to some extent is not functioning as it should. The response is then not to call this a non-veridical experience, but to find ways how the apparatus could be fixed, like investing glasses for short-sightedness. Before the person got glasses, the entire world seemed blurry. But to the person, the blurry visuals also *seemed* like veridical experiences.

3.4 Implications for verification

The implications we have gained from this account of template-matching for olfactory verification are:

First, knowledge and an explanation of how there can be two veridical experiences of the same odor molecule. The important point is that, on the template-matching model, when a person has a different olfactory experience than that of a friend, perhaps even one a bit peculiar, it does not automatically mean that the experience is non-veridical. The previous instance that one has encountered the smell before, and its constellation (i.e. co-occurrence with other stimuli) influences the overall experience that a person has of an odor molecule. So, what it is for an olfactory experience to be veridical is not only a matter of what the odor molecules are but also – in so far as what it is to have an olfactory experience to be partly dependent on template-matching – the particular set of experiences the person has had when encountering those molecules.

Second, a match of patterns is an indicator that a person has encountered a stimulus before. To be made aware of such a possible match, a person's sense of familiarity and recognition of the odor can be measured. As the patterns within templates get more coded (through exposure to the odor and related stimuli), the odor gets more familiar and is easier to recognize in future encounters.

And third, familiarity also increases anchoring of the odor, in the sense that the experience is less influenceable by verbal labeling efforts and could in effect become more consistently of one type when encountering a particularly anchored odor molecule. For instance, when smelling isovaleric acid, I always think of my dirty gym socks (not vomit, or parmesan). This results in sets of experiences regarding an odor, that are evaluated for overall similarity or path-dependency. To

track this, some form of identification of odor would be good and confidence assessments of the perceiver's own evaluation about their performance.

In the above, the first point concerns the nature of veridicality in olfactory experience. However, this is only indirectly related to verification in the sense that it doesn't tell you what verification actually involves. [But it is still important since what verification involves will depend upon what it is for that kind of perceptual experience to be veridical.] In contrast, the second and third points are directly related to verification.

Together these three points provide initial explanations of an account of olfactory verification that satisfies the three desiderata of this thesis. The account allows that there can be two different veridical experiences of the same object, that these can be independently verified, and that the experiences can be evaluated for overall consistency and appropriateness.

Conclusion

At the beginning of this thesis, we were worried about olfactory verification, as one odor molecule could result in so many varying experiences for people. We deemed that experience-related variation should be permitted in olfactory verification but reasoned that we needed a satisfactory account of perceptual stability to act as a limiting factor for what can be considered a veridical experience.

In this thesis, the phenomenon of perceptual stability was described, after which the perceptual constancy model was inspected and whether it could provide a good account of perceptual stability in olfaction. To do this, examples with everyday peculiar experiences in olfaction demonstrated that the perceptual constancy model is not sensitive to the variation that is necessary in olfaction. These cases also clarified expectations that we have towards a satisfactory account of perceptual stability.

Having rejected the perceptual constancy model of perceptual stability, I introduced a second account, the 'template-matching model'. I argue that this model can provide a satisfactory account of perceptual stability. According to the template-matching model, perceptually stable olfactory experiences have two core characteristics: appropriateness and consistency. This means that an olfactory experience is appropriate, if there is a match of patterns between the current and previous instances when the odor molecule is being perceived, and if the current experience fits into an overall set of prior olfactory experiences.

This thesis demonstrates the importance of perceptual stability in the context of olfaction, as this can explain how our olfactory experiences are not random but are path-dependent to previous experiences we have had with odors. This then influences what people think they are experiencing when smelling odors and also what they expect when encountering these in future instances. Ideally, further research into perceptual stability can sharpen our understanding of olfaction as a sense modality, providing the possibility to accommodate these insights into claims of veridicality.

Abstract of thesis

Olfaction refers to our sense of smell and the act or process of smelling. Unlike in vision, perceptual experiences of the same object can vary considerably without one experience being obviously better than any other. In this thesis, I consider whether olfactory experiences can be perceptually stable – where perceptual stability is a limiting factor on such variation.

I first consider the 'perceptual constancy model' of perceptual stability. Examples of everyday peculiar experiences in olfaction demonstrate that the perceptual constancy model is not sensitive to the variation which is necessary in olfaction. I then introduce what I call the 'template-matching model' and argue that this model can provide a satisfactory account of perceptual stability.

According to the template-matching model, perceptually stable olfactory experiences have two core characteristics: appropriateness and consistency. This means that an olfactory experience is appropriate, if there is a match of patterns between the current and previous instances when the odor molecule is being perceived, and if the current experience fits into an overall set of prior olfactory experiences.

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