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Vision, Olfaction, and the Unity of Senses

Analytic papers concerning the content of olfactory experiences commonly start with a statement that olfaction has gained significantly less philosophical attention than vision. While it is certainly true, in recent years philosophers have formulated a significant number of alternative accounts of olfactory content. These positions share two characteristics. First, olfactory experiences are interpreted as representational (Batty 2009; Lycan 2014), i.e. they are not only "modifications of consciousness" but also represent the environment as being in a certain way. Second, olfactory experiences represent odours, like coffee odour or vanilla odour (e.g., Batty 2010b). Despite these two common assumptions, authors disagree how to properly characterise olfactory content. For example, it is claimed that olfaction represents odours instantiated by surrounding space (Batty 2010c), or instantiated by entities that are sources of odours (see Batty 2011; Lycan 2000; Mizrahi 2014 for a discussion), like an onion odour instantiated by an onion. On the other hand, it is postulated that odours are represented not as features of some entities, but rather as objects which themselves possess features and have mereological structure (Carvalho 2014, Young 2016). More generally, there seems to be an ontological controversy between two views: the first states that odours represented by olfaction should be characterised as features and the second states that they should be interpreted as objects.

The above ontological controversy is a difficult one not only because of the internal complexity of the "olfactory content" debate, but also because in philosophical works there are various, competitive notions of what it means to be an object or a feature. In this paper, I aim to systematically address the "feature or object" status of odours represented by human

olfaction, starting from considerations about the visual content. We have a strong intuition that vision represents objects, for example a red square, possessing features like redness and squareness. What is more, a great deal of our intuitions regarding what it means to be an object or a feature is grounded in the way in which entities are visually represented. Hence objects and features represented by vision may be considered as paradigmatic examples of perceptually represented objects and features. Starting from this point one may analyse the characteristics that differentiate objects and features represented by vision. On this basis it may be then investigated whether the entities represented by olfaction possess characteristics that justify including them in the same ontological category as visually represented objects or features. This procedure also allows to reveals whether olfactorily represented odours are *sui generis* entities that differ significantly in their characteristics from visually represented ones.

Such investigations constitute a first step in establishing whether various human modalities are ontologically unified by organising the environment according to the same categories. For example, perhaps all of them represent entities which, in virtue of sharing ontological characteristics, should be named 'objects'. On the other hand, it is possible that human perceptual modalities are dis-unified, as they represent entities which possess significantly differing characteristics.

The paper starts by explicating the notion of "perceptually represented entities" and specifying the type of perceptual experiences I am interested in (section 1). Later (section 2), I present three major types of ontological characteristics that will be used in investigating the ontology of entities represented by vision and olfaction. Subsequently, by using the types of characteristics identified, I compare visually and olfactorily represented objects by (I) investigating whether these entities are subjects or properties (section 3), (II) analysing their mereological structure (section 4), and (III) formulating their identity conditions (section 5). Relying on the results of this analysis (section 6), I argue that olfactorily represented odours

constitute a *sui generis* ontological category which differs from the categories of visually represented objects and features. However, odours and visually represented objects share an important characteristic: they are both *primary subjects*.

1. Entities and Experiences

Before starting to analyse the ontological characteristics of olfactorily and visually represented entities, it is important to clarify two methodological points. First, the entities I want to analyse, and second, the perceptual experiences that are relevant to my investigations.

For the first point, perceptually represented entities should be distinguished from the entities that causally influence the perceptual system (see Young 2016 for a similar distinction in terms of "intentional" and "external" entities). In a typical olfactory experience, it may be represented that there is a vanilla odour in the surroundings, probably because there is a complex chemical mixture that influences olfactory receptors. One can also experience an olfactory hallucination when a vanilla odour is represented without the presence of a corresponding chemical mixture (see Mole 2010). In these examples the vanilla odour is a represented entity, while the chemical mixture is the causally influencing entity. It is important to notice that these entities may have differing ontological characteristics. For instance, the chemical mixture has a complex mereological structure composed of various molecules, but the represented vanilla odour is rather uniform.

In this paper, I am interested in the ontological characteristics of perceptually represented entities and not external entities that causally influence perceptual mechanisms. In other words, I investigate the ontological description of the environment as it is presented through the senses.

The second methodological point concerns the perceptual experiences which I plan to investigate. The olfactory and visual experiences may be understood in two broad ways as (1) multimodal perceptual experiences or as (2) experiences combined with amodal beliefs that are only partially formed on the basis of perceptual experiences. For example, if I see a milk bottle, grab it and sniff to check whether the milk is spoiled, that is a multimodal experience with visual, tactile, and olfactory aspects. When I sense smoke I can form a belief, relying on a perceptual experience together with some additional knowledge, that my neighbour is making a barbecue; this would be an experience associated with a belief only partially formed on the basis of perceptual experiences.

In this paper I do not investigate such broad experiences. The following analyses are restricted to unimodal olfactory and visual experiences with intuitive examples like "feeling a vanilla odour which is sweet and very intense" or "seeing a red square in the centre of visual field". In the case of visual perception, I am concerned with relatively low-level features, like colours and shapes, as there is no agreement within the philosophy of perception about whether human vision represents kinds or causal relations (e.g., Bayne 2009).

2. Ontological Characteristics

Authors working in the field of analytic metaphysics distinguish various ontological categories of entities, like objects, properties (interpreted as universals or tropes), kinds, events, processes and relations, to name the most common ones. A criterion for enlisting an entity as an element of one of the ontological categories is whether this entity satisfy characteristics that are possessed by each member of this category. Within ontological discussions three types of such characteristics seem to be the most relevant.

(1) Relations to other entities

Entities belonging to different ontological category have varying abilities to stand in relation to other entities. Probably the best known philosophical distinction of this kind is that between subjects and properties. It is often claimed that there is an asymmetry of instantiation between the entities characterised as subjects and entities characterised as properties: subjects instantiate properties but not *vice versa* (see Clark 2004a; Matthen 2004 for discussion in the context of vision)[1]. Using the classical example, it seems that Socrates is a subject instantiating a property of "being wise", but "being wise" does not instantiate Socrates. As will be shown later, this distinction is of high relevance in discussions regarding olfactorily represented entities.

(2) Internal structure

Another type of characteristics that may differentiate entities of distinct categories concern their structure. Such characteristics may describe a mereological structure where the fundamental distinction divides atomic entities (i.e. which do not have any parts) from complex ones, or a topological structure which differentiates between entities that may exist while being spatially dispersed, and those which have to be topologically connected (Casati, Varzi 1999).

(3) Identity conditions

The third type of characteristics describe identity conditions both in their synchronic and diachronic aspect. The synchronic identity conditions determine what is necessary and sufficient for an entity x existing at t_1 and entity y also existing at t_1 to be identical. Analogously, diachronic identity conditions characterise such rules for entities existing at different moments. An example of using identity conditions to differentiate between

[1] Later, I use the term „property" to name entities which, unlike subjects, are instantiated by something and the term „feature" to name entities such as colours and shapes. Because of that it cannot be automatically inferred that features are properties.

ontological categories comes from debates about the universal or particular status of properties: strict similarity is sufficient for synchronic identity of universals but not in the case of tropes (i.e. particular properties (Ehring 2011: 40-41)).

In the subsequent sections I argue, referring to the above three types of characteristics, that visually represented objects and visually represented features belong to different ontological categories. Relying on this result, I determine whether olfactorily represented odours belong to the same category as visually represented objects or as visually represented features.

In further examples a red square will serve as a paradigmatic object represented by vision, while a shade of red and squareness will be treated as paradigmatic visually represented features. I do not assume that vision represents only objects and features (and not, for instance, events). In addition, I accept that there may be visually represented entities that are commonly named 'objects' but in fact differ in ontological characteristics from paradigmatic objects like red squares so strongly that they should be interpreted as members of a different category.

3. Relations to Other Entities: Subjects and Properties in Vision and Olfaction

There is a strong intuition that a subject/property distinction differentiates between visually represented objects and visually represented features. It is a red square that posses a shade of red and squareness and not the other way round. However, less obvious is the source of this intuitive asymmetry. For instance, it is not an asymmetry of existential dependence: features represented by vision are always instantiated by something (an object, or sometimes a place (Clark 2004a)), and conversely, objects are not visually represented as featureless. In addition, it is not an asymmetry of uniqueness: a feature may be visually represented as

instantiated by many objects, for example we may perceive several objects of the same shade of red, but a single object is represented as having many features.

I propose that the intuitive subject/property asymmetry in vision should be explicated by referring to the unificatory role of visually represented objects. It is widely accepted that human vision is able to resolve the so-called Many Properties Problem, i.e. it can distinguish between situations of perceiving different arrangements of the same elements (Clark 2004a). For example, a person can easily visually differentiate between a presentation of (1) a red square and a green triangle, and a presentation of (2) a red triangle and a green square. In both cases the represented elements are the same: two objects, redness, greenness, triangularity, and squareness, but they are combined differently. Hence many authors postulate that visual content cannot be characterised as a list of elements, as a single list would serve both of the above situations. On the contrary, content should be described in terms of objects connected with features through an instantiation-like relation (Clark 2004a; Cohen 2004; Keane 2008; Matthen 2004).

While the Many Properties Problem is solved by combining objects with features, these two types of elements do not play the same role. In particular, there is an asymmetry of unification: a single object unifies many features into a perceptual unit, but a single feature does not unify many objects into such a unit. If redness and squareness are combined with the same object, then a red square is represented. It is a perceptual unit which is crucial for perceptual organisation of a visual scene on which further visual processes operates. In particular, a red square (1) can be easily attentively selected what allows for a detailed analysis of its features and spatial structure (Scholl 2001; Qiu and von der Heydt 2005), (2) can be tracked and re-identified despite its movement and changes in features (Pylyshyn 2007; Scholl 2007), and (3) may be combined with other units to become a part of a larger whole (Xu and Singh 2002).

However, a feature does not usually create a perceptual unit from several objects. For example, if a red square is represented on the left side of the visual field and a green square on the right side, these two figures do not compose a single perceptual unit despite being both combined with squareness. First, it is much harder to simultaneously focus attention on two objects "unified" by a common feature than to focus attention on a unit composed of single objects and some features (as in case of a red square, Alvarez and Scholl 2005; Scholl et al. 2001). Second, within a unit unified by a single object, the part-status of one component influences the part-status of other components. For instance, if a square shares an edge with a larger figure X, and so this edge is a part of X, then it is very likely that other edges of the square will also be recognised as parts of X (Palmer and Rock 1994). However, it is not the case with objects "unified" by a single features. Referring to our previous example, if we have two objects "unified" by squareness, then one of them may become a part of a larger figure X, but it is not likely to cause the other object to be also perceived as a part of X. Third, while it is very easy to track changes in a unit unified by a single object, it is much harder to do so when a task involves tracking several objects, even if they share some features. In such cases re-identification errors occur and changes in features are often difficult to notice (Pylyshyn 2007: 37).

Because of the above difference, the intuitive subject/property asymmetry between visually represented objects and visually represented features may be grounded in the unificatory role of objects in creating perceptual units. However, this postulate needs a further specification. First, it seems that visually represented features can also play an unificatory role for other features. For example, a particular shade of red unifies its features like those describing its brightness and saturation. Second, it is not universally true that features cannot

unify objects into perceptual units, since several nearby objects may be perceived as a single perceptual group if they share features such as colour or shape. Third, some philosophers of perception claim that at least in certain cases the unificatory role in solving the Many Properties Problem is served not by objects but by places (Clark 2004a).

Nevertheless, these observations do not undermine the special unificatory role of objects represented by vision. First, while features may unify other features into some type of perceptual units, they themselves, in order to solve the Many Properties Problem, must be unified into perceptual units by objects. This is not the case with objects that unify features without a need to be themselves unified into another perceptual unit. Second, while a feature like colour may unify objects into a perceptual group, such a grouping process operates on already formed perceptual units: figures in which features, with colour among them, are unified by objects. Third, while I argue that objects are subjects in relation to features, I do not claim that they are the only visually represented subjects. It is possible that there are also other entities, for instance places, with the characteristics of subjects.

We may express the crucial difference by stating that objects are *primary subjects* as they create perceptual units without themselves being constituents of perceptual units unified by something else. On the other hand, features create perceptual units only by being constituents of units already unified by something else (mainly objects or places). Because of this asymmetry they may be characterised, when they constitute a perceptual unit together with objects, as *properties* of objects and, due to their limited unificatory abilities, characterised at most as *secondary subjects*.

The above considerations show that visually represented objects have differing ontological characteristics, in terms of relations to other entities, to visually represented features. Now, we can ask whether odours represented by olfaction are, like visually represented objects, the *primary subjects*.

The first question that should be asked is whether olfaction, like vision, is able to solve the Many Properties Problem. Some authors claim that human olfaction has no ability to solve it, mainly due to the rudimentary spatial aspect of olfactory experiences. Probably the best-known argument against olfactory abilities to solve the Many Properties Problem is the air freshener example provided by Clare Batty (2010a). Let's imagine that someone tries to cover a cigarette odour with an air freshener odour and as a result has a perceptual experience in which two odours are represented. Visually, I can perceive two objects in many ways, for example the first object on the left of the second one, or *vice versa*, or one partially overlapping another. However, there seems to be no such variation in olfactory experiences; when we perceive cigarette and air freshener odours we do not discern between a situation in which the cigarette odour is to the right or left of an air freshener odour.

While the above description may be accurate, it focuses too strongly on the contingent way in which the Many Properties Problem is solved by vision. The core ability to solve the Many Properties Problem lies in discriminating situations which contain varying arrangements of the same elements. Vision, due to its rich capability for spatial discrimination, may discern between situations where the same objects are situated in varying positions and it may be the case that olfaction, due to its limitations in representing space, cannot make analogous discriminations in the case of odours. However, it does not follow that there are no other cases of the Many Properties Problem in which olfaction can succeed (see Carvalho 2014 for a similar observation).

In particular, olfaction does not only represent odours but also their various features, such as higher or lower intensities (Morton 2000), hedonic features (Castro and Seeley 2014), and trigeminal features such as irritating or cooling (Laska et al. 1997). Let's consider a rather unfortunate case in which one experiences high-intensity cigarette odour and low-intensity onion odour both quite irritating. It is plausible that this situation can be olfactorily

distinguished from another in which the same elements are represented but the intensities are reversed: low-intensity cigarette odour and high-intensity onion odour both quite irritating. If such situations can be olfactorily distinguished, then as in standard descriptions of the Many Properties Problem, the olfactory content cannot be characterised as a list of elements: cigarette odour, onion odour, low-intensity, high-intensity, and irritating, because such a list applies to both situations. The content should be described in terms of odours-intensities-trigeminal features combinations.

Some authors believe (see Batty 2014) that the odour perception does not involve combining features with odours, rather odours are recognised as exemplars of categories and their features follow from this categorisation. For instance, if an odour is categorised as vanilla, then it follows that it has a feature of being sweet. However, the above example shows that this is not universally the case. In fact, the intensity-features seem to be particularly well suited to constructing olfactory examples of the Many Properties Problem. This is evidenced through cases of anosmia, where people can perceive intensities of odours without representing their qualitative character (Morton 2000). It suggests that the intensity-features and qualitative-features of odours are represented separately and that the task of the perceptual system is to unify them within a more complex representation. Other plausible examples involve hedonic features that may change with experience and trigeminal features that are processed by a different physiological mechanism to the one that processes features like sweetness.

Furthermore, the above example of solving the Many Properties Problem in olfaction reveals an asymmetry of unification between odours and other elements of olfactory content. A combination of an odour with features seems to form a perceptual unit and in both of the above situations two such units can be distinguished: one corresponding to the onion odour with its features and other to the cigarette odour with its features. This conviction is supported

by the fact that we are able to attentively chose each of the represented odours in order to analyse their features and structure (Gottfried 2010: 638). Further, we can track the selected odour despite changes in its features, for instance, as it becomes more or less intense (Richardson 2013). This suggests that odours, similar to visually represented objects, create perceptual units.

However, the reverse does not hold. Onion and cigarette odours do not form a single perceptual unit unified by a trigeminal feature despite the fact that they are both irritating. Analogously for other olfactory features, the fact that two represented odours have a common feature of "being sweet" or "being unpleasant" does not seem to cause that they form a perceptual unit. This intuitive conviction is supported by the presence of figure/ground discrimination in olfaction. It is claimed that cases of representing two odours are situations in which one odour is discriminated against the background constituted by another odour (Batty 2010a; Gottfried 2010; Young 2016). However, figure/ground discrimination phenomena occur not within one, but between two competing perceptual units. Hence one cannot simultaneously attentively select two odours "unified" by a common feature, since focusing on one odour causes the second odour to be perceived as an unattended ground. Analogously, tracking one odour to recognise changes in its features makes the second odour unattended and it is likely that changes in its features will not be registered. It suggests that when two odours are represented, then each one, together with its features, constitutes a separate perceptual unit.

Taking into account the above observations, odours can be characterised as subject of features analogously to visually represented objects. However, one may doubt whether odours satisfy conditions for being *primary subjects*. Such a status of odours is controversial as some positions state that olfaction represents odours as instantiated by the space around us or by entities that are sources of odours (see Batty 2010c for discussion). This may justify a claim

that while odours bind features into perceptual units, they themselves are constituents of units unified by something else.

I believe that the idea of "odours instantiated by space" is unjustified mainly because space around us does not usually unify olfactorily represented entities. If an entity is a subject of odours, then it should have an ability to be combined with more than one odour and, at least in usual circumstances, unify these odours into a perceptual unit. As stated earlier, human olfaction has limited abilities to make spatial discriminations. Olfactory experiences dispose us to actions, like sniffing to feel an odour more strongly or waving our hands in front of our face to reduce an unpleasant odour, which suggests that odours are represented with a spatial characteristic of being around us (Richardson 2013).

However, unlike visual objects, odours are not represented with precise spatial localisation or spatial boundaries. Hence odours represented simultaneously often seem to have similar spatial characteristics, and in fact, according to positions which characterise odours as instantiated by places, they are assumed to be instantiated by a single place "somewhere around" (Batty 2010c). If such a place is interpreted as a subject of odours, then in a typical olfactory experience representing two odours, a single perceptual unit composed of both odours unified by a place is represented. However, this is not the case, since the presence of figure/ground discrimination phenomena shows that in typical olfactory experiences odours are treated as separate, competing units despite having the same localisation "somewhere around".

According to the second idea, the olfactory *primary subjects* are not odours but their sources. There is no consensus that olfaction represents sources, and philosophers have offered several arguments against this idea (e.g., Batty 2010b). First, the phenomenal character of unimodal olfactory experiences does not suggest that anything else beyond odours and their features are represented. Second, it is commonly the case that an odour is

perceived long after its source is gone. Because perceptual content is commonly understood as determining accuracy conditions of experiences (e.g., Siegel 2010), a perceptual experience representing the source of an odour would be inaccurate if the source was no longer present. However, it is implausible to interpret such cases as olfactory illusions.

I believe that even if such arguments are unsuccessful and olfaction indeed represents the odours' sources, there is still no justification for interpreting them as subjects of odours. In this case, in every olfactory experience, two types of elements are represented: an odour and a source. Olfaction can recognize the number of odours by processing input to olfactory receptors similarly to vision that can recognize the number of objects by processing information gathered on retinas. However, human olfaction cannot recognize the number of sources independently from recognizing the number of odours as there is no causal influence from a source, let's say an onion, to an olfactory system apart from detecting certain chemical compounds in the surrounding space. It is rather the case that the number of sources is inferred from the represented number of odours.

From this perspective, let's consider two situations: (1) two separate perceptual units are represented: a chocolate odour and an orange odour, and (2) where one perceptual unit is represented: a complex chocolate-orange odour formed by unifying separate odours from situation (1). If sources are the subjects of odours, then in (1) there should be two represented sources, but only one source in (2). However, because olfaction represents the number of sources by inferring from the represented number of odours, sources do not unify perceptual units, but are attributed to already recognised perceptual units. In situation (1), two perceptual units are represented and the presence of two sources is inferred. In contrast, in situation (2), two simple odours are unified into one complex perceptual unit, probably due to an activation of a previously learned chocolate-orange odour category (Batty 2014; Wilson and Stevenson 2003), and as an effect a single source is represented. In this interpretation, while sources are

represented and their number corresponds to the number of represented odours, they do not play any unificatory role.

The above considerations show that olfactorily represented odours are *primary subjects* just like objects that are represented by vision. This supports a hypothesis that odours should be interpreted as belonging to the same category as visually represented objects and not as visually represented features. In the next sections, I judge whether this verdict is also supported by considerations regarding the internal structure and identity condition of odours.

4. Internal Structure: Mereology of Vision and Olfaction

In the previous section, I have expressed an intuition that visually represented objects seem to be subjects of features represented by vision. The second, equally strong intuition is that visually represented objects not only possess features but also have parts.

Simple visually represented objects may become parts of more complex ones, particularly when they are spatially connected (Palmer and Rock 1994). For example, it is likely that when two squares connected by sides, one red and one green, are represented, then a more complex, rectangular figure composed of these two squares is also represented. Components of this figure have features that differ from the whole: they differ in shape, size, and colour as they are wholly green or wholly red which is not the case in the complex figure. Furthermore, simpler objects still maintain their status of two separate objects after being combined into a more complex entity. In the above example we can focus attention on each of the two squares or track changes in their features independently of one another. Generally speaking, there exist complex visually represented objects, whose components are simpler visually represented objects having differing features to the whole they compose.

Considering above observations we may ask whether visually represented features also have parts. Specifically, we may ask whether visually represented features can have feature-components with characteristics distinct from those of a whole they compose.

If we choose a shade of red as a paradigmatic example of a visually represented feature, then it seems that the above hypothesis is false. Within a shade of red we are unable to distinguish feature-components that have different characteristics, like hue, brightness, or saturation, to the considered colour. Furthermore, there is no visual process which combines two colours into another, more complex colour in which the initial, simpler colours can still be distinguished as separate elements maintaining their characteristics from before the combining. For example, combining a shade of red with a shade of yellow will produce a shade of orange which has characteristics that makes it similar both to redness and yellowness, but these colours are not perceived as two separate components of orange.

On the other hand, the result will probably be different if one takes squareness as an example of a visually represented feature. The feature of squareness seems to be composed of several other features, for instance describing orientation of edges or angles at which edges meet. One of these orientation-features may be "verticality" or "horizontality" but the squareness itself is not horizontal or vertical. In addition, shape-features may be visually combined into more complex shapes while still maintaining their status as separate entities. For instance, by combining squareness with triangularity a house-like shape can be obtained. In such a shape its square component and triangular component can still be easily distinguished, and have different characteristics to the house-like whole (like "having four edges" and "having three edges" in contrast to "having six edges" as displayed by the whole shape).

So the category of visually represented features is not uniform in respect of internal structure. There are types of features (e.g., shape) that, like visually represented objects, can

be combined into a whole, while preserving their status of separate entities. However, some types of features (e.g., colour) cannot be combined into part-discernible wholes. Considering these observations we may ask whether odours are mereologically more like objects or features represented by vision.

It is commonly claimed that olfactory perception is more 'synthetic' than 'analytic' (e.g., Barwich 2014; Wilson and Stevenson 2003), meaning that olfactory experiences do not reflect the complexity of chemical mixtures influencing the olfactory receptors, but represent homogenous odours. An example from psychological literature is the lemon odour which does not seem to have any internal structure. However, some odours, like the one arising from being presented with pyridine and lavender mixture (both examples from Lawless 1997: 141-142), seem to be composed of two odours, each with individual features (e.g., one component may be more sweet or pleasant than the whole). Therefore one may suppose that odours are mereologically more like visually represented features than visually represented objects. In respect of their internal structure the category of odours in not uniform. It seems that some combinations of odours result in representing a new uniform odour (like in case of a visual mixture of yellow and red), and other combinations result in a complex odour with the initial odours as parts (analogous to combining squareness and triangularity into a house-like shape).

However, the mereology of odours has some peculiar features which suggest that the their internal structure is significantly different from the structures of both objects and features that are represented by vision. The empirical investigations show that while people can perceive some odours as having odour-components with features different to the whole complex odour, this ability is limited in the number of odour-parts that can be distinguished. For instance (Jinks and Liang 1999; Laing and Francis 1989; Livermore and Liang 1998), when a complex odour composed of several simpler ones (like strawberry, lavender, honey etc.) is represented, 90% of participants can distinguish no more than four of its odour-parts.

These components have different features to the whole complex odour in the same analogue way that red and green squares have different features to the rectangle they compose. For instance, a red square is wholly red, and that is not true about the rectangle. Similarly, a honey component of a complex odour is wholly honey-like, which is not true about the complex odour.

Particularly interesting, is that such odour-parts do not seem to exhaust the qualitative character of the complex odour. For instance (Laing and Francis 1989: 813), people perceive that the qualitative character of a multi-component odour is not reducible to the combination of its three or four odour-parts that a person can distinguish. Using the synthetic/analytic opposition, it can be stated that complex odours are analysed as having several parts but they are also synthetic wholes which cannot be reduced to the combination of their parts. This has important consequences for olfactory mereology.

Classical mereological conceptions characterize parthood-relation as reflexive, antisymmetric, and transitive. What is more, they accept two common-sense rules knows as *weak supplementation principle* and *strong supplementation principle* (Casati and Varzi 1999: 38-39). In intuitive terms, *weak supplementation principle* states than an entity cannot have only one proper part, i.e. a part that is not identical with the whole object[2]. According to the *strong supplementation principle*, if an entity *x* is not a part of entity *y*, then *x* has not exactly the same parts as *y*[3]. These supplementation principles seem to be satisfied by visually represented objects and those visually represented features that can be plausibly described as having parts. In fact, it seems even senseless to speak about objects represented by vision that have only one proper part, like a red square whose only proper part would be its bottom edge,

[2] More precisely: if *x* is a proper part of *y*, then there is *z* such that *z* is a part of *y* and *z* does not have any common part with *x*.

[3] More precisely: if *y* is not a part of *x*, then there is *z* such that *z* is a part of *y* and *z* does not have any common part with *x*.

or a complex feature like house-shape whose only part would be triangularity. Similarly, if a visually represented object or a shape-feature is not a part of another object or feature, then the part-structure of these objects or features has to be distinct. For instance, it seems impossible to visually represent a spatially separated red square and a green square having exactly the same edges.

On the other hand, it is likely that the mereology of odours is non-classical as it does not satisfy any of the supplementation principles. Sometimes a person can identify only one odour-component of a complex odour (Livermore and Liang 1998: 655). In such a case olfaction represents an odour which has exactly one part, which is a proper one as it is not identical to the whole odour. For instance, a person may be able to distinguish only a honey-component in a mixture composed of several odorants while this mixture is not perceived as identical to the honey-odour. This result falsifies *weak supplementation principle* by showing the possibility of odours having only one proper part[4].

Further, because distinguished odour-components do not exhaust the qualitative character of a complex odour, it seems possible to represent two odours, neither of which is a part of another, as having exactly the same parts. For instance, let's assume that there are four chemicals, numbered *1*, *2*, *3*, and *4*, that give rise to experiences of simple, partless odours. Combining these chemicals leads to experiences of complex odours in which some odour-parts can be distinguished. However, as shown in empirical studies (Livermore and Liang 1998), in some cases a person can distinguish less than four odour-components while representing a complex odour. Therefore we cannot refute the possibility of a person being presented with both mixtures *{1, 2, 3}* and *{1, 2, 4}* but being able to distinguish only odour-components corresponding to chemical *1* and *2* regardless of whether she focuses on

[4] In fact, it also falsifies the *strong supplementation principle* as the *weak supplementation principle* is entailed by the strong one (Casati and Varzi 1999: 38-39).

combination *{1, 2, 3}* or *{1, 2, 4}*. Nevertheless, the joint presentation of *{1, 2, 3}* and *{1, 2, 4}* gives rise to the experience of two qualitatively different odours, reflecting a difference in their chemical composition. This possibility is inconsistent with the *strong supplementation principle* as olfaction simultaneously represents two distinct odours which both have the same parts.

The above observations suggest that the internal structure of odours represented by human olfaction is significantly different from that of visually represented objects and features. While objects and features represented by vision satisfy the basic principles of classical mereology, this is not the case with odours, whose mereology is not a classical one, since it does not satisfy the supplementation principles.

5. Identity Conditions: Essential Characteristics and Continuity

The investigations concerning the identity conditions have two aspects. First, is the question of the synchronic identity condition which is answered by providing an identity criterion for entities that exist at the same moment. Second, is the question of the diachronic identity conditions which, by analogy, can be answered by specifying an identity criterion for entities existing at different moments. Below, I begin by discussing synchronic, and then diachronic identity conditions for visually represented objects and features as well as for olfactorily represented odours.

5.1 Synchronic identity

Human vision can represent several objects that share features. For instance, one may simultaneously perceive two red squares of the same size, so a synchronic identity criterion

for visually represented objects cannot be formulated in terms of having the same colour, size, shape etc. However, it seems that two squares cannot be represented as having the same localisation, as a representation of such a perfect overlap would not be visually different from a representation of a single square.

Nevertheless, some authors doubt that two objects located at the same place cannot be visually represented. The provided examples include semi-transparent, overlapping gabor-patches (Pylyshyn 2007: 40-42), colourful mists that mix with each other (Cohen 2004), or moving objects whose trajectories intersect, so that are momentarily at exactly at the same place (like in well-known ambiguous streaming/bouncing stimuli, Sekuler and Sekuler 1999). On the other hand, there are reasons to believe that such examples do not constitute genuine cases of representing two objects at exactly same location (Clark 2004b), as they may be described in terms of objects whose locations partially overlap or which are positioned in the same direction but at differing distances from the observer.

However, if there are indeed cases in which two objects are represented as being at the same place, then a different characterisation of objects' synchronic identity conditions has to be adopted. In this case it is possible to visually represent two objects sharing both features describing location, and those describing visual qualities like colour or shape. In order to properly formulate a synchronic identity criterion for visually represented objects it has to be postulated, as in philosophical theories of "thisness" (see Adams 1979), special identifying features whose only function is to individuate objects. According to this view, vision represents objects not only as having locations, colour, shapes, etc., but also as having a feature similar to "being the object A" or "being the object B" (numerically different from A). In fact, some psychological theories postulate mechanisms, like visual indices or object-files (Kahneman et al. 1992; Pylyshyn 2007), whose function is to individuate objects without representing their qualitative features.

I do not attempt to resolve the above controversy. It is more important in the context of this paper that both the above positions share an important property. According to the first position, having the same location is the necessary and sufficient identity condition for the objects represented by vision. The proponents of the second position believe that sharing the location is not sufficient for identity; visually represented objects are identical if and only if they have the same identifying feature. Therefore we can state that according to both of the above theories visually represented objects are synchronically individuated by a *unitary individuator*, because there is a single feature whose sameness constitutes the synchronic identity criterion. I believe that no characteristic has such a distinguished individuatory role in the case of visually represented features.

A visually represented feature like a shade of colour has characteristics describing its hue, brightness, and saturation. Sharing some of these characteristics is not enough for visually represented features to be identical, as they may be shared by multiple colours, for instance by a shade of red and a shade of green with the same brightness. However, sharing all of these characteristics seems to constitute a necessary and sufficient condition for synchronic identity. If we are comparing a colour-feature F and a colour-feature G, then F and G would be the same feature if hue, brightness, and saturation were all the same in both colour features. The same is true about shape-features like squareness. Sharing a single characteristic, for example describing the number of edges or connections between them, does not guarantee that one shape is the same as another, but sharing all such characteristics seems to entail synchronic identity.

In addition, having the same localisation is not sufficient for the synchronic identity of visually represented features, since two features can be represented as being in the same place, for example a colour and a texture. Minimally, to formulate a proper synchronic identity criterion, two characteristics have to be taken into account: localisation and a

characteristic specifying the feature-type. For instance, vision does not represent two colour-type features, like a shade of green and a shade of red, at exactly the same place.

It seems that there are two approaches to characterising synchronic identity conditions of visually represented features. The first relies on the identity of all qualitative characteristics and the second is based on the identity of the location plus a characteristic describing the feature-type. However, none of these approaches characterises visually represented features as having a *unitary individuator* as there is no single characteristic whose sameness solely constitutes the synchronic identity criterion of features.

Below, I argue that the synchronic identity conditions of odours represented by human olfaction have the same general properties as the synchronic identity conditions of visually represented features, i.e. odours do not have *unitary individuators*.

In the previous sections, I pointed out that olfaction represents various types of features, such as the intensity-features, trigeminal-features, hedonic-features, or qualitative features like sweetness. However, it seems that there is no single feature that guarantees the identity of odours. For instance, one may perceive two sweet odours, two irritating odours, or two odours of the similar intensity. In addition, the sameness of location is not sufficient for the identity of odours, because due to the limited abilities of olfactory representations of space, the common case is that two odours are represented in the same general place, i.e. "around us" (Batty 2010c). On the other hand, it would be too strong to postulate that the synchronic identity of odours demands the sameness of all features. For example, it is not likely that odours can be perceived as distinct while differing only in their intensity.

Such intuitive observations suggest that the synchronic identity criterion of odours should be formulated in terms of similarity, where higher similarity is correlated with a higher number of shared features. In fact, while the number of odours that the human olfaction can distinguish is a matter of debate, it is established that there is a correlation between the

overlap of compounds in chemical mixtures and the ability to cause indistinguishable olfactory experiences (Gerkin and Castro 2015; Bushdid et al. 2014). This suggests that the synchronic identity conditions of odours are connected with the similarity of their features, because similarity in the composition of chemical mixtures is likely to be correlated with the ability to cause perception of similar olfactory features. In this case an odour O_1 is identical to an odour O_2 if and only if O_1 shares a sufficient number of features with O_2, where 'sufficient' is a matter of detailed empirical investigations. In other words, there are no cases in which two odours are simultaneously represented while exceeding some level of similarity. Given such a similarity-based criterion, odours cannot be characterised as having a *unitary individuator* as they are not individuated by a single element but by sharing a certain number of features.

5.2 Diachronic identity

The topic of how human vision represents the diachronic identity of objects is well investigated within cognitive psychology. The main research paradigms are (1) Multiple Object Tracking in which participants track and re-identify several moving target-objects among distractors (see Pylyshyn 2007) and (2) Object-Specific Preview Benefit where the task is to recognise whether one of the objects presented later has the same feature as an object presented earlier (see Kahneman et al. 1992). The theoretical assumption behind these paradigms is that factors which make the re-identification of objects harder or which make the time needed to find the common feature of objects longer, are likely to break the represented diachronic identity. Measuring rates of errors and reaction times, rather than participants' verbal reports about perceived identities, allows the investigation of how sameness is

established by a low-level, perceptual mechanism without the changes introduced by higher-level beliefs.

The psychological investigations resulted in a widely held consensus that vision represents objects as being diachronically the same, as long as they move in a spatiotemporally continuous fashion and maintain spatial coherence (Scholl 2007). This means that diachronic identity stops being visually represented when objects, *inter alia*, do not move continuously but "jump" between places, or disappear for a long period of time[5]. Similarly, diachronic identity breaks when objects undergo topological changes like dividing into fragments or even if a hole is added to an object, as such changes disrupt spatial cohesion (van Marle and Scholl 2003; Zhou et al. 2010). Changes, for example in colour or topology-preserving shape changes, are claimed to be contingent for diachronic sameness (Pylyshyn 2007: 37).

The scientific results suggest that the diachronic identity criterion for visually represented objects should be formulated both in terms of some of the object's features and a relation of spatiotemporal continuity. There are topology-related features, whose change leads to the object after the change not being represented the same as the object before the change, but there are also changes in features which do not break identity. Using classical metaphysical terminology, we can name these features essential and contingent respectively. However, sharing essential features is not sufficient for objects to be diachronically identical as they also have to stand in a spatiotemporal continuity relation. So we can state that an object *x* is diachronically identical to an object *y* if and only if *x* has the same essential features as *y* and *x* is continuous with *y*.

[5] The only exceptions are cases of brief occlusion where the contours of an object are gradually deleted and then gradually reappear. Such deviations from spatiotemporal continuity do not break the sameness of objects (Scholl 2007)

The division between essential and contingent features seems to be also applicable to visually represented features. For instance, colours represented in subsequent moments are not recognised as being the same if they differ in hue. However, a feature is recognised as the same even if it changes its localisation through time. What differentiates visually represented objects and visually represented features in regard of diachronic identity is the role of continuity relations.

The disturbances of continuity are likely to break the diachronic identity between objects but this is not the case for visually represented features. Let's consider a situation in which one perceives a square object at place P_1 which is then suddenly replaced by a triangular object at place P_2, which in turn is replaced by a square object at place P_3. I believe that there is a strong intuition that the shape of the earliest object will be recognised as the same as the shape of the last object. This is the case despite the lack temporal continuity as there is a gap between the presentation of the first and the second square object, a lack of spatial continuity since objects appear in disjointed places, and a lack of 'qualitative continuity' as shapes of objects do not change gradually. Therefore a diachronic identity criterion for visually represented features may be formulated solely in terms of essential features, without a reference to continuity relations.

Analogously as in case of synchronic individuation, diachronic identity conditions of odours seem to be more like those of visually represented features than visually represented objects. Within features possessed by odours represented by human olfaction we can also draw a distinction between essential and contingent ones. For instance, we can track an odour and recognise it as being the same despite changes in its intensity (Richardson 2013). However, categorisation-features of odours are essential. If at one time an odour categorised as coffee is represented and at a subsequent moment an odour categorised as vanilla is represented, then these odours will not be recognised as diachronically identical.

The presence of a distinction between contingent and essential characteristics is applicable to odours, visually represented objects, and to visually represented features. Nevertheless, it seems that the continuity relations are far less important for formulating a diachronic identity criterion for odours than is the case where objects represented by vision are concerned. Similarly, as in the case of visually represented features, one can easily imagine a situation of first being presented with a coffee odour which then suddenly disappears and after an odourless period a coffee odour with the same features is presented again. As in the case of visually represented features, such a situation is likely to be recognised as two occurrences of the same odour despite a lack of temporal and qualitative continuity.

In fact, the difference between the importance of continuity in vision and olfaction is well justified by differences in the properties of entities that cause visual and olfactory experiences. Human vision is suited to tracking solid objects with quite well-defined boundaries which move along continuous trajectories. Conversely, olfaction reacts to chemical combinations whose boundaries are vague, can easily mix with other combinations, and may change their condensation in rather unpredictable ways due to various environmental factors. In such circumstances, particularly given the very limited abilities of human olfaction to represent space, it is more reliable to re-identify odours referring to their features than to patterns of continuity relations.

6. Objects, features, and odours

The above investigations clearly show that visually represented objects and visually represented features differ significantly in their ontological characteristics and can be plausibly treated as belonging to different categories of entities. Objects represented by

human vision: (1) are *primary subjects*, (2) at least some of them are complex objects having parts, (3) have *unitary synchronic individuators*, and (4) not only essential characteristics but also continuity relations are crucial for their diachronic identity. Conversely, concerning visually represented features: (1) they are at most *secondary subjects*, (2) there are feature-types to which only partless features belong, (3) they are synchronically individuated by combinations of characteristics, and (4) the diachronic identity condition of features can be formulated solely in terms of essential characteristics without invoking the notion of continuity.

It is also not difficult to notice that olfactorily represented odours cannot be easily interpreted as belonging to the same category as visually represented objects or visually represented features. Odours (1) are *primary subjects* just as visually represented objects, (2) they posses non-classical mereological structure what significantly differs them from both visually represented objects and features, (3) just like visually represented features, they do not have *unique individuators* and (4) their diachronic identity criterion can be formulated without ascribing a significant role to continuity relations. To sum up, odours share the status of subjects with visually represented objects, but are individuated in a way similar to that of visually represented features, and have original, non-classical mereology.

Given the above results it is not surprising that there is an ongoing controversy about interpreting olfactorily represented odours as objects or as features. They share some, but not all, characteristics with paradigmatic perceptually represented entities, i.e. objects and features represented by vision. Therefore one should postulate that odours represented by human olfaction constitute a third ontological category which is different both from the category of visually represented objects and from the category of visually represented features. In this sense, human vision and human olfaction are dis-unified as they represent entities with significantly differing ontological characteristics.

However, this disunity is not complete. In particular, both vision and olfaction represent entities that allow for forming perceptual units by being *primary subjects*. It is worth noting that these common ontological characteristics of visually represented objects and olfactorily represented odours are achieved despite the fact that only vision has an extensive ability to represent space.

The above results pose a question concerning the ontological unity of all human perceptual modalities. Further investigations may reveal that entities represented by other senses, like auditorily represented sounds, gustatorily represented flavours, or tactilely represented objects, should also be characterised as *primary subjects*. Furthermore, one can also investigate whether, and to what extent, vision or olfaction are ontologically unique in relation to other human perceptual modalities. For instance, one may ask if the classical mereology of vision is a standard among senses or constitutes an exception, since the mereology of entities represented by other modalities is more like the mereology of odours.

6. Conclusions

The analysis of ontological characteristics possessed by olfactorily represented odours shows that that they constitute a different category of entities to objects and features represented by vision. This suggests that in the debate concerning object or feature status of odours both alternatives are false as odours differ significantly from paradigmatic, visually represented features and objects. However, the ontologies of human vision and human olfaction are not completely different as both these modalities represent entities that are *primary subjects*. The question for further investigations is whether this common aspect ontologically unifies all human senses.

7. References

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