



Common Structure of Vision and Olfaction

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Abstract

According to a common opinion, human olfactory experiences are significantly different from human visual experiences. For instance, olfaction seems to have only rudimentary abilities to represent space; it is not clear whether olfactory experiences have any mereological structure; and while vision presents the world in terms of objects, it is a matter of debate whether there are olfactory object-representations. This paper argues that despite these differences visual and olfactory experiences share a hierarchical subject/property structure. Within this structure, olfactorily experienced odours and visual objects have the same status: they are primary subjects which unify other represented elements into perceptual units.

Keywords Olfaction · Vision · Perception · Content · Subject · Property

Perceptual experiences not only present certain entities but also present them in a certain way, specific for a given modality. For instance, a characteristic of vision is to present objects as positioned within a coherent, three-dimensional spatial field (Richardson 2013) and establish diachronic sameness of objects by relying on relations of spatiotemporal continuity (Scholl 2007). On the other hand, it is likely that audition does not present entities as located within a spatial field but merely as position in spatial directions, and in determining diachronic sameness it relies more on nonspatial factors such as differences in pitch (O’Callaghan 2008). Even in cases when the numerically same entity is perceptually presented by distinct senses, it may be presented in distinct ways connected with the functioning of each modality. For example, while vision and touch may represent the same object, such as a circle, it seems that each of these modalities present the circle in a structurally distinct way as, for instance, the tacitly presented circle does not seem to be experienced as positioned in a bounded space such as visual field (Martin 1992). Generally speaking, experiences related to distinct modalities have specific structures determined by, inter alia, characteristics of a

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spatiotemporal framework in which presented entities are positioned, rules governing the way in which simple entities are presented as constituting more complex ones, and principles used in establishing synchronic and diachronic sameness between presented elements.

The contemporary philosophical considerations regarding structures of olfactory experiences have been characterized by a suspicion of the “visuocentric” approach, according to which, vision provides a model for all human perceptual experiences (see Kubovy and van Vankelburg 2001; O’Callaghan 2012). In consequence, there are many works focusing on differences between structural aspects of olfactory experiences and other types of perceptual experiences, such as visual ones. For instance, while there are debates concerning the specific character of olfactory space, it is generally agreed that olfaction does not present entities as positioned within a topologically connected spatial field analogous to the visual field (see Aasen 2019; Batty 2010b; Keller 2011; Richardson 2013; Young 2020 for details of alternative approaches). Further differences concern mereological structure as it is not obvious whether olfaction presents entities as composed of proper parts (see Mizrahi 2014 for arguments against olfactory mereology, and Skrzypulec 2019 for a thesis that such mereology is nonclassical). Similarly, it has been proposed that olfactory modalities operate within longer temporal frames than visual modality (Young 2020) and that in olfaction, unlike in vision, object categorization may occur without object individuation (Batty 2014). Finally, while usual visual experiences are not pleasurable or unpleasurable in any significant way, the olfactory experiences have a strong evaluative aspect (Keller 2016, pp. 123–128).

However, in contrary to a general tendency to focus on differences between vision and audition, I aim to argue that there is a significant structural similarity between olfactory and visual experiences. More precisely, I claim that human visual and olfactory experiences share a common subject/property structure. To express this claim, I propose a category of *primary subject* which contains entities that are subjects of properties without simultaneously being properties of some other subjects. I argue that odors are perceptually presented as *primary subjects* and that they play the same role in organizing olfactory experiences that visual objects play in the case of visual experiences. This role consists in unifying other experienced elements into perceptual units without the need to be a component of a perceptual unit unified by some other element.

The question concerning whether odors are experienced as subjects of properties is closely related, but not identical, to a debate about olfactory experiences and whether they present the environment in terms of objects (see Carvalho 2014; Stevenson 2014; Millar 2019; Young 2016 for arguments in favor of this view and Barwich 2019; Batty 2010a; Keller 2016; Lycan 2000 for arguments against). This close relation occurs because being a subject of properties is considered as one of the characteristics necessary for objecthood, so if odors are represented as subjects, this strengthens the thesis that they are represented as objects. Despite this close connection, the considerations presented in this paper do not merely restate, from a different perspective, the theses and arguments already presented in debates concerning olfactory objecthood. First, while authors arguing in favor of the thesis that odors are represented as objects often claim that they are experienced as subjects of properties, it is rather assumed and not argued for. Instead, the argumentation focuses on other indicators of objecthood such as ability of diachronic persistence, possession of mereological structure, or presence of olfactory figure/ground organization (in particular, see Millar 2019;

Stevenson 2014; Young 2016). In contrast, I provide arguments specifically aimed to justify the experiential subject-status of odors. Second, the thesis that odors are represented as subjects of properties is usually stated simply by referring to intuitions, without investigating what it means to be a subject in the perceptual context and whether the same notion of ‘subject’ is applicable both to olfactorily presented odors and to visually presented objects. Furthermore, the fact that an entity is represented as instantiating properties does not mean that it is not itself represented as a property; there are properties which themselves may instantiate some second-order properties. On the contrary, I propose a precise notion of *primary subject* and show that the same notion is applicable both to odors and visual objects. Third, there are authors who believe that olfactory experiences have subject/property structure, yet they treat odors not as subject but as properties instantiated by surrounding space (Batty 2010b, 2011) or by objects that are sources of odors (Mole 2010; Todd 2018). In opposition to such views, I present arguments showing that odors are the best candidates for olfactory *primary subjects*.

The paper starts by introducing the formal characteristics of subjects and *primary subjects* (Section 1). Subsequently, it is argued that vision presents objects as *primary subjects* (Section 2) and also that olfaction presents odors as *primary subjects* (-Section 3). Finally, in Section 4, I compare the subject/property structures of vision and olfaction and show that there are significant similarities between them.

1 The Subject/Property Distinction

Before deciding whether both odors and objects are perceptually presented as *primary subjects*, we need to investigate what it means to be a subject. In order to do so, I formulate a definition of *primary subjects* relying on intuitions present in metaphysical works concerning the distinction between subjects which instantiate properties, and properties which are instantiated by subjects (see Orilla and Swoyer 2020 for a review). This allows the development of a formal characteristic of *primary subjects* which can be applied to various types of entities. In consequence, the proposed definition does not presuppose that it is satisfied by odors or visual objects, by both, or by neither. Relying on such neutral characterization, I further argue that both visual objects and odors are experienced as subjects in the same sense as they satisfy the same notion of *primary subjects*.

Philosophical intuitions concerning the subject/property distinction come from investigations regarding states of affairs such as *ball is red*. It is assumed that *ball* is a subject instantiating the property of *being red*. Analyzing such examples can give an insight into the most important characteristics of subjects.

First, it is easy to notice that a single subject such as *ball* can simultaneously possess many properties. For instance, it is not only the case that *ball is red*, but also that *ball is big*. Hence, we may assume that an important characteristic of a subject is that it is possible for it to simultaneously instantiate more than one property.

Second, the connection between a subject and properties is asymmetric. *Ball* instantiates redness, but redness does not have *ball* as its property. Generally speaking, if S instantiates F, then F does not instantiate S. In consequence, entities combined by a symmetric tie are not candidates for standing in a subject/property relationship (or at least not in respect to standing in this symmetric relation).

Third, subjects unify possessed properties into a single entity. The result of such unification is a complex being that is constituted by a subject and all its properties. If *ball is red* and *ball is big*, then there is an entity that is red and big. On the other hand, properties do not have an analogous unificatory power, as a single property does not unify several subjects into a single being. For instance, from the facts *ball is red* and *table is red*, it does not follow that there is an entity constituted by *ball*, *table*, and the property of redness that is shared by both objects. Relying on this observation, we may specify that the asymmetry occurring between a subject and properties is an asymmetry of unification. A subject unifies all instantiated properties into a single, complex entity, but the converse does not hold: a property does not unify subjects instantiating this property.

Finally, unifying and being unified does not seem to be contingent for subjects and properties. There are no free-floating *being red* or *being big* properties that are not instantiated by any subject (like an object or a place).¹ Analogously, a subject like *ball* cannot be propertyless, but is always related to some properties and unifies them.²

The above characteristics of subjects allow for a situation in which the elements of a category *S* are subjects of entities belonging to a category *P*, but are themselves properties of entities belonging to some other category *G*. In other words, the definition makes it possible for some entities to be both subjects and properties. For example, one may postulate that while *being red* is a property of *ball*, it itself is a subject of a property *being a color*. Given this, a notion of *primary subject* can be introduced which describes subjects that are not properties of anything:

(PRIME) *Entities belonging to a category S are primary subjects if and only if.*

(a) *they are subjects, and.*

(b) *there is no category such that its members are subjects of entities belonging to S.*

The *primary subjects* play a special unificatory role. This is because they unify some other entities, i.e. their properties, into complex beings, but do not themselves need to constitute complex entities unified by something else. As a result, they serve as a foundation on which complex entities are created from simpler elements. It should be noted that, despite what the example with *ball* may suggest, the above characterizations do not entail that a subject has to fall under a concept expressing a natural (or artificial) kind.

Subsequently, I show that the above formal characteristics of subjects can be applied, after certain additional interpretations, to objects considered with respect to how they are visually experienced and odors considered with respect to how they are olfactorily experienced. In particular, I argue that both objects and odors are perceptually presented as *primary subjects*.

¹ This seems to be the dominant view among philosophers investigating the nature of properties (see Armstrong 1978, pp. 64–77; Levinson 2006; Schaffer 2001).

² Even proponents of the so-called metaphysical “bare substrata” do not claim that subjects can exist unrelated to any properties. Instead they deny that the relation between “bare substrata” and properties is a relation of possessing a property (see Davies 2003; Magalhaes 2007).

2 Visual Objects as Primary Subjects

Philosophers of perception often express an intuition that within visual experiences, features like colors, shapes, or sizes are presented as properties of objects (e.g., Clark 2004; Cohen 2004; Keane 2009; Matthen 2004; O’Callaghan 2008). Indeed, it seems obvious that objects are visually experienced as being characterized by many features at the same time. For instance, an object can be experienced as being square, red, and small. In addition, objects’ relations with features can be plausibly characterized as asymmetric. It is an object that is experienced as possessing the feature of being red, and not the other way around. Furthermore, this asymmetry is intuitively connected with unification. A single object combined with several visual features is experienced as a perceptual unit, for example a figure that is a red, small square. Such a perceptual unit is a complex visual entity constituted by an object and features related to it. On the other hand, a single feature simultaneously instantiated by several objects does not automatically unify them into a perceptual unit. For instance, if an experience presents a red square on the right side of the visual field and a red circle on the left side, it is not the case that we have an experience as of a perceptual unit constituted by two figures unified by common redness. Finally, the occurrence of asymmetric unification is not contingent for visually experienced objects and features. In visual experiences, objects always unify some features while features always constitute some perceptual units, usually unified by objects or places. Of course, the above “necessity” is weaker than the usual logical or physical necessity discussed in metaphysical works. The relation between visually experienced objects and features is not contingent in the sense that under normal conditions, when the functioning of perceptual mechanisms is not seriously disturbed, people do not have visual experiences as of featureless objects or uninstantiated features.

These intuitive observations suggest that objects are visually presented as satisfying the main characteristics of subjects in their relation to features, and features are visually experienced as properties of objects. Visually experienced objects asymmetrically unify features related to them and those features are always visually presented as constituting perceptual units unified by objects or some other entities (like visual places).

2.1 Psychological Data

The subject-status of visually experienced objects is supported not only by the above intuitive observations, but also by a wide range of psychological results suggesting that objects and features differ in their unificatory role. The first point concerns the mere ability to focus visual attention. While it is very easy to focus attention on an object with several features, it is much harder to attend to disjointed objects unified only by their possession of a common feature (Alvarez and Scholl 2005; Scholl 2001; Soto and Blanco 2004). Spatially disjoint objects sharing a visual feature cannot usually be simultaneously visually attended to just by attending to their common feature. In consequence, it seems that objects “unified” only by the sharing of a feature are not natural candidates for being selected as perceptual units by visual attentional mechanisms.

Second, it is well established that a visual element, like a letter, is recognized faster if it is presented again, shortly after a first presentation, within the same object (the so-

called “object-specific preview benefit”, Gordon and Irwin 1996; Moore et al. 2010). On the contrary, an analogous effect does not occur in the case of objects sharing a single feature. For instance, if there is a red square and a red circle, and a certain element, e.g. a letter, is presented first within the square and subsequently within the circle, then the object-specific preview benefit will not occur. This suggests that an object together with its features is visually represented as a perceptual unit such that elements belonging to this unit are represented in relation to the whole they constitute. In consequence, they can be rapidly re-identified when they appear again within the same perceptual unit. On the other hand, such a level of unity is not obtained as a result of sharing a visual feature. This difference has led psychologists to formulate the notion of an object-file, i.e. a mental structure that gathers information concerning a single object (Kahneman et al. 1992).

Third, as shown in studies concerning visual working memory, it is easier to notice whether one of the presented features changes if the considered features are distributed among fewer objects (Xu 2002, 2006). For example, a person may be presented with two subsequent displays and has to decide whether the second display differs from the first in color or in terms of the orientation of one of the presented objects. Such a task is more difficult if a display contains ten objects such that five of them change color (e.g., colorful circles) and five change orientation (e.g. black bars), than in a case of a display with five objects that can each change in respect to color and orientation (e.g., colorful bars). This is because the number of objects is the primary factor that determines how many units have to be processed in order to successfully resolve the memory task (see Cowan 2000 for a review). While the number of relevant features may be the same, it is easier to retain information concerning them if they constitute units created by a smaller number of objects.

Fourth, while it is quite trivial to track a single moving object and observe whether one of its features changes, it is far more difficult to notice qualitative changes while tracking several moving objects, even if they are “unified” by having the same features (e.g., they are all black circles of the same size, see Scholl 2007). It has been observed that when several such objects are simultaneously tracked, people often do not notice that some of their features have been modified during the period of movement (Pylyshyn 2007, p. 33). Again, this suggests that the perceptual processing of several objects sharing a feature is far more demanding than the task of processing a single object that has several features, and so features do not seem to have the same unificatory power as objects.

2.2 Many Properties Problem

Furthermore, it is commonly claimed that objects play a crucial role in resolving the visual version of the so-called Many Properties Problem, i.e. the problem of visually distinguishing between situations constituted by different arrangements of the same elements.³ It is clear that an experience as of a red triangle and a green square is

³ Austen Clark (2000) originally characterized Many Properties Problem in terms of feature-placing consisting in ‘proto-predicating’ features over places and not over objects. However, nowadays it is usually maintained (see Cohen 2004; Keane 2009; Matthen 2004; O’Callaghan 2008) that this problem has also a version concerning object-perception.

different from an experience as of a green triangle and a red square. For this reason, the content of visual experiences cannot be characterized simply as a conjunction of visual features, as in both cases such a conjunction would be the same: redness and greenness and squareness and triangularity. On the contrary, content should be characterized in terms of objects connected with features by an asymmetric, instantiation-like relation (see Clark 2004; Cohen 2004; Keane 2009; Matthen 2004). By combining features into different perceptual units unified by objects, a visual system is able to distinguish situations that lead to the Many Properties Problem. For instance, in one case there is an object that combines greenness with triangularity and a second object unifying redness with squareness, while in the second situation the same features are combined differently: redness with triangularity and greenness with squareness. Such object-defined units are crucial for the perceptual organization of a visual scene and are items on which further perceptual processes operate. In particular, they may be combined into mereologically complex wholes (Palmer and Rock 1994), may be tracked through time and change (Scholl 2007), and may be recognized as members of general categories of things (Hummel 2013).

Nevertheless, despite the above arguments, one may wonder whether the phenomenon of perceptual grouping poses a threat to the subject-status of visually presented objects. In virtue of grouping processes, several objects are experienced as a group with a certain level of perceptual unity (Elder and Goldberg 2002; Kubovy and Wagemans 1995). Because perceptual grouping usually requires representing a similarity between objects, and thus requires that the considered objects are presented as sharing some features, it may be the case that features can also unify objects into perceptual units. If the unificatory relation between visually experienced objects and features were symmetric, objects could not be characterized as subjects of features.

However, there are reasons why perceptual grouping does not force us to abandon the unificatory asymmetry between objects and features. First, asymmetry is present because grouping is a derivative phenomenon, i.e. to make a group out of some objects, a feature F must already be experienced as instantiated by these objects. If objects are grouped by color or common motion, they must be experienced as exhibiting this color or pattern of motion. In consequence, grouping by a feature F already presupposes that this feature belongs to the perceptual units unified by the grouped objects. Second, visually presenting a single feature as shared by several objects is not sufficient to present these objects as unified into a perceptual group. For a grouping to occur, objects also must be experienced as standing in appropriate spatial relations concerning proximity and relative position (Kubovy et al. 1998). For instance, scattered, distant visual objects do not form a group even if they are qualitatively the same, but arranging them into a line with small spaces between them is likely to result in grouping. In consequence, perceptual groups are not unified by a single feature, but rather by virtue of perceived spatial and similarity relations between objects.

2.3 Primary Subjects

While the above considerations show that objects are visually presented as subjects of visual features, they do not entail that such objects are the only subjects that figure in visual experiences. For instance, it seems plausible to assume that visual features like colors, while being presented as properties of visual objects, are themselves visually presented as subjects

unifying second-order visual features such as brightness or saturation. Furthermore, visually experienced objects do not seem to be the exclusive subjects of features, as at least some features may be also presented as the properties of visual places (see Clark 2004). This is particularly salient in experiences involving figure/ground competition between perceived regions (as in a case of a Rubin-vase display, Pomerantz and Kubovy 1986). A spatial region designated as a ground is not presented as a visual object, but nevertheless it is experienced as possessing some features.⁴

On the other hand, there are strong reasons to accept that objects are not only visually presented as the subjects of visual features but are also presented as primary subjects, i.e. they do not have to constitute a perceptual unit unified by an element that is different from them. As has been already shown, there are no obvious visual cases in which a single feature creates a perceptual unit from several objects. In addition, while objects can be visually unified into perceptual groups, grouping is not a necessary a prerequisite for visually experiencing an object, as there are many visual experiences in which objects are not elements of a group.

A more tempting hypothesis may be that places are experienced as subjects of visual objects. To play such a role, it should be possible to visually experience a place as asymmetrically combined with more than one visual object in the same moment in such a way that the place together with its objects creates a perceptual unit. However, it is doubtful whether there are visual experiences in which one perceives two visual objects as positioned in exactly the same place. In particular, such an experience would be indistinguishable from an experience representing a single object.

Furthermore, examples from the psychological literature that can, with some plausibility, be interpreted as involving two objects visually presented as sharing a location do not support the hypothesis that a common place unifies visual objects into a perceptual unit. In particular, there are cases in which two objects occupy the same region but are semi-transparent and so can be distinguished as distinct individuals (Pylyshyn 2007, pp. 40–41). However, studies concerning the perception of two overlapping, semi-transparent gratings that change their features over time have shown that in such cases objects are treated as separate perceptual units. Each can be independently chosen by a focus of attention and tracked through time, while the other is treated as a ground whose qualitative changes are less salient (Blaser et al. 2000). If the relation between a place and objects visually presented as located within it were analogous to that between an object and its features, then focusing attention on the common place should lead to an enhanced processing of both objects. On the contrary, both objects are treated as separate units and assigning attentional resources to one of them leads to a decrease in the processing of the other.

The above considerations show that while there are strong reasons for accepting that objects are visually presented as subjects of features, there is no significant justification for the thesis that such objects themselves are presented as properties of some other elements. In consequence, visually experienced objects should be characterized as *primary subjects*. In the next section, I argue the function of objects in visual experiences is analogous to that served by odors in the case of olfactory experiences, as odors are also perceptually presented as *primary subjects*.

⁴ While one may argue that features such as colors are not possessed by places but are rather positioned *in* places, there are other types of visual features, like sizes or shapes, in case of which attributing them to places seems less controversial.

3 Odors as Primary Subjects

In talking about olfaction, I assume a regular representationalist position according to which olfactory states represent odors, which are usually understood as chemical mixtures or structures (e.g., Batty 2009, 2010a; Cavedon-Taylor 2018; Young 2016). From this perspective, odors are different from odor-sources, which are understood as entities from which odors emanate (e.g., a cigarette may be considered the source of a cigarette odor). The considerations in the previous section have demonstrated that visual objects satisfy a notion of *primary subject* due to the fact that they unify visual features into perceptual units but themselves do not need to be constituted by complex entities unified by something else. The question is whether the same notion of *primary subject* is also satisfied in the case of odors.

This is not obvious for three reasons. First, while authors who postulate that odors are experienced as objects usually treat them as subjects (e.g., Carvalho 2014; Millar 2019; Young 2016), the particular notion of ‘subject’ that is used has not been established, so it is unclear whether odors are subjects in the same way that visual objects are. Second, one of the main reasons why visual objects are *primary subjects* is that they play a crucial role in solving the Many Properties Problem. However, serious arguments have been proposed in order to demonstrate that human olfaction, in opposition to vision, does not have abilities to solve this problem (Batty 2010a, 2014; Keller 2016). Third, some authors believe that odors are experienced as instantiated by some other type of entities, like locations (Batty 2010b) or odor sources (Mole 2010). This is inconsistent with characterizing odors as *primary subjects*, so some arguments are required to refute these views.

The further argumentation is specifically shaped to address the above concerns. I argue that odors are *primary subjects* in the same sense as visual objects, i.e., they unify properties into perceptual units but themselves do not need to be constituted by complex entities unified by something else. This is done by (a) showing that there are similar intuitions concerning subject-statuses of odors and visual objects (-Section 3.1), (b) demonstrating the presence of psychological results suggesting the subject status of odors (Section 3.2), (c) arguing that odors play a major role in solving the olfactory version of the Many Properties Problem (Section 3.3), and (d) showing that odors are not experienced as subjects of some other entities (Section 3.4). The point (c) is directly related to the second concern as I address the arguments by Batty and Keller aimed to show that olfaction cannot solve the Many Properties Problem. Similarly, point (d) corresponds to the third concern as I argue why odor sources and places are not good candidates for subjects of odors. Finally, in Section 3.5, I additionally demonstrate that the arguments provided against the idea of olfactory object perception do not threaten my thesis concerning odors as *primary subjects*.

3.1 Intuitions Concerning Odors

I believe that there are analogous intuitive reasons to treat perceptually experienced odors as subjects of features, just as in the case of visually experienced objects. First, it seems that a single odor is presented as combined with many olfactory features, for instance a certain intensity, a certain pleasantness, and various qualities such as fruitiness or woodiness. In addition, odors are usually presented as having a feature

determining the odor-type to which they belong. For instance, odors are experienced as being onion-odors or strawberry-odors. Furthermore, a relation between an experienced odor and its features can be plausibly characterized as an asymmetric unification. For instance, in the case of a complex perceptually presented odor, like a perfume, the odor may be experienced as possessing a woody note, but it would be implausible to state that a woody note possesses the whole perfume. In addition, a perceptually experienced odor together with all its features constitutes a perceptual unit that can be attended, analyzed, and evaluated. Such a level of unity does not seem to be present in the case of experiencing two odors as sharing a feature, like in a case of a cigarette odor partially masked by an onion odor, which may both possess the feature of being unpleasant. Finally, the relation between odors presented in olfactory experiences and their features does not seem to be contingent. In particular, there are no experiences as of free-floating olfactory features, such as a fruitiness that is not presented as a fruitiness of any odor; rather they are always experienced as related to some odors.⁵

All the above intuitive observations suggest that perceptually experienced odors satisfy the crucial characteristics of subjects in their relation to features. They are presented as combined with many such features and as asymmetrically unifying them into perceptual units. It should be noted that, as mentioned in section one, despite what the examples may suggest, I do not assume that being experienced as a subject necessarily requires being categorized as a member of some category of odors (e.g., as a cherry odor or a cigarette odor).

3.2 Psychological Data

While the empirical results concerning olfactory perceptual units are not so abundant as in the case of vision, in this context too one can find data showing the asymmetry between the unificatory role of odors and features. First, the ability of human olfaction to represent multiple odors at the same time seems to be limited (see Stevenson and Mahmut 2013). In particular, simultaneously presented odors are usually experienced in such a way that one odor is distinguished from an olfactory ground constituted by the other odors, which are represented in a more rudimentary fashion (Batty 2010a; Gottfried 2010; Millar 2019; Stevenson and Wilson 2007; Young 2016). Such a figure/ground character of olfaction suggests that an odor together with its features is presented as constituting a perceptual unit, differentiated from the other olfactory stimuli forming ‘ground’. On the other hand, two perceptually presented odors “unified” through their sharing a feature, like a cigarette odor and an onion odor united by unpleasantness, do not achieve such a level of unity. It is so because one of them would be experienced as a figure while the second will be experienced as a ground that obtains only a sketchy representation.

Some authors claim that the relation between simultaneously experienced odors should not be characterized as a distinction between a figure and a ground because, in contrast to the case of vision, such odors do not stand in appropriate spatial relations (Keller 2016, pp. 72–75). However, this does not change the presented argument, as it

⁵ The only situations in which this is not the case are those related to serious disturbances in the functioning of the olfactory mechanism. For instance, there are cases of anosmia where people experience only olfactory intensities without being able to recognize that they are intensities of some odors (Morton 2000).

requires only that odors in some way compete for resources no matter whether this competition is characterized as a spatial figure/ground discrimination or otherwise.

Another possible counter-argument is to postulate that if two odors sharing a feature, like an onion and a cigarette odor, are simultaneously experienced, then they are also experienced as components of a third, complex onion-cigarette odor. In this case, even if they compete for resources, they are still experienced as belonging to a higher-level perceptual unit. Nevertheless, while the individuation criteria of perceptually experienced odors are not completely clear, the literature strongly suggest that sharing a single feature, like “being irritating”, is not sufficient to experience odors as components of a complex whole. Because of this, not all cases of experiencing odors sharing a feature will be also experiences presenting a unit composed of these odors. To experience such a higher-order unit some additional conditions have to be satisfied, for instance, it is more likely that odors will be experienced as unified within a higher-level whole if they are connected by complex relations of congruency; they have previously been frequently experienced together; and a person possesses a concept that allows her to recognize that the odors are likely to come from a single source (see Batty 2014; Stevenson and Wilson 2007).

Furthermore, the unificatory asymmetry between odors and features presented in olfactory experiences is revealed in the case of olfactory tracking. People are able to find the location of an odor-source by following an odor (Porter et al. 2007). Such an ability involves recognizing that an odor is the same despite the fact that during tracking its intensity or some qualitative properties may undergo modifications (Richardson 2013). Hence, it seems that a perceptually presented odor, together with its features, defines a perceptual unit that can be followed through time and change. On the other hand, such a unit is not created when an odor at an earlier moment and an odor at a later moment are presented as having the same feature. Having a common feature does not guarantee that odors are experienced as being the same. It is so because there are many odors that people recognize as being clearly distinct despite the fact that they share some features (Zarzo and Stanton 2009). As a result, perceptual “units” – created by several subsequent perceptually presented odors sharing a feature – are not useful in tracking odor-sources, because having a common feature does not provide a strong justification that the same thing is being tracked. Such observations suggest that the perceptual units used in olfactory tracking are odors with features and not several odors that share an olfactory feature.

3.3 The Many Properties Problem

Furthermore, I believe that odors in the context of olfactory experiences serve an analogous role in solving the Many Properties Problem as visual objects do in the case of visual experiences. Nevertheless, there are authors who doubt whether olfaction has the ability to solve the Many Properties Problem because of severe limitations concerning the olfactory ability to represent space. For instance, it may happen that one attempts to mask a cigarette odor with an air freshener odor and in consequence has an experience presenting both these odors (an example proposed by Batty 2010a). In the visual domain, two objects can be presented in many ways by virtue of the richness of visual spatial representation. For instance, one object may be presented on the right of another or objects may partially overlap. On the other hand, such variety does not

seem to be present in the case of olfactory experiences. For example, it is unlikely that one can have two distinct experiences such that in one the air freshener odor is presented as being on the left of the cigarette odor and in the second the air freshener odor is on the right of the cigarette odor.

One way to refute the above argument is to claim that it neglects the actual olfactory abilities for spatial representation. In particular, it is proposed that to properly assess the way in which olfaction represents space, olfactory experiences should be considered as temporally extended in order to accommodate the time needed for various exploratory activities such as sniffing while moving around. According to this perspective, olfactory experiences may represent ‘smellscapes’ i.e., arrays of spatially positioned odors, which are useful in olfactory navigation and tracking (see Young 2020; Young et al. 2020). If olfaction represents smellscapes, then it can solve the Many Properties Problem in a manner that is analogous to the visual solution, since distinct combinations of the same properties may be distinguished by the way in which properties are distributed among spatially positioned odors.

Nevertheless, even if olfactory abilities to represent spatial properties are severely restricted, the argument against olfactory resolution of the Many Properties Problem relies on a controversial assumption that all solutions to the Many Properties Problem must involve spatial discriminations. Indeed, it may be the case that vision has the ability to create spatial representations that allow us to distinguish between situations where the same elements are present but differ only in terms of their occurring spatial relations, while olfaction is unable to make analogous discriminations in the case of presented odors. However, such a result is not sufficient to claim that there are no alternative ways for olfaction to resolve some cases of the Many Properties Problem (see Carvalho 2014 for a similar observation). This is because the ability to solve the problem lies in distinguishing varying arrangements of the same elements, and making spatial discriminations is only one possible way to achieve this goal.

In particular, olfaction, apart from presenting odors, also presents their various qualities. For instance, odors are experienced as having some intensity (Morton 2000), trigeminal features⁶ such as irritating or cooling (Laska et al. 1997), and hedonic features (Castro and Seeley 2014). Relying on this observation, let’s again analyze a situation in which one is presented with a cigarette odor and an onion odor. It may be the case that both these odors are experienced as unpleasant and irritating, but the cigarette odor is experienced as having a high intensity while onion odor is presented as being less intense. But it seems that olfaction is also able to present a different situation composed of the same elements with reversed intensities, such that the cigarette odor has a lower intensity but the onion odor has high intensity. If olfaction presents such situations differently, then it is able to resolve some cases of the Many Properties Problem. In consequence, it is not adequate to characterize olfactory content in terms of a list of elements, like odor categorized as an exemplar of the onion-category, odor categorized as an exemplar of the cigarette-category, low intensity, high intensity, and unpleasantness, because in both considered situations the list would be the same.

⁶ Some trigeminal mechanisms can plausibly be treated as a part of the olfactory perceptual modality because the majority of odors activate trigeminal mechanisms (see Millar 2017), and it is believed that trigeminal data processing is crucial in the ability to track odors (Young et al. 2014).

Instead, in order to solve the olfactory Many Properties Problem, the experiential content should be characterized in terms of perceptual units constituted by odors and their features. Such a characterization allows us to distinguish the olfactory experiences described above. In the first, there is (1) a cigarette odor with a high intensity that is also unpleasant, as well as (2) an onion odor with low intensity that is also unpleasant. In the second case, the perceptual units are different because a cigarette odor is experienced as having low intensity and an onion odor as having a high intensity.

In contrast, it has been argued by Keller (2016, pp. 75-55) that even if human olfaction has some non-spatial ways of solving the Many Properties Problem, this occurs not due to rules of perceptual organization, but as a result of higher-level expectations. For instance, we may perceive a pizza-odor and an anchovies-odor as composing a perceptual unit because we ordered a pizza with that topping and so expect these odors to emanate from a single source. However, it is not obvious why some of the rules governing odor-binding cannot be perceptual. For instance, they may be acquired by perceptual mechanisms by detecting statistical regularities in combinations of perceived odors without the necessity for involvement of high-level concepts (see Young 2019b for a similar point). In fact, human olfaction offers significant abilities for perceptual pattern-learning, which allows for successful odor recognition despite changes in the composition of chemical stimuli (see Stevenson and Wilson 2007).

Another way of arguing against the idea of non-spatial means of solving the olfactory Many Properties Problem is to claim that in fact Many Properties Problem does not arise in case of olfaction (Batty 2010a, 2014). In particular, one of the major functions of olfactory mechanisms is to classify odors as exemplars of odor types (Stevenson and Wilson 2007). The classification of odors may determine which properties are attributed to them and in consequence the Many Properties Problem does not arise. For example, recognizing an odor as a cigarette odor entails that it is irritating and recognizing that it is a rose odor entails that it is flowery. In consequence, there are no cases in which the olfactory system has to choose between alternative combinations of the same properties, since the unique pattern is determined by odor classification.

However, the cases considered above show that this is not universally true. In particular, intensity-features are suitable for constructing olfactory versions of the Many Properties Problem. It is not the case that mere odor categorization is sufficient to determine the intensity of an experienced odor and it is likely that information about the recognized intensity and the qualitative aspects of an odor have to be additionally combined by the olfactory system. This is suggested by cases of anosmia, in which one can detect intensity-related features without being able to classify an odor and recognize its qualities (Morton 2000). Other versions of the olfactory Many Properties Problem may be constructed by referring to hedonic features, which are likely to change independently from other qualitative features due to acquired positive and negative experiences, and trigeminal features, which are detected by physiological mechanisms distinct from those that process typical olfactory features.

3.4 Primary Subjects

The above considerations show that there are reasons to treat perceptually experienced odors as subjects of features, analogously to visually experienced objects. The subject-

status of odors presented in olfactory experiences is suggested by our intuitions concerning olfactory phenomenology, and is supported by results in olfactory science, as well as by the role of odors in resolving the olfactory version of the Many Properties Problem. However, a further question is whether we experience odors as *primary subjects*. In the philosophical literature, we find two positions according to which odors are themselves experienced as properties of some other elements. First, they are considered as properties of places (Batty 2010c). Second, they are interpreted as properties of odor-sources (see Mole 2010; Todd 2018 for discussion of this point). If either of these options is correct, then olfactorily odors are not perceptually presented as *primary subjects*, even if they are presented as subjects of features.

Within the philosophy of perception, there is no agreement on how exactly olfaction represents space. In particular, some authors believe that olfaction represents odors as being merely external or positioned in a vague, “somewhere around” region (e.g., Batty 2010b; Richardson 2013), while others ascribe to it additional spatial abilities related to representing spatial extension and the direction of odors (e.g., Aasen 2019; O’Callaghan 2016; Young 2020).⁷ To be subjects of perceptually experienced odors, olfactory places should be presented as simultaneously related to many odors and should unify those odors into a perceptual unit. Despite differences in the characterization of olfactory space, it seems likely that the first of these conditions can be satisfied. In particular, if only one “somewhere around” place is olfactorily presented, then all simultaneously experienced odors are presented as related to this place.

However, it is not plausible that a common place unifies several odors into a perceptual unit. As stated earlier, human olfaction presents odors simultaneously in such a way that one is an olfactory “figure” distinguished from a ground constituted by other odors (Batty 2010a; Gottfried 2010; Young 2016). In consequence, even if two such odors are experienced as related to the same olfactory place, they do not constitute a single perceptual unit.

According to the second option, odors are not experienced as *primary subjects* because they are experienced as properties of odor-sources. If this is the case, then olfactory experiences present not only odors, features, and places, but also entities from which odors emanate. For instance, an experience representing an onion odor also represents its source: an onion or some onions. It should be noted that there is no consensus that olfaction presents sources, and philosophers have offered several arguments against this idea (e.g., Batty 2010a, however see Todd 2018 for arguments in favor of a thesis that sources are olfactorily represented). First, the phenomenal character of olfactory experiences does not suggest that anything beyond odors and their features is presented. Second, it is often the case that an odor is experienced long after its source is gone. Because perceptual content is commonly understood as determining the accuracy conditions of experiences (e.g., Siegel 2010), a perceptual experience representing the source of an odor would be inaccurate if the source were no longer present. However, it is implausible to claim that such cases are olfactory illusions (see Batty 2010a).

⁷ It should be noted that such statements are not inconsistent with the claim that people have significant abilities to track odor-sources (see Porter et al. 2007), because tracking may rely on detecting changes of odor intensity and not on making elaborate spatial discriminations (see Keller 2016, pp. 69–70).

Nevertheless, I believe that even if olfactory experiences present odor-sources in addition to odors, it is not the case that such odor-sources are presented as subjects of odors. Analogously to case of olfactory places, if odor-sources are experienced as subjects of odors, then they can be presented as simultaneously related to more than one odor and should be experienced as unifying these odors into a perceptual unit. However, in case of odor-sources, even the first condition is hardly satisfied. To fulfill this condition, and thus present at least two odors as simultaneously having the same source, human olfaction has to be able to (a) recognize the presence of two odors, (b) establish their sources, and (c) identify the source of the first odor with the source of the second.

However, it is implausible that the olfactory mechanism can succeed in achieving (c). This is because information about sources that can be inferred from detected odors is quite limited. For instance, it does not allow one to establish how many items constitute a source (e.g., whether an onion odor is emanating from a single onion or from several onions). In addition, as our olfactory abilities to represent space are limited, at most allowing us to represent an approximate spatial extension of an odor, it is also difficult to determine the exact location of a source from the spatial characteristics of an experienced odor. While some data show that source of an odor can tracked by detecting the changes intensities in response to one's movements (Porter et al. 2007), it is not clear if, as a result of such tracking process, two odors can be localized and attributed to the same source. Finally, it is often difficult to recognize what type of object is the source of an odor. For instance, an onion odor may be caused either by an onion or by a packet of onion-flavored crisps. In consequence, when two odors are simultaneously presented in an olfactory experience, there is not enough available data to allow us to determine whether their sources are identical.

Neither olfactory places nor odor-sources are plausible candidates for being subjects of perceptually presented odors. Because there are no other serious candidates for this kind of subject, it should be accepted that odors are not only perceptually presented as subjects of features but are also presented as *primary subjects*. As a result, they play a role in olfactory experiences analogous to that of objects in visual experiences: they unify other presented elements without the need to constitute perceptual units unified by something else.

3.5 Olfactory Subjects and Objects

In the introductory section, I have observed that it is debated whether human olfaction presents odors as objects and that being a subject is a necessary characteristic of being an object. Hence, we may ask what the connections are between the debate regarding olfactory objecthood and my thesis that odors are presented as *primary subjects*. In particular, it is important to consider whether arguments against treating odors as olfactorily presented objects may also undermine the subject-status of odors. It should be noted that even if odors are not experienced as objects they may still be experienced as *primary subjects*: Being a subject is only a necessary and not a sufficient condition for being an object, and there are entities such as events or processes which are commonly considered as subjects but not as objects. Nevertheless, it is still possible that arguments against olfactory objecthood of odors may undermine their status as perceptual *primary subjects*.

The thesis that olfaction presents odors as objects has been challenged by Barwich (2019), who proposes three arguments against olfactory objecthood: (a) olfaction does not provide stable representations of the physical stimuli, (b) perceptual constancy is absent in human olfaction, and (c) figure/ground discrimination differs significantly in olfaction compared to vision. This critique is particularly interesting as it relies on the current empirical knowledge concerning functioning of olfactory mechanisms. Below, I argue that Barwich's arguments do not threaten the thesis that odors are experienced as subjects. In fact, the positive account of olfactory experiences proposed by Barwich is not plausible without ascribing the subject-status to odors.

According to the first argument, olfaction does not present the environment in terms of objects due to the fact that there is no stable relationship between qualitative elements of olfactory experiences and external chemical properties. In particular, there is no one-to-one correspondence between the olfactory phenomenal character and the chemical characteristics of stimuli since, depending on concentration and presence of other substances, the same substances may smell differently, or significantly distinct substances may evoke similar qualities. Furthermore, there are considerable individual differences concerning the way in which people experience chemical stimuli, and experiences of a single individual may change due to gained memories and formed expectations.

There are two ways in which such lack of stability may undermine the thesis that odors are experienced as subjects. First, due to the way in which chemical stimuli are processed, the olfactory phenomenology may be so variable and unstable that it does not make sense to postulate that in olfactory experiences some properties are attributed to odors. Nevertheless, it does not seem to be the case, since phenomena such as olfactory tracking show that one can perceive an odor as having the same features despite changes in intensity and spatial position. Second, the lack of stable correspondence between olfactory qualities and chemical properties may suggest that olfactory experiences should not be treated as representations, rather they should be conceptualized in processual terms (see Barwich 2018). Such a conclusion would be problematic for the thesis concerning the subject-status of odors as this thesis has been proposed in representational terms. While I believe that phenomena discussed by Barwich should be taken into account by proponents of representational approaches to olfaction, their presence is not enough to refute the core representational thesis that experiences have accuracy conditions. In particular, a proponent of representational account does not have to assume one-to-one correspondence, unaffected by changes in context and presence of top-down influence, between phenomenology and stimuli properties. Furthermore, a representationalist may even postulate that properties ascribed to odors in olfactory experience do not really exist (see Mendolovici 2018 for such 'error-theory' of olfaction). In fact, even if one agrees that the role of olfaction is not to represent chemical properties but to evaluate stimulus—for instance as unpleasant or harmful—there are also representational theories of evaluative aspects of experiences (mainly developed in the context of pain perception, see Bain 2012 for a review). In consequence, because the thesis that odors are presented as subjects does not assume any particular representational theory, but only a general representationalist framework, it is not undermined by phenomena described by Barwich.

To establish her second point concerning the lack of olfactory constancy perception, Barwich provides several examples of cases in which an odor is experienced as being

qualitatively distinct due to external, contextual changes without modifying the actual chemical composition of a stimulus. For instance, a chemical mixture may be experienced differently depending on preceding stimulation, expectations evoked by verbal labels, or mere time of stimulation due to adaptation effects. I believe that such way of arguing is problematic; since olfaction does not achieve constancy in some circumstances, it does not follow that olfactory constancy perception is completely absent. For example, it seems plausible that olfaction is able to present sameness of odors and their properties despite intensity changes. Nevertheless, even if lack of olfactory constancy were successfully demonstrated, such a result poses no significant threat for the subject-status of odors, because the thesis that odors are experiences as subjects concerns the experiential relation between odors and properties and is neutral regarding the way that the diachronic sameness of odors and olfactory properties is perceived. In other words, odors may be experienced as subjects even if contextual changes are always connected with perception of property change and not perception of property constancy.

Finally, in consideration regarding distinguishing figure from ground, Barwich agrees with Keller (2016) in postulating that there is no olfactory phenomenon analogous to visual figure/ground discrimination. Instead, she proposes that the olfactory experiences should be described in terms of perceptual grouping of properties, which serves as a basis for odor recognition, evaluation, and conducting actions. I believe that the idea of olfactory grouping not only does not undermine the subject-status of odors, but in fact is likely to require the odors-subjects in order to be plausible. To convincingly argue in favor of olfactory grouping one has to explain what it means for olfactory properties to be experienced as grouped. In this context, it is not enough to postulate that olfactory properties are grouped simply in virtue of spatiotemporal co-occurrence. In this case, one would not be able to distinguish that there are two odors in the environment, differing in their qualitative character and intensity, as all co-occurring properties would be grouped with each other. Similarly, mere spatiotemporal grouping does not allow to successfully evaluate and act upon olfactory stimuli as proper evaluation and action require recognizing which of the detected properties are co-instantiated and not only that they jointly occur at a given moment. Treating odors as subjects allows omitting these problems, because then olfactory grouping can be understood in terms of creating perceptual units composed of odors and properties ascribed to them.

4 The Structure of Vision and Olfaction

Typical visual experiences present the environment as composed of several types of entities. Most importantly, these entities are objects, places, and features. As shown in section two, objects are visually presented as *primary subjects* that possess features as their properties, but are not properties of anything. Furthermore, some features seem to be presented both as properties of objects or places and also as subjects of second-order features. For instance, redness may be experienced as the property of a visual object but also as the subject of a second-order visual feature related to saturation. It is difficult to assess whether there are also third-order visual features, but it is plausible to assume that the hierarchy of features presented in visual experiences is not infinite and thus that there are some features that are presented only as properties and not as subjects of anything.

An interesting question is whether visually presented places are also *primary subjects*. One may propose that such places are experienced as properties of visual objects. In fact, it seems that an object can be presented as encompassing many visual places and can incorporate them into a perceptual unit, such that a place becomes one of the object's properties alongside the visual features that the object instantiates. However, places figuring in visual experiences do not satisfy one of the crucial characteristics of properties. As stated in section one, properties cannot be present without constituting a unit unified by some subject, and if the only candidates for the subjects of visually experienced places are visually experienced objects, then this necessity does not occur. This is because visual experiences can present places as possessing some features while not being occupied by any object. For instance, the ground surrounding a figure is not experienced as an object but can be experienced as having some size.

The above considerations suggest that both objects and places are visually presented as *primary subjects*. In addition, these two types of elements are presented as subjects of features. Among visually presented features we find some that are both properties (of objects or places) and subjects (of higher-order visual features), and some that are only properties (the highest-order visual features instantiated by lower-order visual features). In consequence, visual experiences have a hierarchical subject/property structure in which every element belongs to a perceptual unit that is finally unified by an object or by a place. However, while their formal role as *primary subjects* is identical, perceptual units created by visual objects seem to be more cognitively important than those created by visual places in the context of ordinary visual experiences.

Relying on the arguments presented in section three, it can be stated that the subject/predicate structure of olfactory experiences is very similar to that of visual experiences. In the case of olfactory experiences, the environment is presented in terms of odors, olfactory features, places, and, according to some authors, odor-sources. Odors are presented as *primary subjects* that have features as their properties. Analogously to the case of visual experiences, it is plausible that some olfactorily presented features may be presented both as properties of odors and as subjects of higher-order olfactory features, while other olfactory features are presented only as properties and not as subjects (however, see Young 2019a for arguments that hierarchy of olfactory features may be less developed than in case of vision).

In considerations concerning vision, visually experienced places have been characterized as *primary subjects*, such that there seem to be two types of visual *primary subjects*. It is less clear whether the same can be stated about olfaction. In particular, it is less plausible to interpret olfactorily presented places as *primary subjects*. In fact, there are important reasons to characterize them as properties of odors. First, if human olfaction can make some spatial discriminations (e.g., Aasen 2019; Millar 2019), such as between “being on the left” and “being on the right”, then a single odor can be experienced as simultaneously related to more than one olfactory place. Second, olfactory attention picks odors but not places and attending to an odor results in a more elaborate processing of both olfactory place and the olfactory features related to the attended odor (Laing and Jinks 2001; Porter et al. 2007). This suggests that olfactory places constitute perceptual units unified by odors.

Similarly, it is also implausible to interpret odor-sources as a second type of *primary subjects*. First, as was argued earlier, they are not good candidates for being experienced as subjects of odors. Second, analogously to the case of olfactorily presented

places, there are no olfactory experiences that present odor-sources as unrelated to odors and olfactory attention cannot pick out odor-sources independently from focusing on odors. Third, because human olfaction has limited abilities to individuate odor-sources (see Section 3.4), odor-sources are not useful in resolving the Many Properties Problem and so are unlikely to be experienced as subjects of olfactory features.

The above points show that there are serious reasons to support a view that places and odor-sources are not olfactorily experienced as *primary subjects*. This would mean that in the case of human olfactory experiences there is only one type of *primary subject*: odors. However, such a conclusion relies on a possibly controversial assumption concerning the way in which space is olfactorily represented, as well as the functioning of olfactory attention, and as such should be a matter of further investigation.

Despite the above possible difference in the number of *primary subjects*, the subject/predicate structures of visual and olfactory experiences are significantly similar. In the case of visual experiences, there are two types of *primary subjects*, visual objects and places, which instantiate elements, i.e. features, that are both properties and subjects of other, higher-order, features. At the top of the hierarchy are visual features that are only properties. It is likely that olfactory experiences involve only one type of *primary subject*, namely odors, which, analogously to visually presented objects, are also subjects of features. These olfactorily presented features can be both subjects and properties or only properties. In consequence, the odors presented in olfactory experiences are counterparts of visually experienced objects: odors are the only olfactory *primary subjects*, while objects are the most cognitively important visual *primary subjects*. Both types of element play a crucial role in organizing other perceptually experienced entities into perceptual units, as each experienced element is ultimately a constituent of a unit involving a *primary subject*.

5 Conclusions

It seems that the structure of human olfactory experiences is very different from the structure of visual experiences, in particular in terms of spatial and mereological relations. However, despite these differences, they possess a strikingly similar, hierarchical subject/property structure. Within these structures, visual and olfactory elements are organized into perceptual units created by subjects that possess properties. Such units are items on which further perceptual processes may operate, which allows for grouping, tracking, and categorizing. In both vision and olfaction, the subject/property structure is founded on *primary subjects*, i.e. elements that are subjects but not properties of anything. Because of this, *primary subjects* are able to create perceptual units without themselves constituting a perceptual unit unified by something else. The most cognitively important visual *primary subjects* are objects, but it is plausible to treat places as a second visual type of *primary subject*. In the olfactory context, it is likely that the only *primary subjects* are odors. In consequence, perceptually presented odors are counterparts, with respect to their role within the subject/property structure, of visually presented objects.

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Compliance with Ethical Standards I comply with the Ethical Standards of „Philosophia”.

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