Phenomenology and the Cognitive Sciences (2022) 21:487–513
https://doi.org/10.1007/s11097-021-09733-2

On the content of Peripersonal visual experience

Gabriele Ferretti [1,2]

Accepted: 15 February 2021 / Published online: 6 May 2021

Abstract
In a recent paper, '*Peripersonal perception in action*' (*Synthese*, 2018), Frédérique de Vignemont tackles the problem of defining what is peculiar to the visual perception of objects falling within the peripersonal space of the observer, i.e. the space immediately surrounding the body, and which is commonly described as the space in which action takes place. In this paper, I first discuss the proposal offered by de Vignemont about what characterizes peripersonal perception. Then, I suggest an extension of this account that offers a meticulous description of the nature of the *Content of Peripersonal Visual Experience* - a topic never explicitly considered in the philosophical literature on vision - by discussing some peculiar features of it that, as recognized also by de Vignemont's account, still need to be explained. In particular, I offer a philosophical examination of the specificity of *peripersonal visual experience*, in relation to its phenomenological dimension, its optical mechanisms and its neurophysiological underpinnings, in the light of our best theories from vision science, and in comparison to the visual experience of other visual spaces.

Keywords Peripersonal space · Egocentric space · Action · Motor representations · Vision · Extra-personal space · Vista space · Motoric

1 Introduction

In her recent paper (de Vignemont 2018), Frédérique de Vignemont tackles the problem of defining what is peculiar of visual perception of objects falling within the peripersonal space of the observer, i.e. the space immediately surrounding the body, and which is commonly described as the space in which action takes place.

✉ Gabriele Ferretti
fairg@live.it; gabriele.ferretti88@gmail.com

1 Institute for Philosophy II, Ruhr-University Bochum, GA 3/151, Universitätsstr. 150, 44780 Bochum, Germany

2 Eikones – Center for the Theory and History of the Image, University of Basel, Rheinsprung 11, 4051 Basel, Switzerland

In this paper, I first discuss the proposal offered by de Vignemont about what characterizes peripersonal perception (§2). Then, I suggest an extension of such an account by offering a description of the *Content of Peripersonal Visual Experience* - a topic never explicitly considered in the philosophical literature - by discussing some features of it that, as recognized also by de Vignemont's account, still need to be explained. I will analyze the peculiarity of *peripersonal visual experience*, in relation to its optical, phenomenological and neurophysiological aspects, in the light of our best theories in vision science, and with respect to its perceptual differences with *extra-personal space*, the space immediately falling otuside *peripersonal space* (§3). At this point, I will also describe the perceptual differences between *peripersonal space* and a space that presents objects very far compared to peripersonal coordinates: *vista space* (§4). Then, I will discuss the relation between *peripersonal visual experience*, its *demand character* related to the *feeling of answerability* and to affordances, and the body (§5). After this, I will discuss the emotional components of *peripersonal visual experience* (§6). Finally, I will also explore the nature of *peripersonal visual experience* in case of optical deficits and bodily impairments (§7).

First of all, we should go slowly on what precisely is *peripersonal space* and what is the question at stake in the present paper. We can start from the account offered by de Vignemont (2018).

2 de Vignemont's account of Peripersonal perception

"Does seeing a big rock close to my foot differ from seeing the moon in the sky?" (de Vignemont 2018). This is the general question de Vignemont's account (henceforth: DVA) of peripersonal perception starts from. The background assumption of DVA is that peripersonal space is "the space in which the world is literally at hand for interaction" so that "whatever is perceived in peripersonal space is relevant for action" (Ibid.).[1] The crucial question is, then, the following:

> **Q1.** "How to characterize in details this relation to action? And is it specific to the perception of peripersonal space or can it also be true of the perception of far space?" (Ibid.)

This question is important because, after all, "Seeing a lion thirty meters away has clearly an impact on my behavior and I should not wait to react for the lion to be next to my body, when it is actually too late. In what sense, then, is the perception of peripersonal space unique?" (Ibid.).

DVA starts from the well-known difference proposed in cognitive science between *peripersonal* space, which is the space close to the body, reachable for action, in which indeed motor interaction can take place, and *vista* space, which is the space beyond thirty meters, and discusses some peculiar characteristics of peripersonal space.

First, in peripersonal space, *object detection* is improved, thought it is not clear, looking at the empirical literature, whether this is due to attentional processes (see the

[1] For a recent and critical experimental result concerning this point see (Di Marco et al. 2019).

analysis by de Vignemont 2018: Sect. 1.2 of experimental results by Dufour and Touzalin 2008; Reed et al. 2006, 2010 and Abrams et al. 2008).

Second, *object discrimination* is improved for what concerns temporal properties, as well as spatial properties as orientation and shape, while not for colors (see the analysis by de Vignemont 2018: Sect. 1.2 of experimental results by Goodhew et al. 2015; Gozli et al. 2012; Kelly and Brockmole 2014; Blini et al. 2018).

These results are, according to DVA, in accordance with what the famous '*Two Visual Systems Model*' (henceforth: TVSM) (Milner and Goodale 1995/2006; 2008) has taught us about visual processing: peripersonal perception is subserved by dorsal visual processing for action guidance, while spatial perception of far space is subserved by ventral visual processing for object recognition[2] (Ibid.).

Thus, it is suggested that *peripersonal* perception and perception of *far* space do not depend on the same computational information processing, and the main characteristic of the former is its special relation to action processing (Ibid.).

All this suggests that "action determines peripersonal perception" (Sect. 2.1). But DVA also wants to understand "in what manner peripersonal perception determines action" (Ibid.).

In order to offer such an explanation, DVA considers some options. First, it considers Clark's (2001) assumption of the '*Experience-based Control*' (EBC), according to which "Conscious visual experience presents the world to the subject in a form appropriate for the control and guidance of fine-tuned, real world activity" (Sect. 2.1). According to DVA, the EBC is "too extreme" (Ibid.) if we follow the results on the dissociation above quoted coming from the TVSM, as "most action guidance is based on unconscious visuomotor processing of peripersonal space" (Ibid.). However, we can still embrace Clark's (2001) assumption of '*Experience-based Selection*' (EBS), according to which "Conscious visual experience presents the world to a subject in a form appropriate for the reason-and-memory based selection of actions" (Ibid.). That said, DVA pushes the line even further, by suggesting that: "Conscious visual experience presents *peripersonal space* to a subject in a form appropriate for the *motor selection* of actions" (Ibid.). Now, since peripersonal space is the space of action, "peripersonal perception cannot afford to be relatively detached from the motor system, at a more abstract level or in a different time frame. Roughly speaking, the motor system does not have the time for the reason-and-memory based selection" (Ibid.). However, we cannot support the EBC, in the light of the TVSM. Thus, following the distinction proposed by Grush between 'type-selecting disposition' (the selection of the *type* of action) and 'detail-specifying disposition' (the selection of the *details* of the specific action) (Grush 2007: 393, discussed in Sect. 2.1), de Vignemont suggests that: "The perception of the object close to us directly contributes in selecting the type of movement (arm withdrawal, for instance), but it not does provide the exact parameters on how to perform it" (Sect. 2.1).

All this is also related to the notion of *affordance* perception: "Affordances consist in what one can do *here and now* (…). Their relation to action is then more direct and because it is more direct it is more likely to be specific to the perception of the space within which the body can act" (de Vignemont 2018: Sect. 2.2). This seems to be, according to DVA, in line with the *demand character* of affordances in peripersonal space, which foster a *feeling of answerability* (Siegel 2014), as suggested by de Vignemont (2018: Sect. 2.2).

[2] Though it is quickly mentioned that dorsal processing can participate in object recognition (Ibid.).

However, the *feeling of answerability* of such a *demand character* during affordance perception has to be explained, as "one may claim that the feeling of answerability is experienced more vividly when objects are next to the subject but she can still experience it even for objects that are far" (de Vignemont 2018: Sect. 3.1). At this point, then, a question remains:

Q2. "Why is the force more powerful when the object is seen as close?" (Ibid.)

DVA rejects the too strong idea that: "One can experience mandates only when the seen property or object appears as being located in peripersonal space. The perception of far space does not normally present the subject with actions that she needs to answer to" (de Vignemont 2018: Sect. 3). Indeed it is possible that "one experiences a feeling of answerability for objects beyond the immediate surrounding of one's body" (de Vignemont 2018: Sect. 3.1). Accordingly, DVA endorses that there might be a continuous gradient of demands between *far* and *peripersonal* space, and not simply either absence or presence concerning the demand character.

That said, we still need to explain Q2, i.e. why the demand character is more powerful when the object is seen as close to the subject (Sect. 3.2). The lighter answer provided by DVA is that "peripersonal perception does not have the same relationship to action as the perception of far space" and "peripersonal perception specifically evolved for one to experience mandates, while this is not the case of the perception of far space. Mandates are present-directed: they are about what one has to do now. Feeling that one needs to answer to what one perceives implies feeling ready to do it" (Sect. 3.2). In this view, "peripersonal perception is characterized by this readiness to act because it was designed for situations in which one has no choice but to act, namely, when one is under threat" (Ibid.). What we cash out from such an account is, then, that "From an evolutionary perspective, peripersonal perception is always prepared to make one act because it originally evolved for the purpose of the detection of close threats and self-defence. From a neuroscientific perspective, peripersonal perception is always prepared to make one act thanks to its implementation within brain structures involved in action guidance. From a computational perspective, peripersonal perception is always prepared to make one act because it is informed by what one can and cannot do at each instant" (Ibid.). This seems to be confirmed by studies showing that "if one stops paying attention to peripersonal space, as this occurs in the neurological syndrome of peripersonal neglect, one collides more into objects (Nijboer et al. 2014)" (de Vignemont 2018: Sect. 3.2). However, according to DVA, while the answerability content (cfr. Siegel 2014) does not entail that one feels obliged to respond to the demand character of an affordance, which is always related to peripersonal space perception, it is still a peculiarity of peripersonal perception (de Vignemont 2018: Sect. 3.1). That said, then, DVA declares that we still have to answer a final important question:

Q3. "What kind of content do peripersonal experiences have?" (Sect. 4).

This remains an open question in DVA, which is related to whether the notions of demand character and answerability are appropriate to define such a content.

In what follows, I extend DVA by offering a meticulous description of the peculiarity of the content of *peripersonal visual experience*, which considers some aspects of such an experience that are not accounted for by DVA.

3 On the content of Peripersonal visual experience

What is the peculiarity of *the content of peripersonal visual experience*? This question has never been explicitly considered in the philosophical literature. In the next sections, I will develop an account whose aim is to answer this question. I first offer some conceptual and terminological clarification on space (§3.1). Then, I discuss the peculiarity of peripersonal visual experience, with respect to its optical and phenomenological aspects (§3.2), and its neurophysiological basis (§3.3).

3.1 A visual grammar of Space*s*

Before going into *medias res* with an analysis of the peculiarity of peripersonal space visual experience, there is the need to offer some important clarifications on the terminology used to denote different but related notion of space*s*, with respect to the scientific and the philosophical jargon. This will be crucial in order to appreciate my novel account.

Beyond *peripersonal space*, described above as the space surrounding the body in which action takes place, we find *extra-personal* space, i.e. the spatial location beyond the reach of our limbs (Iachini et al. 2014, 2017; Berti and Frassinetti 2000; Ferretti and Zipoli Caiani 2019; cfr. §3.2). As we go deeply far beyond this space, we find *vista* space, which locates beyond the thirty meters (until reaching the space in which landscapes are appreciated) (Vishwanath 2011, 2014; Cutting and Vishton 1995; Matthen 2005; Ferretti 2016c, 2018, Nanay 2011; Ferretti and Zipoli Caiani 2019; cfr. §4). However, there is also another notion of space, that of *egocentric* space, a space which is deeply related to the perceiver's perspective. There is an important specification about the difference between the notions of *egocentric* and *peripersonal* space.

Sometimes philosophers have equated the notion of egocentric space to the one of action space (see Matthen 2005; Nanay 2011; Ferretti 2016a, 2016c, 2018; Briscoe 2009 for a review), suggesting that the possibility of performing egocentric localization with respect to an object is related to the ability to localize the object for the purpose of motorically interacting with it. However, such a definition does not take into account the crucial notion that egocentric space is simply about the point of view of the perceiver (though, as we shall see, different frames of reference can be considered with respect to distinct bodily parts of the perceiver). And the point of view shapes and modulates visual perception even in visual scenarios, for example concerning *vista space,* in which the object is located far away (e.g. a building) and, *ipso facto*, being not located within the peripersonal action space, does not offer any possibility of suitable interaction. Therefore, the possibility of performing egocentric localization of an object does not rely on the ability to perceive the object as offering motor interaction. Indeed, it has been suggested that vision is always egocentric (Foley et al. 2015; Briscoe 2009; Briscoe and Schwenkler 2015; Ferretti 2016b, 2018). But, as said, not all vision is related to peripersonal space (as in the case of *extra-personal* space and *vista* space). Therefore, peripersonal space is always egocentrically encoded, but not all egocentric space is related to peripersonal space (Nanay 2011: 468–469, footnote 8; Ferretti 2016a, 2016c, 2017c, 2018; Ferretti and Zipoli 2019: Sect. 4). In this respect, the ability to perceive the object as offering motor interaction (e.g. manipulability) depends on its representation as falling within the peripersonal action space (Ferretti 2016a, 2016b, 2016c, 2018, 2021a; Cardellicchio et al. 2011; Costantini et al. 2010, 2011; Iachini et al. 2014). Thus, peripersonal action space and action performance cannot be detached. Differently, egocentric localization and action performance can - but only in the specific sense that action processing always involves an egocentric frame of reference, while an egocentric frame of reference is not only involved with visual representations for action in the peripersonal space, as it is also in play with other spatial localizations not related to the perception of any action possibility (Ferretti 2016a, 2016c, 2017c, 2018, 2019b). This is in line with the idea that visual experience is (most of the time, if not) always, egocentric in the sense of 'egocentric' above described.

All I am saying, of course, also depends on the definition, I am relying on in this paper, of peripersonal space as reachable space for suitable action performance. This definition precisely captures the main interest of this paper concerning the aspects of visual experience examined here. So, this is the one endorsed in my philosophical analysis of the neuroscientific results that will follow. I acknowledge, however, that this is one (massively discussed) definition of peripersonal space in the neuroscientific literature, but not the only possible, or plausible one. (In this respect, note that there can be neurons considered related to peripersonal space, which can have receptive fields that can be extended, sometimes, beyond what is taken to be a reachable distance; for example, neurons whose activity is anchored to a specific limb, and when the hand is extended, also the receptive field is extended further than reachable space, cfr. §7.2).

There is a further crucial specification here. There could be, in principle, as many different peripersonal spaces as the portions of the body we want to consider (e.g. the head, the torso, the feet, the eyes, the mouth, etc.; see Hunley and Lourenco 2018; Briscoe 2009; de Vignemont and Iannetti 2015; see also Graziano 2009; Rizzolatti et al. 1997). The specific borders between these representations of spaces are very unlikely to be sharp, especially when it comes to action and motor processing. Of course, we can consider these parts as anatomically, and also partially functionally, separated, and then focus on how different portions of the brain represent different peripersonal spaces with respect to each of them. However, there is compelling evidence that the plethora of sensory feedbacks, concerning both proprioceptive information coming from different regions of the body, and perceptual information coming from the external environment, work to build spatial transformations that permit to establish, on the one hand, the object location in a way that takes into account its distance with respect to the whole body in action, while, on the other, and at the occurrence, permitting to maintain a special focus on the limb directly involved in the specific motor context and with respect to the particular action that has to be performed (Graziano 2009; Rizzolatti et al. 1997). In this respect, while a very interesting case concerning peripersonal space representations is the one of grasping (Ibid.), and while I will discuss different aspects of peripersonal space, the final interest here is about the whole body in action, most of the time a specific action, with respect to the relevant representation of reachable space, in that context, related to visual experience.

3.2 Presence for action: Optical and phenomenological aspects of Peripersonal visual experience

A peculiar aspect of visual experience is that we usually represent objects as *present*[3] (Matthen 2005, 2010; Ferretti 2016c, 2017b, 2018, 2019a, 2020a, 2020c, 2021b). Interestingly for this paper, the content of visual experience related to the perception of presence seems to entertain a special relation with peripersonal representations. According to Mohan Matthen, the representation of an object as present is "tied to the ability to locate an object in space in such a way as to be able to interact with it" (2010, p. 122). In this respect, the representation of presence is a particular *visual* representation (Ferretti 2016c, 2017b, 2018, 2019a, 2020a, 2020c, 2021b; Ferretti and Marchi 2020). Indeed, from an *optical point of view*, within the peripersonal space we find the conscious visual impression that we can derive what in vision science is called *Egocentric Absolute Depth* (Vishwanath 2011, 2014; Ferretti 2016c, 2017a, 2017b, 2018, 2019a, 2020a, 2020c), which is related to a particular visually represented spatial relation that the observer entertains with the object of perception (Ferretti 2016c), as the "observer has knowledge of the depth relations scaled in some meaningful way to the actions of the observer" (Vishwanath 2011: 222; see also p. 206). Here is, then, an important notion concerning the *content of peripersonal visual experience*: when a subject S visually attributes the property of being *present* to an object *o*, S visually represents *o* as an object that is situated in S's peripersonal action space and, thus, that offers the visual impression of reliable motor interaction (see the analysis by Ferretti 2016c). Furthermore, the visual representation of absolute egocentric depth is related to stereopsis (Ferretti 2016c, 2018). Thus, at the *optical* and *psychophysical* level, *stereopsis* related to *egocentric absolute depth* is the peculiar visual process that allows us to perceive an object as vividly present in our action space (Ferretti 2016c, 2018, 2020a, 2020c, 2021b). For this reason, vision science has reliably shown that the strongest perception of presence of an object in our visual experience is given when the object is presented within the peripersonal action space (Vishwanath 2011, 2014; Ferretti 2016c, 2018, 2020a, 2020c, 2021b).

This perceptual fact is, in turn, strictly related to some peculiar aspects of the visual, phenomenal dimension of stereopsis, in the domain of the *peripersonal content of visual experience*. Indeed, the visual representation of presence due to stereopsis, related to objects presented within the peripersonal space, fosters in us a particular visual phenomenology. During peripersonal visual experience of presence of an object in our motor space, we usually have a phenomenology enriched with particular properties, depending on specific visual qualities related to material aspects, leading to an enhanced sense of strong three-dimensionality, solidity and immersiveness (Vishwanath 2011, 2014; Ferretti 2016c, 2017b, 2018, 2020a, 2020c, 2021b). The perception of present objects falling within the peripersonal space, related to stereopsis, leads us to visually experience a 'sense of real separation in depth between points on an object/part or between objects/parts themselves; the former yielding the characteristic visual impression of "solidity", and the latter yielding the impression of a "real" negative space' (Vishwanath 2014: 174). This also relates to a 'sense of tangibility'

[3] I am not analyzing here the relation between 'presence' and 'reality', see (Ferretti 2016c, 2018, 2021b; Matthen 2005, 2010).

as an ‘impression of the manipulability of a real material object’ (Ibid.) and of ‘spatial immersivity’ as an ‘impression of the capacity to move through a palpable negative space’ (ibid.; see also Vishwanath and Hibbard 2013). Furthermore, this experience fosters the ‘vivid sense of protrusion where a tangible solid object reaches or looms out through the negative space toward the observer’ (ibid.) allowing us to reach the strong sense of presence linked to stereopsis and often called the ‘plastic effect’ (Vishwanath 2011: 224–225, 2014; Vishwanath and Hibbard 2010, 2013; Ferretti 2016c, 2017b, 2018, 2020a, 2020c, 2021b), which is related to the visual, spatial aspect of presence more connected to the feeling of a capacity to suitably interact with the perceptual object, being absolute depth estimated. This is in turn related to ‘a sense of clarity and visual sharpness’ (ibid.), not directly depending on depth, as well as to ‘a more enhanced impression of color and color variation’ (ibid.) and ‘material qualities such as glossiness, shininess, roughness’ (ibid.). All this leads to the visual impression of a capacity to effectively interact with present objects in our peripersonal action space.

An important clarificatory remark is that here the notion of ‘egocentric absolute depth localization’ is related to the notion of ‘peripersonal action space localization’ because the notion of ‘egocentricity’, in Vishwanath’s jargon, refers to the possibility of a peripersonal encoding in high-level recognition of presence for action with respect to the perspective of the viewer, which, of course, is in line with the notion of egocentricity discussed here (for a technical review, see Ferretti 2016c, 2018). This terminological endorsement does not conflict with the fact that egocentric localization, as described above, is given also for objects falling in the extra-personal and vista space (cfr. §3.1). This is just a matter of terminological distinction between ‘egocentric’ and ‘peripersonal’ (Ibid.).

So, the plastic effect fosters the most enhanced *vividness in the visual content of experience* concerning presence of an object, and is reached only through *stereopsis*, which depends on the representation of *egocentric absolute depth,* which is possible (except for special experimental cases) only with *objects presented in the peripersonal space* (Ferretti 2016c, 2018, 2020a, 2020c; Vishwanath 2011, 2014).

This is in tune with recent experimental research showing enhanced perception of objects located in the peripersonal space of the viewer (with respect to extra-personal-space), particularly in their detection and discrimination – this is not just simply because objects located close to our body are perceived as bigger than farther ones, as even in particular experimental conditions in which farther objects appear bigger than closer ones, those shapes presented in peripersonal space are better discriminated, arguably due to the availability of ocular vergence and particular depth cues (Blini et al. 2018; cfr. §2). This is also reflected by studies suggesting that several stages of visual processing show deep selectivity and preference for stimuli presented within such a spatial location (Quinlan and Culham 2007). This is, arguably, because objects in peripersonal space are indeed processed for an efficient manipulation - not by chance, object perception is very accurate near the hand (Dufour and Touzalin 2008; Reed et al. 2006, 2010). Thus, object discrimination and peripersonal space representation are deeply related: objects located in peripersonal space offer special visual benefits that result into enhanced visual processing, as depth cues can, within this space, improve shape perception, regardless of the physical size of the object perceived (Blini et al. 2018).

Accordingly, based on the idea that objects in peripersonal space, but not in the extra-personal space, directly trigger action responses – things being arguably so in order for the subject to avoid dangerous objects or events in the environment (cfr. §6) - it has been clearly shown that the accuracy of visual predictions of possible collisions between moving objects visually perceived is determined, with respect to the spatio-temporal constraints related to the movement of the objects presented, by whether or not such objects are presented within peripersonal space, with respect to extra-personal space (Iachini et al. 2017).

Taken together, these sets of evidence suggest a special link between the enhancement of visual perception and the mechanism of peripersonal space localization (with respect to extra-personal space).

This leads us to suppose, as we shall see (§4), that with respect to the visual representations responsible for detecting visual presence in peripersonal space for motor interaction, the closer objects are placed with respect to us, the more our visual experience changes, this meaning that visual changes are greater as distance decreases.

This description of the *peripersonal content of visual experience*, which is based on both psychological, optical and phenomenological aspects, provides an interesting and solid answer to Q3: it tells us what kind of *peculiar* content peripersonal experiences do have. Furthermore, in doing so, it also explains the peculiar relation of action and peripersonal space when it comes to the contents of visual experience, by specifying how to characterize the visual content of experience with respect to action performance in motor space, thus satysfying Q1, Q2 and Q3. But this also tells us something important about Q2. The demanding character of objects presented in peripersonal space is arguably given by their peculiarity in our visual phenomenology. Indeed, these data confirm the idea that object detection and discrimination are improved in peripersonal space - they "demonstrate a persistent shape-discrimination advantage for close objects" (Blini et al. 2018: 1868) - but also suggest an enhancement in color processing.

What I am saying is very important for the literature, as the nature of peripersonal perception is in the spotlight of a lively debate in cognitive science (Hunley and Lourenco 2018; de Vignemont and Iannetti 2015), but visual experience of objects close to us is so natural in everyday life that the peculiarities of this experience have not been discussed (Blini et al. 2018), especially from a philosophical point of view.

As we shall see in the next section, the way peripersonal experience is structured is also reflected by the way our visual streams cooperate in realizing such a peculiar visual experience (§3.3).

3.3 On the neurophysiological aspects of Peripersonal visual experience: The 'Two Visual Systems' model

At this point, however, there is a problem. We saw that DVA follows the TVSM, according to which the activity of the portion of the visual system responsible for generating the content of our visual experiences, i.e. the ventral stream, is detached from the activity of the portion of the visual system responsible for the guidance of action in the peripersonal space, i.e. the dorsal stream. Thus, it is only the dorsal stream that subserves peripersonal perception.

If the activities of the two streams, respectively related to conscious recognition and action processing, are anatomo-functionally separated, how can we reconcile optical, psychological and phenomenological evidence with the neurobiological evidence about the neurophysiology of vision when it comes to the idea that the peripersonal content of visual experience is specially tied to motor action, as discussed in (§3.2)? The DVA suggested that, according to the TVSM, we cannot defend the EBC, namely the idea that "Conscious visual experience presents the world to the subject in a form appropriate for the control and guidance of fine-tuned, real world activity" (de Vignemont 2018: 2.1). However, we can still embrace the EBS, according to which "Conscious visual experience presents the world to a subject in a form appropriate for the reason-and-memory based selection of actions" (Ibid.). And, more precisely, "Conscious visual experience presents peripersonal space to a subject in a form appropriate for the motor selection of actions" (Ibid., cfr. §2). This would still suggest that visual experience of peripersonal space (even that of the sort I've described in §3.2) is, in some manner, related to action. This would not be, however, the whole story.

Indeed, it is worth noting that DVA is taking into account the old view of the TVSM, according to which the ventral stream selects targets for action by recognizing an object in the visual scene and, at that point, the dorsal stream computes the thin motor parameters for suitable action performance with that specific object (Milner and Goodale 1995/2006, 2008), i.e. the famous *Tele-Assistance View* (Milner and Goodale 1995/2006; Clark 2001), in accordance with the EBS.

Now, it is true that, due to *response selection*, which is a recognition process involving conscious visual experience, the ventral stream selects objects for *action planning*, while the thin motor parameters represented on the basis of the geometrical arrangement of the object, and which generate overt visuomotor interaction with it, are due to the motor computations of *motor programming* computed by the dorsal stream (Ferretti 2016a, 2016b, 2018). However, recent compelling evidence suggested that several visual tasks related to perception for action are subserved by strong anatomo-functional interactions between the streams (Ferretti 2018, 2019b, 2020d, 2021a; Briscoe 2009; Briscoe and Schwenkler 2015; Chinellato and Del Pobil 2016; de Haan et al. 2018). In this respect, not only the two streams interact, even for what concerns *motor programming* and *action planning*, but it has been suggested that it would be more appropriate to say that we can distinguish between mainly ventral and mainly dorsal interplays: saying that an interplay is 'mainly ventral' means that, although its processing is given by interstream interactions, ventral processing plays the predominant role with respect to dorsal processing in the task subserved by this interplay in a given visual context; the same holds for the manly dorsal interplay (Ferretti 2018, 2019b). Thus, both object recognition and action processing depend on these two different interstream interactions, and are never fully processed, in healthy humans, by just one stream. Accordingly, *action planning* depends on a mainly ventral interplay, while *motor programming* relies on a mainly dorsal interplay (Ibid.). If so, we might suppose that peripersonal visual experience depends on interstream interaction and not only on dorsal processing. In turn, also the EBC might be true. Let us go more slowly on this, concerning some specific evidence crucial for the point at stake here.

First of all, the dorsal stream participates in object recognition mainly subserved by ventral processing, as well as in the generation of visuospatial awareness of objects presented in peripersonal space, which is crucial for *action planning* mainly ventrally generated (for a critical review, see Brogaard 2011; Gallese 2007; Ferretti 2016a, 2016b, 2016c, 2017c, 2018, 2019b, 2020d, 2021a).

Second, it has to be noted that stereopsis massively depends, following the TVSM, on the activity of the ventral pathway, for the reasons reported above about its crucial role in recognition, also for action planning purposes (Ferretti 2016c, 2018). But, if peripersonal space is related to stereopsis (cfr. §3.2), peripersonal visual experience should have a special link with ventral processing. However, it is not exclusively related to it. Interestingly, some recent study suggested a particular recruitment of the posterior parietal cortex when viewers have visual experience, documented with phenomenal reports, of the visual qualities related to stereopsis, described in (§3.2) (Uji et al. 2019a, 2019b). This confirms how stereopsis is so deeply related to the visual experience of presence for interaction that also parietal regions related to the dorsal stream, which is the cutting edge of motor programming, are activated during visual experience related to stereopsis, mainly subserved by ventral processing. Accordingly, the parieto-occipital cortex seems to display a strong preference for responses toward objects located in the peripersonal space, compared to far space (Quinlan and Culham 2007). In this respect, depth and near vergence information, processed also in the dorsal stream, are crucial for the perception of close objects, given their importance in order to properly give rise to stereopsis, and for reaching visual estimates guiding accurate action processing (see Quinlan and Culham 2007 for optical and neural details)[4] - as cases of optical deficits suggest (§7.1).

[4] Interestingly, from an optical point of view (cfr. §3.2), in an experiment assessing the preference of the visual brain for close stimuli, based on depth cues related to the looming effect of the object, "one strong cue to depth was the near response based on oculomotor cues. The near response occurs when subjects gaze at a close object, causing the eyes to rotate inward (convergence), the lens to thicken (accommodation), and the pupils to dilate. These three yoked responses – vergence, accommodation and pupillary diameter – are sometimes referred to as the near triad" (Quinlan and Culham 2007: 168). That said, while the 'near triad' is, in standard perceptual cases, usually 'yoked', this does not happen necessarily, e.g. in every visual scenario. For example, vergence can be dissociated from accommodation in the case of virtual realities. This is the case discussed by Svarverud et al. (2012), in which participants remain unaware of a 4-fold expansion, in size, of a virtual room (and, thus, in the distance of virtual objects), when the pictorial cues are manipulated in a way that changes related to vergence, accommodation and proprioception (this being related to walking across the room in order to view the object) cannot serve as basis to perceive the size and/or distance of objects. I agree that: "This astonishing lack of awareness of object size and distance is potentially highly informative about the central processing of spatial information" (p.1), as this results tell us something new about possible dissociations of optical mechanisms. That said, the reader should note that the evidence on dissociations in distance cues (and the related impossible non-transitive perceptions of distance that can be produced), does not affect at all the philosophical account presented here, as they are due to special experimental scenarios reached by means of virtual scenes. But the present article is interested in usual cases of standard perception we have in normal conditions. More specifically, even if relying on experiments, it wants to investigate what we can say about peripersonal visual experience in standard perceptual cases, not in cases in which virtual realities are involved. So, the fact that these mechanims can be, in principle, and by means of a virtual reality setting, dissociated does not deny that they are the crucial ingredients, working together in everyday situations, at the basis of the standard optical mechanisms subserving visual experience of presence within peripersonal space.

Thus, in the light of all the evidence above mentioned, the complex mechanisms of visual stereopsis, peculiarly related to peripersonal visual experience, seem to depend on interstream interplay.

In this respect, crucially, also the ventral stream directly participates in visuomotor processing for *motor programming*, as several portions of the ventral pathway are involved in directly controlling online motor performance (for a technical review see Briscoe and Schwenkler 2015; Chinellato and Del Pobil 2016; Ferretti 2018, 2019b, 2020d, 2021a). This is not surprising, given the crucial ventral role in stereopsis, which is arguably massively related to action planning, and given the special link between stereopsis enhanced visual features and the possibility of perceiving presence for reliable action within peripersonal action space processing, which is deeply dorsally processed.

Furthermore, it has been recently suggested that a mainly ventral interplay is the one involved in the conscious recognition of an object as present and suitable for *action planning* for motor interaction, and for its discrimination *contra* pictorial objects, as well as for objects presented in *vista* space (Ferretti 2018; see also Ferretti 2016c). Indeed, given the ventral specialization in object recognition, while obtaining an important contribution from dorsal processing in object awareness within the peripersonal space, such an interplay is the one that is arguably mostly involved in *absolute egocentric localization* and, thus, allows us to appreciate, in our visual phenomenology related to the content of peripersonal visual experiences, those visual qualities discussed above that are peculiar of present objects, which are those presented in the peripersonal space for motor performance (Ibid.). This is in tune with the evidence on how the interaction between the streams, giving raise to the interplay between *action planning* and *motor programming*, is at the basis of reliable *affordance* perception (cfr. §5) (only) with present objects falling within the peripersonal space, *contra* those falling outside this space (for a review of how the streams give raise to such a particular interplay when detecting an affordance related to a present object, see Ferretti 2016a, 2016b, 2016c, 2018, 2020b, 2021a; Chinellato and Del Pobil 2016; Ferretti and Chinellato 2019; Zipoli Caiani and Ferretti 2017).[5]

Accordingly, it has been suggested that, due to interactions, both the streams participate in spatial perception, for what concerns egocentric representations (Briscoe 2009) – recall that vision, independently of which is the visual stream or the visual context, is always egocentric (Ibid., cfr. §3.1) - viewer-variant and viewer-invariant object reconstruction (Farivar 2009) and conscious monitoring of objects in the peripersonal space (Ferretti 2018).

In the light of these sets of evidence, it is possible to claim that peripersonal perception is, thus, not subserved only by dorsal processing, as the DVA suggested, but by the interaction between the streams, especially by a mainly ventral interplay, which generates the visual experience, related to stereopsis, of presence for interaction in action planning within the peripersonal space. This interplay,

[5] The account on interstream interplay can also explain how the visual sense of presence can be gradually lost as the object pertains to far space (Ferretti 2016c, 2018; cfr. §4).

indeed, constitutes the neurophysiological basis for the computational distinction between present and pictorial objects, as well as, in turn, between near objects within the peripersonal space and far objects in vista space (for a recent review see Ferretti 2018; cfr. §4).

If so, we have a much stronger relation than the one proposed by DVA when it comes to peripersonal perception and visual consciousness: not only visual experience does participate in the selection of the targets for action, but can also be involved in the control of action performance upon the object. Thus, when it comes to the nature of peripersonal space, not only do these studies support the EBS, but the evidence on interstream interaction does also crucially support the EBC: peripersonal visual experience is at the service of *planning*, *programming* and, thus, *control* of motor actions.

This effectively illustrates, beyond the DVA, through a confirmation of the EBC, but also of the EBS, the role of interstream interplay, in particular a mainly ventral interplay, in the generation of the visual experience of presence for interaction within the peripersonal space (§3.2), thus further suggesting both how 'action determines peripersonal perception' (de Vignemont 2018: sect. 2.1) and 'in what manner peripersonal perception determines action' (Ibid., cfr. §2).

All this suggests that optical, psychological and phenomenological evidence about a peculiar phenomenology of the peripersonal content of experience (§3.2) is perfectly in line with the neurobiological evidence about the neurophysiology at the basis of the functioning of our visual system.

Now, a way to better appreciate the peculiarity of peripersonal space is by comparing the visual difference between this space and a space that presents objects very far compared to peripersonal coordinates: *vista* space. This is the aim of the next section.

4 Far beyond Peripersonal spatial experience: Vista space and Pictoriality

I anticipated (§3.2) that the more we get far from peripersonal localization, the more our perception changes, especially with respect to the visual representations responsible for detecting visual presence for interaction. These sets of evidence presented in (§3.2) allow us to say more on the peculiarity of peripersonal visual experience. They answer to the question – i.e. Q3 - of which are the peculiarities of the contents of peripersonal experience with respect to the contents pertaining to the visual experience of far objects. Indeed, differently from objects presented in peripersonal space, objects falling within '*vista space*', which is the space in which we find the objects that populate the visual scene of a landscape, e.g. the threes far away on that mountain, foster almost absent plastic effect and, for this reason, distant objects located within landscapes usually appear *pictorial* (Vishwanath 2011: 225–228): "the plastic effect appears to diminish with viewing distance under *binocular* viewing of real scenes, although conflict among cues does not change with viewing distance under these conditions. This can be easily demonstrated by going outdoors to a location that affords visible objects ranging in distance from less than a meter to more than several hundred meters, as well as an unobstructed view of more distant objects beyond (in so-called vista space). When one compares the difference in "plasticity" between monocular and binocular viewing for successively farther object clusters, the differences appear quite marked at near distances but diminish with increasing distance and are essentially absent in vista space beyond. This occurs despite any changes in cue conflict. In fact, observers comment on how distant landscapes often appear "pictorial." Widespread empirical evidence indicates that the reliability of various sources of egocentric distance information (vergence, accommodation, disparity) reduces with increasing distance, which suggests a link between the reduction of the plastic effect and the reduction in reliability of egocentric distance information; and, in turn, the reliability of absolute depth estimates that rely on distance estimates" (Vishwanath 2011: 225). Accordingly, "while perceived distances are significantly foreshortened for objects located more than 30 m away, in what Cutting and Vishton (1995) call *vista space*, the egocentric distances of objects located up to 2 m away, in personal space, are perceived with nearly metric accuracy. The difference in precision is a function of the spatial information available to the visual system. Estimates of depth for objects in personal space are powerfully constrained by stereopsis, convergence, and accommodation. As distances lengthen, these binocular sources of depth information drop off in effectiveness, and the visual system must rely increasingly on somewhat less precise monocular or "pictorial" cues in the light sampled by the eyes" (Briscoe and Schwenkler 2015: 1435–1436). So, depth processing related to close objects is useful (cfr. Ibid.) to "the ability of human observers to accurately manipulate objects around them" (Cutting and Vishton 1995: 100, also quoted in Briscoe and Schwenkler 2015: 1436). Crucially, in accordance with (§3.3), while computation of different (peripersonal vs. vista) visual spaces requires different mechanisms, it cannot be precisely segregated in a distinction between ventral and dorsal processing, as the DVA suggested, as it is still an interstream interplay, particularly a mainly ventral interplay, the one responsible for this visual computation (Ferretti 2018).

All this is perfectly in line with our everyday phenomenological experience, as well as our philosophical investigations, according to which, when it comes to our visual experience of landscapes, it is often judged pictorial (Matthen 2005: 322-323; Ferretti 2016c: 8, Ferretti 2018: footnote 27; Nanay 2011: 470): "Our grasp of spatial relations in a distant mountain range is likely very little different from that of objects in a picture" (Matthen 2005: 323).

Summing up, the visual representation of presence is deeply linked to peripersonal space for motor interaction: the more an object falls near to our action space, the more it will foster presence in our visual content of experience, with the consequent changes in the specific phenomenology of the features described above. Thus, the visual representation of absolute egocentric depth is poor when distance is too pronounced (Vishwanath 2011: 225-228) and, for this reason, the content of vista space visual experience carries no presence.

This further answers to Q1, about whether we should characterize in details the relation between peripersonal space and action and why such a peculiar relation to action is not possible in the case of the perception of far space, i.e. vista space.

This also further explains, in relation to Q2, how the force of the more demanding character of objects presented in peripersonal space is given by their peculiarity in our visual phenomenology, with respect to the phenomenology of those objects falling within our vista space.

Finally, this suggests that presence can be appreciated in many shades: objects can be visually represented as less present the further they are away, outside of our action space.

5 Demand character, answerability, affordances and the body

All I've said in the previous sections suggests how peculiar the demanding character of *peripersonal visual experiences* can be, especially compared to the experiences of objects in *vista space* (§4), in relation to Q1, Q2 and Q3.

Indeed, in responding to Q2, the DVA suggests that there is a special demand character of objects in peripersonal space, which fosters a feeling of answerability due to their affordances, and this is due to evolutionary reasons for interaction, survival and defense actions.

At this point, my analysis of visual experience (§3.2), as well as of the relation between the TVSM and the EBC (§3.3), also confirms how the answer to Q2, proposed by the DVA (which I agree with) is related to the answer to Q3. In relation to Q2, the feeling of answerability to the demand character of experience in the peripersonal space is particularly related to the way we visually experience the objects found in this space, which display all the peculiar, enhanced visual cues related to motor action that only objects found in peripersonal space can display, thanks to the possibility of stereopsis and absolute egocentric localization (cfr. §3.2). This suggests a special relation between the presence of a feeling of answerability to the demand character of objects affording action (Siegel 2014), which are found in the peripersonal space (de Vignemont 2018), and the quality of their visual experience, as confirmed by the absence of the visual characteristics of such an experience in vista space (cfr. §4).

Thus, the feeling of answerability fostered by the demand character of objects available to action within peripersonal space is grounded on the way they are encoded in our cortical networks with respect to action and space (§3.3), and, in turn, reflected by the way we visually experience them (§3.2). This is suggested by the fact that we can embrace, in the light of the TVSM, the EBC, which suggests how visual conscious experience and action processing are deeply related, giving raise to a peculiar visual peripersonal experience, grounding both the selection of targets for action and the motor programming to be used with them, and whose visual content shapes special visual features that objects falling outside peripersonal space cannot offer (cfr. §4).

As anticipated, this answer to Q2 is related to the answer to Q3. Indeed, concerning the relation between Q2 and Q3, the peculiar visual enhancement of the presence for interaction displayed by objects presented within the peripersonal space, whose description is crucial for an answer to Q3, is related to the perceptual fact, whose description is crucial for an answer to Q2, that our visual system better discriminates them, selects them, and then computes possible reliable interaction with them in the best manner, with respect to the peculiar motor possibility they afford to us, in order to satisfy the feeling of answerability they foster, at the basis of their peculiar demand character.

Summing up, the way the content of peripersonal visual experience is structured, an answer to Q3, is directly related to its powerful demand character, recalling a possible answerability, whose description offers an answer to Q2.

However, I maintain that, while such a peculiar content of visual experience fosters an enhanced sense of presence for motor interaction, in line with DVA, it has no demand character that puts the subject in the position of feeling that she is obliged to act.[6] Indeed, it has been suggested that affordance perception is not *normative* (Nanay 2013), and that our brain encodes affordances regardless of whether we were looking for them, or we will act on them (Ferretti 2016a, 2016b, 2016c, 2017c, 2018, 2019b, 2020b, 2021a).

All this suggests that the peculiar demand character of visually experienced objects falling within the peripersonal space, related to the affordance of action, and concerning the enhanced feeling of answerability, is reflected on *neural*, *behavioral*, *optical* and *phenomenological* aspects.

For this reason, as previous studies have stressed, and in line with the DVA (§1), peripersonal space is the space of affordances[7]: affordances are offered by objects we can act upon, but objects we can act upon are presented within peripersonal space, thus, peripersonal space is the space where affordances are detected. Detection of affordances in particular, and motor responses in general are, thus, peripersonally spatially constrained (for a review of different aspects of this link see Cardellicchio et al. 2011, Costantini et al. 2010, 2011; Iachini et al. 2014; Ferretti 2016a, 2016b, 2016c, 2018, 2019b, 2021a). This is due to the fact that peripersonal space is reachable space (not surprisingly, thus, objects in reachable space are perceived with the visual enhancement fostering motor action described up to now). This reflects what I have already anticipated (§3.2) that the ability to visually experience an object as offering motor interaction (e.g. manipulability) depends on its representation as falling within the peripersonal action space (Ferretti 2016a, 2016b, 2016c). Thus, peripersonal action space and action performance cannot be detached. (Again, this, of course, also depends on the definition, discussed in this paper, of peripersonal space as reachable space for action performance, cfr. §3.1).

And it is not by chance that such a peripersonal space of affordances is peculiarly related to the body, and that the integration of several multimodal stimuli occurring within peripersonal space is crucial for obtaining bodily self-consciousness (for a review see Blanke et al. 2015; Serino 2019; Noel et al. 2015; Hunley and Lourenco 2018: 4.1; de Vignemont and Iannetti 2015) – accordingly,

[6] For completeness, it is worth mentioning the interesting case of particular frontal lobe deficits, which can lead to the famous '*utilisation behavior*', which represents an example where the demand character induces the unavoidable urge to act in the patient (see Eslinger 2002).

[7] In accordance with the neurophysiological analysis within the framework of the TVSM, we know of a special relation between action and peripersonal space that is grounded on some structural, anatomo-functional connections between the (parietal-premotor) cortical networks underlying motor action and those underlying peripersonal encoding of reachable space (for a review see Chinellato and Del Pobil 2016; for a philosophical review see Ferretti 2016a, 2016b, 2016c, 2017c, 2018, 2019b, 2021a).

the body is a crucial egocentric reference for the content of our peripersonal space visual experience (§§3.1, 3.2, 7.2). In this respect, it has been suggested, on both phenomenological and neurophysiological grounds, that the body is something we experience as a power for action related to the numerous motor possibilities that the environment affords us and which determine the representations of our surrounding space (for a review see Gallese and Sinigaglia 2010, 2011). I'll get back to the relation between the body, peripersonal representations and the content of visual experience in (§§ 6, 7.2).

But this is not the whole story. Peripersonal space is also related, as we have seen (§2), to defensive behavior, which makes it a peculiar emotional space. This emotional aspect of peripersonal space is addressed in the next section.

6 An emotional space

The DVA suggests the presence of an emotional peculiarity in peripersonal space perception (de Vignemont 2018: Sect. 3.2, cfr. §2), especially when it comes to threat and fear, which arguably also relates to the content of peripersonal experiences. Indeed, peripersonal space is the space of action, but action is not always related to *inter*-action, as it can usually relate to defensive behavior for the purpose of escaping a dangerous situation, thus avoiding possible problematic interactions.

First of all, compelling neurophysiological evidence can relate my description of the peculiarity of peripersonal visual experience to this particular feature mentioned by DVA. Indeed, both visual streams project to different areas of the orbito-frontal cortex, in turn connected to other brain areas involved in emotional encoding (Barrett and Bar 2009). First, the medial orbito-frontal cortex is connected to the dorsal stream and to its lateral parietal areas (MT and MST). Thanks to magnocellular pathways, it receives low spatial visual information that is used to generate an initial representation of the identity of the visual target (Barrett and Bar 2009: 1329) for computing the initial affective information about it, triggering the internal bodily responses needed for potential action performance related to that particular target in that specific context (Barrett and Bar 2009: Sect. 6). Thanks to neuroanatomical connections to the lateral parietal cortex, the medial orbito-frontal cortex can deliver the information, useful for bodily responses, to the dorsal stream, so that an initial estimate of the affective meaning of the target for action is generated (Ibid.). Furthermore, parvocellular pathways connect the lateral orbito-frontal cortex to the inferior temporal areas (TEO, TE and temporal pole) related to the ventral stream (Barrett and Bar 2009: 1330). Since, through the interplay with the inferior temporal cortex, the ventral stream can process high-resolution visual cues that lead to visual experience and since the lateral orbito-frontal cortex manages object identification concerning the emotional significance of a target in relation to a given visual context, then, ventral conscious visual representations of different objects' properties march in step with a conscious emotional response concerning the affective features exhibited by the object. If so, the interconnections between the streams are reflected, thus, not only at the visual level, but also at the level of affective encoding of visual targets, thanks to their anatomo-functional connections with these emotional areas. And this deep link arguably shapes and modulates the visual affective content of peripersonal experiences (Ferretti 2016b, 2017a; Ferretti and Chinellato 2019; Chinellato, Ferretti and Irving 2019), in the light of what it has been said about interstream interaction (§3.3).[8]

Thus, given the threats we can often find within our environment, our motor representations, which are the cutting edge of our vision for action (Ferretti 2016b, 2020d; Ferretti and Zipoli Caiani 2018, 2021, forthcoming) oriented in peripersonal space, and which are based on these cortical interconnections, can be, on occasion, infused with an emotional charge (Ferretti 2016b; Ferretti and Chinellato 2019; Chinellato, Ferretti and Irving 2019). Thus, motor interaction can be sometimes shaped according to such emotional demands.

This is also reflected in the literature about emotional responses to affordances (Anelli et al. 2012): affordances can be consciously perceived as being related to dangerous features and, thus, their conscious perception can be shaped on the basis of an emotional encoding (Ferretti 2017a; Ferretti and Chinellato 2019; Chinellato, Ferretti and Irving 2019).

All I am saying recalls a specific characteristic of peripersonal visual experience, related to a specific aspect of the nature of peripersonal representations. We saw that there is a peculiar visual enhancement of objects within the peripersonal space in order for us to track their presence for suitable interaction (§3.2). However, this presence is not crucial only for positive interaction purposes (detecting an apple as near to me in order to grasp and eat it), but also for avoidant behavior, or for defensive motor responses (detecting a threatening individual close to me in order to avoid it). Indeed, peripersonal visual experience also allows us to meticulously track objects or subjects we do not want to interact with, as broken objects, or dangerous individuals (Ibid.). And this might be another aspect for which peripersonal visual experience is so enhanced (see also Blini et al. 2018: 1868).

This is confirmed by several studies on the notion of *defensive distance* related to *defensive* peripersonal space, the space close to the body in which motor responses for defense are computed (Bufacchi et al. 2017; de Vignemont and Iannetti 2015: Sect. 4).

Interestingly, in line with my characterization of the visual properties of peripersonal experience (§3.2), ocular vergence, related to depth perception, is responsible for the activation of defensive behavior. Crucially, indeed, in accordance with the relation between absolute egocentric depth computation and peripersonal experience (Ibid.): “The adaptive defensive behavior when facing a threat depends on the defensive

[8] Here I am endorsing the notion of emotional space in a very broad sense, just reporting the peculiarities, related to emotional encoding, of visual targets located within peripersonal space. In general, when a subject consciously realizes, for example, that a black blob in the visual periphery is a spider, there is a motor reaction that is also emotionally charged at the level of the subject’s consciousness. However, if the spider suddenly and rapidly enters the peripheral visual field, the motor reaction comes much more quickly. This is due to a quick and unconscious emotional encoding of the visual object. In this respect, the conscious aspect of this emotional charge would be added only later. Concerning the orbito-frontal cortex, the studies I report seem to suggest that this encodes, very quickly, stimuli that can have an emotional impact on our perception when it is unconscious and, thus, in principle related to the fast and automatic guidance of motor (re)action. However, it is also responsible for the conscious elaboration of the emotional encoding related to the visual recognition of an object, at a later stage of visual processing. While emotional states can be conscious or unconscious, also the orbito-frontal encoding seems to operate at both levels.

distance, i.e., the distance between the prey and the predator (…). In a natural environment, this defensive distance will be an absolute distance, i.e., the depth between the prey and the predator. So depth perception might be involved in the mechanisms of the defensive system" (Combe and Fujii 2011: 1). This is in accordance with the evidence that areas subserving the perception of looming effects, such as those related to the perception of an individual coming near to us, are also involved in ocular vergence and, since we need to track the presence of individuals approaching, as they could be predators or, in general, dangerous individuals, then perception of depth thanks to vergence is related to potential defensive behavior: in particular, ocular vergence can trigger defensive responses (see the technical discussion by Combe and Fujii 2011: 1). This evidence of a defensive aspect of peripersonal space representation, reflected in the visual enhancement of peripersonal visual experience, is in tune with the evidence of the possibility of its plastic changes (cfr. §7.2), as confirmed by evidence that during the third trimester of pregnancy, the representation of peripersonal space is extended, arguably in order to protect the subject body from possible dangerous events (Cardini et al. 2019). In this respect, peripersonal representations are very flexible in defensive conditions, as the results in spatio-temporal judgments of presented looming objects depend on whether subjects are presented with dangerous vs. non-dangerous objects (Hunley and Lourenco 2017: 3.2).[9]

This is perfectly in line with the evidence that distributed functional processing such as the parieto-frontal activity is responsible for encoding stimuli related to defensive behavior in our personal space (Graziano and Cooke 2006),[10] which is in tune with what said up to now about the cortical underpinnings of peripersonal visual experience, with respect to the connection between cortical dorsal and ventral visual areas, and emotional orbito-frontal areas.

All this further clarifies the role played by emotions and affective evaluations, especially concerning defensive behaviors, in the acquisition of the visual content of peripersonal experience, in a way that is compatible with DVA, concerning the neurobiological, psychological and phenomenological levels of description of visual processing.

7 Peripersonal space visual experience, optical deficits and bodily impairments

Peripersonal space offers a peculiar visual experience of objects affording action, and depends upon the body. Things become very interesting when considering problems afflicting one of these two components. Discussing these problems is the aim of the next two sections.

[9] It is not by chance that the visibility of objects presented in the peripersonal space automatically modulates postural behaviors (Bonnet et al. 2010). Furthermore, defensive responses in peripersonal space are not always automatic, but can also be influenced by cognitive evaluations (de Vignemont and Iannetti 2015: Sect. 4).

[10] In line with footnote 7, there is also evidence that the cortical networks involved in defensive and non-defensive behavior are also related, in different manners, to those (parietal-premotor) cortical networks subserving peripersonal encoding and motor interaction (Hunley and Laurenco 2018: 3.3).

7.1 Optical and visual deficits

What about the development of peripersonal space in case of optical and visual problems? How would the content of the peripersonal visual experience change in the presence of such deficits? Here are some interesting cases worth discussing.

A first interesting case is that of the famous *stereoblindness*. *Stereoblind* people cannot rely on the visual experience related to stereopsis, as described in (§3.2), this being (usually) due to problems related to the coordination of the two eyes in vergence (i.e. simultaneous movement of the eyes in order to obtain the image of the target object at the center of the retina), such in the case of *strabismus*, in which the eyes do not properly align when fixing a target.[11] As a result, the scene does not display all the enhanced visual cues related to plasticity, absolute depth, interactability and three-dimensionality, described in (§3.2), that are proper of the visual perception of presence for interaction in peripersonal visual experience. One of the most famous cases is the one of Dr. Susan Barry (better known as *Stereo Sue*) a *stereoblind* vision scientist who, in his famous book (2009), reported and discussed several analyses concerning the lack of such visual qualities, described above, in *stereoblind* subjects. For example, some *stereo*-blind people simply see, simultaneously, two scenes (as if they were pictorial, in line with what said in §4), and they have to make guesses at which of the two sisters scenes is the one pertaining to the real environment (for more technical details, see Barry 2009: pp. 26-28). This clearly impairs what should be, in healthy conditions (§3.2), the normal visual enhancement of visual experience of present objects a subject can interact with in the peripersonal space. Fortunately, there are cases of recovery, which confirm the peculiarity of the visual experience of stereopsis related to action and space visual representations, as novel *stereo*-sighted subjects reported the sudden appearing, in their new and astonishing visual experience, of visual qualities such as looming effects, palpable and negative space and immersiveness, and an enhanced three-dimensionality and solidity of what we are describing here as visually present objects suitable for action (for the phenomenal reports in details, see Barry 2009: 122–132). So, after recovery, these people can, for the first time, due to the fast improvement of visual spatial perception (cfr. §7.2), visually appreciate (and then gradually improve in such an appreciation) all the very enhanced visual cues, related to stereopsis, which characterize the visual experience of objects perceived within the peripersonal space. This evidence on recovery, with the related reports, clearly suggests the importance of stereopsis for peripersonal space visual experience (in action).

In this respect, it would be interesting to test *stereo*-blind people before and after recovery in order to properly investigate, both on phenomenological and neurophysiological grounds, the specific relation between stereoblindness, whose disruption of stereopsis causes the impossibility of relying on all the very enhanced visual cues responsible for the visual experience of presence for reliable motor interactability, and changes in peripersonal space visual perception. This would indeed give us an idea of the special link between the possibilities of relying on visual stereopsis and the

[11] While it has been shown that stereopsis could be achieved even in monocular conditions, but in special experimental contexts (Vishwanath 2014; for philosophical discussion, see Ferretti 2016c, 2018, 2021b), stereoblind people cannot achieve it, due to these ocular problems related to the inappropriate motor behavior in the coordination of both eyes.

possibility of visually mapping and experiencing peripersonal space, with respect to the visual experience of presence for motor interaction.

A second interesting case is that concerning the recovery of visual experience after complete blindness (Ferretti 2017c, 2020b; Ferretti and Glenney 2020; Ravenscroft 2019). In line with the notion of a plasticity of peripersonal representations for action (cfr. § 7.2), recent studies (Chen et al. 2016) suggested that vision for motor interaction can be restored very fast, for example in the case of a 44-month-old child with congenital cataracts, who underwent a surgery for the removal of cataracts and the implantation, in both eyes, of intraocular lens. The infant, tested immediately after bandage removal can, after six minutes, look at target and after thirteen minutes, reach and grasp objects with difficulty, while after twenty minutes grasp performance increases, and after a day also object avoidance can be performed (p. 1069). And quite after this development, the child could soon perform also (though poor) object recognition (pp. 1070–1072). These studies explicitly show that neuroplasticity permits to rapidly develop, through recalibration and learning, visuomotor performance concerning eye-hand movement coordination (see the discussion by Ferretti 2017b of Chen et al. 2016: 1070, 1072; see also Ferretti 2020b; Ferretti and Glenney 2020).[12] Implicitly, they suggest that mapping of peripersonal visual space can be developed very fast after training.

In this case, it would be interesting to test, along with phenomenal reports, how peripersonal space is visually experienced, with respect to the visual cues related to stereopsis, as well as to understand how it is mapped within the visual brain, after recoveries such as this are performed. This would suggest how specifically visual peripersonal space representation is developed. This case is important as, while peripersonal space has been massively studied in adults, only recently there has been interest about its development in infants and newborns (Orioli et al. 2019), and, to my knowledge, there is no mention of its development after sight restoration.

Of course, peripersonal space can also be non-visually represented, as it has a strong multimodal nature (Serino 2019; de Vignemont and Iannetti 2015). An interesting point concerns when vision is not available, but peripersonal space can still be mapped, for example, in the case of auditory-tactile peripersonal space representations developed in blind people. In this respect, it has been suggested that, in the case of blind subjects who make everyday use of a cane for navigation purposes, there is the possibility of building an auditory peripersonal space, based on audio-tactile information, related to the spatial region around the hand (the auditory peri-hand space), which has similar plastic dynamic properties compared to the visual peri-hand space. As comparison of performance in blind and sighted individuals show, furthermore, on the basis of the amount of everyday practice, such space representations are, on the one hand, highly plastic, as they can be quickly modified by experience and training, while, on the other,

[12] It would be interesting to consider a Molyneux's question formulation concerning peripersonal visual experience (and even in relation to stereoblindness), on the basis of what it has been already said in the literature concerning this question and spatial and motor perception (Ferretti, 2017c, 2020b; Ferretti and Glenney 2020).

they tend to remain intact over time if developed and reinforced in a specific manner within a long-term experience (Serino et al. 2007; cfr. §7.2).[13]

7.2 Bodily impairments and plasticity

As we saw that peripersonal space representations are related to the body (§5), it is interesting to consider what happens to such representations in the case of bodily impairments, as well as in conditions impairing normal movement. In this respect, there are interesting cases like amputations or congenital limb defects where the visual system is not affected, but the motor possibility is limited. Is the content of visual experience different in such cases? Let us go more slowly on this.

Recent empirical attempts tried to understand the nature of peripersonal space representations when it comes to subjects affected by amputations (Canzoneri et al. 2013). These studies clearly suggest, in line with results on the high plasticity of peripersonal space representations (but cfr. footnote 15), coming from studies investigating whether tool use can reshape and extend peripersonal representations (Berti and Frassinetti 2000), that the use of prosthesis can modify the peripersonal representation related to the use of a specific limb.

The reader should note that, as the studies on the plasticity of peripersonal space representations show (for a review see Serino 2019), while several bodily peripersonal representations in the brain, with respect to specific limbs - as we can have different limb/effector/bodily-centered peripersonal representations, and so on – can be modified through practice, most of these peripersonal representations are generated at the unconscious level of representational responses (Hunley and Lourenco 2018; de Vignemont and Iannetti 2015). It is not by chance that such plasticity of body representations is related to the sense of agency and bodily schemas (D'angelo et al. 2018), in line with the notion that the space of the body is the space of affordances (§5).

For the point at stake in this paper, which is about peripersonal visual experience in general, and not any sort of peripersonal representation related to specific limbs, an interesting question is the following: can these plastic changes concerning specific peripersonal representations, and related to particular body parts - documented both in the case of plastic remapping of peripersonal space in healthy individuals, with tool use, and of remapping of peripersonal space in the case of patients with amputations, with prostheses - be reflected in the general visual content of peripersonal experience (i.e. can they change such a visual experience), or do they remain confined to specific unconscious processing of such body parts?

Take the case of patients with amputated limbs, in which prosthetic use increasing the perceived length of the limb leads to a consequent extension of the (representation of) peripersonal space toward the spatial region occupied by the prosthesis (Canzoneri et al. 2013).

In cases of particular plastic changes of peripersonal representations with respect to a limb such as this, visual peripersonal experience arguably is, overall, not altered. Recall

[13] For a very recent and critical review of the best explanation of the relation between auditory representations and peripersonal space extension, see (Holmes et al. 2020). In this respect, it seems that the nature of the possible auditory representations of distance in the human brain is not very clear. One reason is that it is theoretically very difficult to compute auditory distance in an unambiguous manner. Thus, an alleged auditory dimension of peripersonal space localization would be very different from the visual one. I thank a reviewer for this suggestion.

that here I am not interested in specific visual experiences related to limb peripersonal space alteration, but to the general visual experience of the subject concerning the visual external environment. In this respect, after all, if the visual system of the subject is still functioning well, all the visual mechanisms at the basis of the visual experience of presence that the subject has evolved in her ontogenetic development remain the same: overall, her visual experience of the peripersonal portion of the external environment can still represent the space around the whole body as a present space of action, in line with the above mentioned evidence that peripersonal space is deeply related to the acting body (§5). If not (paradoxically), such patients with limb problems would also experience the visual deficits described above, as in the case previously mentioned of an improper development of visual experience of presence (cfr. §7.1, see also §4), which is not the case: subjects do not lose the visual enhancement of the effect of visual presence.[14] Accordingly, in these cases, though the subject does not dispose of the physical possibility for performing correct interaction with respect to a given limb, and though perceptual judgments of length concerning the part of the body that is impaired can change, she can still act upon the object, with respect to some other part of the body, and by using different peripersonal representations related to non-impaired parts of the body. Again, thus, she can visually experience objects as present for interaction. Note that, when not wearing the prosthesis, the boundaries of peripersonal representation of the subject decrease with respect to the amputated limb, while they increase with prosthetic use (Canzoneri et al. 2013). But this can unlikely modify the broad peripersonal visual experience, as their visual experience of stereopsis (§3.2) remains intact.

This line of argument should hold, in principle (and *a fortiori*), for all the experimental cases, with healthy individuals, in which peripersonal representations with respect to a given portion of the body are altered, as reported in the empirical literature quoted above, but the visual system is perfectly functioning.

Summing up, there are many specific peripersonal space representations (Hunley and Lourenco 2018; de Vignemont and Iannetti 2015; see also Graziano 2009; Rizzolatti et al. 1997; cfr. §3.1), which can be, of course, modified at the level of subpersonal mapping of the body, and act at an unconscious level of perceptual processing. But here I am describing our broader peripersonal visual experience of the external environment (§3.2). Such an experience does not seem to change due to these plastic alterations of specific peripersonal representations.

8 Conclusion

I this paper, I have investigated the structure and the nature of the *Content of Peripersonal Visual Experience*, in the light of phenomenological, optical, neurophysiological and clinical evidence. I have done that by starting from the DVA and by suggesting what are the peculiarities of such a visual content of experience that were not addressed by it. Hopefully, as new empirical evidence will be offered, and philosophical investigation will obtain more

[14] This is in line with the idea that peripersonal representations are modulated on the basis of knowing-how (Jackson 2014), which could be still present in these cases, even if overt motor execution cannot be performed due to physical problems (see the analysis by Noë 2005).

conceptual tools,[15] future research at the crossroad between philosophy of vision and of the motoric, vision science, and phenomenology, will be able to uncover all the complex peculiarities at the basis of the special nature of *Peripersonal Visual Experience*.

Acknowledgements I would like to warmly thank two anonymous reviewers and Nick Holmes for addressing important comments, both on the experimental and on the philosophical side, which led me to significantly improve the first version of this article. I would also like to thank Silvano Zipoli Caiani, Anna Borghi, Giorgia Committeri, Eris Chinellato, Vittorio Gallese, Albert Newen, and Bence Nanay for offering interesting conversations on the topics addressed in the present article. Since the finalization of the work for the publication of the present article has been done during the transition from one research position to another, I would like to acknowledge support from both the corresponding fellowships. This work was supported by a NOMIS Fellowship, awarded by the Eikones - Center for the Theory and History of the Image at the University of Basel, Switzerland. This work was also supported by a Humboldt Fellowship, hosted by Professor Albert Newen at the Institute for Philosophy II, Ruhr-University Bochum, Germany.

References

Abrams, R. A., Davoli, C. C., Du, F., Knapp, W. H., & Paull, D. (2008). Altered vision near the hands. *Cognition*, *107*(3), 1035–1047.

Anelli, F., Borghi, A. M., & Nicoletti, R. (2012). Grasping the pain: Motor resonance with dangerous affordances. *Consciousness and Cognition, 21*, 1627–1639.

Barrett, L. F., & Bar, L. F. (2009). See it with feeling: Affective predictions during object perception. *Philosophical Transactions of the Royal Society, 364*, 1325–1334. https://doi.org/10.1098/rstb.2008.0312.

Barry, S. (2009). *Fixing my gaze*. New York: Basic Books.

Berti, A., & Frassinetti, F. (2000). When far becomes near: Remapping of space by tool use. *Journal of Cognitive Neuroscience, 12*(3), 415–420.

Blanke, O., Slater, M., & Serino, A. (2015). Behavioral, neural, and computational principles of bodily self-consciousness. *Neuron, 88*, 145–166.

Blini, E., Desoche, C., Salemme, R., Kabil, A., Hadj-Bouziane, F., & Farnè, A. (2018). Mind the depth: Visual perception of shapes is better in Peripersonal space. *Psychological Science, 29*(11), 1868–1877.

Bonnet, C. T., Temprado, J. J., & Berton, E. (2010). The effects of the proximity of an object on human stance. *Gait & Posture, 32*(1), 124–128.

Briscoe, R. (2009). Egocentric spatial representation in action and perception. *Philosophy and Phenomenological Research, 79,* 423–460.

Briscoe, R., & Schwenkler, J. (2015). Conscious vision in action. *Cognitive Science, 39*(7), 1435–1467.

Brogaard, B. (2011). Conscious vision for action versus unconscious vision for action? *Cognitive Science, 35*, 1076–1104.

Bufacchi, R. J., Sambo, C.F., Di Stefano, G. Cruccu, G., Iannetti, G.D., (2017). Pain outside the body: Defensive peripersonal space deformation in trigeminal neuralgia. Scientific Reports, 7: 12487. https://doi.org/10.1038/s41598-017-12466-5.

[15] Of course, while here I am discussing some of the relevant experimental results coming from the empirical literature, there are still some aspects of peripersonal space representations, also related to the perceptual mechanisms reported in this paper, that are under scrutiny within a large neuroscientific debate. In this respect, a final account of the scientific questions concerning the peculiar aspects of peripersonal space discussed in this paper is very desirable, though not available yet, and some of these aspects still are matter of controversy (as, for example, in the case of tool use - for a critical overview see Holmes et al. 2007, Holmes 2012 - or of auditory representations - for a critical overview see Holmes et al. 2020). Just to mention an example here, while, as we saw (§7.2), the hypothesis of an extension of peripersonal space through tool use has been endorsed by several neuroscientists, a critical analysis of this hypothesis has proposed a competing description, according to which using tools does not actually extend peripersonal space representations, but simply fosters an allocation of attention on the spatial region where the tool is manipulated (Holmes et al. 2007).

Canzoneri, E., Marzolla, M., Amoresano, A., Verni, G., & Serino, A. (2013). Amputation and prosthesis implantation shape body and peripersonal space representations. *Scientific Reports, 3*, 2844. https://doi.org/10.1038/srep02844.

Cardellicchio, P., Sinigaglia, C., & Costantini, M. (2011). The space of affordances: A TMS study. *Neuropsychologia, 49*(5), 1369–1372.

Cardini, F., Fatemi-Ghomi, N., Gajewska-Knapik, K., Gooch, V., Aspell, J.E. (2019). Enlarged representation of peripersonal space in pregnancy, 9:8606, https://doi.org/10.1038/s41598-019-45224-w.

Chen, J., Wu, E.-D., Chen, X. Z., L-H, L. X., Thorn, F., Ostrovsky, Y., Qu, J. et al. (2016). Rapid integration of tactile and visual information by a newly sighted child. *Current Biology, 26*(8), 1069–1074.

Chinellato E., Ferretti G., Irving L. (2019). Affective Visuomotor Interaction: A Functional Model for Socially Competent Robot Grasping. In: Martinez-Hernandez U. et al. (eds) *Biomimetic and Biohybrid Systems. Living Machines 2019.* Lecture notes in computer science, vol 11556. Springer, Cham.

Chinellato, E., & del Pobil, A. P. (2016). *The visual neuroscience of robotic grasping. Achieving sensorimotor skills through dorsal-ventral stream integration*. Berlin: Springer International Publishing.

Clark, A. (2001). Visual experience and motor action: Are the bonds too tight? *Philosophical Review, 110*(4), 495–519.

Combe, E., & Fujii, N. (2011). Depth perception and defensive system activation in a 3-d environment. *Frontiers in Psychology, 2*, 205.

Costantini, M., Ambrosini, E., Scorolli, C., & Borghi, A. M. (2011). When objects are close to me: Affordances in the peripersonal space. *Psychonomic Bulletin & Review, 18,* 302–308. https://doi.org/10.3758/s13423-011-0054-4.

Costantini, M., Ambrosini, E., Tieri, G., Sinigaglia, C., & Committeri, G. (2010). Where does an object trigger an action? An investigation about affordance in space. *Experimental Brain Research, 207,* 95–103.

Cutting, J. E., & Vishton, P. M. (1995). Perceiving layout and knowing distances: The integration, relative potency, and contextual use of different information about depth. In W. Epstein & S. J. Rogers (Eds.), *Perception of space and motion* (pp. 69–117). San Diego: Academic Press.

de Haan, E. H. F., Jackson, S. T., & Schenk, T. (2018). Where are we now with 'what' and 'how'? *Cortex, 98*(1), 7–140. https://doi.org/10.1016/j.rehab.2017.02.002.

de Vignemont, F. (2018). Peripersonal perception in action. *Synthese*. Special issue: *Between Vision and Action*, (Eds.) Ferretti G., and Zipoli Caiani, S. https://doi.org/10.1007/s11229-018-01962-4.

de Vignemont, F., & Iannetti, G. D. (2015). How many peripersonal spaces? *Neuropsychologia, 70*, 327–334. https://doi.org/10.1016/j.neuropsychologia.2014.11.018.

Di Marco, S., Tosoni, A., Altomare, E. C., Ferretti, G., Perrucci, M. G., & Committeri, G. (2019). Walking-related locomotion is facilitated by the perception of distant targets in the extrapersonal space. *Scientific Reports, 9*, 9884. https://doi.org/10.1038/s41598-019-46384-5.

D'angelo, M., di Pellegrino, G., Seriani, S., Gallina, P., & Frassinetti, F. (2018). The sense of agency shapes body schema and peripersonal space. *Scientific Reports, 8*, 13847. https://doi.org/10.1038/s41598-018-32238-z.

Dufour, A., & Touzalin, P. (2008). Improved visual sensitivity in the perihand space. *Experimental Brain Research, 190*(1), 91–98.

Eslinger, P. J. (2002). The anatomic basis of utilisation behaviour: A shift from frontal-parietal to intra-frontal mechanisms. *Cortex, 38*(3), 273–276. https://doi.org/10.1016/s0010-9452(08)70658-0.

Farivar, R. (2009). Dorsal–ventral integration in object recognition. *Brain Research Reviews, 61*(2), 144–153.

Ferretti G. and Chinellato E. (2019). Can our robots rely on an emotionally charged vision-for-action? An embodied model for Neurorobotics. In: Vallverdú J., Müller V. (eds) *Blended Cognition, The Robotic Challenge*. Springer series in cognitive and neural systems, vol 12. Springer, Cham.

Ferretti G. and Zipoli Caiani S. (2019). Between vision and action. Introduction to the Special Issue. *Synthese*, https://doi.org/10.1007/s11229-019-02518-w.

Ferretti, G. (2016a). Pictures, action properties and motor related effects. Synthese, Special Issue: Neuroscience and Its Philosophy. https://doi.org/10.1007/s11229-016-1097-x.

Ferretti, G. (2016b). Through the forest of motor representations. *Consciousness and Cognition, 43*, 177–196. https://doi.org/10.1016/j.concog.2016.05.013.

Ferretti, G. (2016c). Visual feeling of presence. *Pacific Philosophical Quarterly., 99*, 112–136. https://doi.org/10.1111/papq.12170.

Ferretti, G. (2017a). Pictures, emotions, and the dorsal/ventral account of picture perception. *Review of Philosophy and Psychology., 8*, 595–616. https://doi.org/10.1007/s13164-017-0330-y.

Ferretti, G. (2017b). Are pictures peculiar objects of perception? *Journal of the American Philosophical Association, 3*(3), 372–393. https://doi.org/10.1017/apa.2017.28.

Ferretti, G. (2017c). Two visual Systems in Molyneux Subjects. *Phenomenology and the Cognitive Sciences, 17*(4), 643–679. https://doi.org/10.1007/s11097-017-9533-z.
Ferretti, G. (2018). The neural dynamics of seeing-in. *Erkenntnis, 84*, 1285–1324. https://doi.org/10.1007/s10670-018-0060-2.
Ferretti, G. (2019a). Perceiving surfaces (and what they depict). In Glenney B. & J. F. Silva (Eds.), the senses and the history of philosophy, London: Routledge.
Ferretti, G. (2019b). Visual phenomenology versus Visuomotor imagery: How can we be aware of action properties? *Synthese*. https://doi.org/10.1007/s11229-019-02282-x.
Ferretti, G. (2020a). Why *Trompe l'oeils* deceive our visual experience. *The Journal of Aesthetics and Art Criticism, 78-1*, 33–42.
Ferretti, G. (2020b). Action at first sight. In Ferretti, G. and Glenney, B. (Eds.). Molyneux's Question and the History of Philosophy, Routledge.
Ferretti, G. (2020c). Do *Trompe l'Oeils* Look Right When Viewed from the Wrong Place? *The Journal of Aesthetics and Art Criticism, 78*(3), 319–330.
Ferretti, G. (2020d). Anti-intellectualist motor knowledge. *Synthese*. https://doi.org/10.1007/s11229-020-02750-9.
Ferretti, G. (2021a). A distinction concerning vision-for-action and affordance perception. *Consciousness and Cognition, 87,* 103028.
Ferretti, G. (2021b). Why the Pictorial needs the Motoric. Erkenntnis. https://doi.org/10.1007/s10670-021-00381-1.
Ferretti, G. and Glenney, B. (2020). Molyneux's question and the history of philosophy. Routledge.
Ferretti, G., & Marchi, F. (2020). Visual attention in pictorial perception. *Synthese*. https://doi.org/10.1007/s11229-020-02873-z.
Ferretti, G., & Zipoli Caiani, S. (2018). Solving the Interface problem without translation: The same format thesis. *Pacific Philosophical Quarterly, 100*, 301–333. https://doi.org/10.1111/papq.12243.
Ferretti, G., & Zipoli Caiani, S. (2021). *Habitual Actions, Propositional Knowledge, Motor Representations and Intentionality*. Topoi. https://doi.org/10.1007/s11245-020-09723-0.
Ferretti, G., & Zipoli Caiani, S. (Forthcoming). How Knowing-That and Knowing-How Interface in Action: The Intelligence of Motor Representations. Erkenntnis.
Foley, T. R., Whitwell, R. L., & Goodale, M. A. (2015). The two-visual-systems hypothesis and the perspectival features of visual experience. *Consciousness and Cognition, 35*(2015), 225–233.
Gallese, V. (2007). The "conscious" dorsal stream: Embodied simulation and its role in space and action conscious awareness. *Psyche, 13*(1), 1–20.
Gallese, V., & Sinigaglia, C. (2010). The bodily self as power for action. *Neuropsychologia, 48*, 746–755.
Gallese, V., and Sinigaglia C., (2011). *How the Body in Action Shapes the Self. Journal of Consciousness Studies*, 18, 7–8, 2011, pp. 117–43.
Goodhew, S. C., Edwards, M., Ferber, S., & Pratt, J. (2015). Altered visual perception near the hands: A critical review of attentional and neurophysiological models. *Neuroscience and Biobehavioral Reviews, 55,* 223–233.
Gozli, D. G., West, G. L., & Pratt, J. (2012). Hand position alters vision by biasing processing through different visual pathways. *Cognition, 124*(2), 244–250.
Graziano, M.S. & Cooke, D. F. (2006). Parieto-frontal interactions, personal space, and defensive behavior. Neuropsychologia 44, 845–859.
Graziano, M. (2009). *The intelligent movement machine: An ethological perspective on the primate motor system*. Oxford: Oxford University Press.
Grush, R. (2007). Skill theory v2.0: Dispositions, emulation, and spatial perception. *Synthese, 159*(3), 389–416.
Holmes, N. P., Sanabria, D., Calvert, G. A., & Spence, C. (2007). Tool-use: Capturing multisensory spatial attention or extending multisensory peripersonal space? *Cortex, 43*(3), 469–489.
Holmes, N. P. (2012). Does tool use extend peripersonal space? A review and re-analysis. *Experimental Brain Research, 218*, 273–282. https://doi.org/10.1007/s00221-012-3042-7.
Holmes, N. P., Martin, D., Mitchell, W., Noorani, Z., & Thorne, A. (2020). Do sounds near the hand facilitate tactile reaction times? Four experiments and a meta-analysis provide mixed support and suggest a small effect size. *Experimental Brain Research, 238*, 995–1009. https://doi.org/10.1007/s00221-020-05771-5.
Hunley, S. B., & Lourenco, S. F. (2018). What is peripersonal space? An examination of unresolved empirical issues and emerging findings. *WIREs Cogn Sci, 9*, e1472. https://doi.org/10.1002/wcs.1472.
Iachini, T., Ruggiero, G., Ruotolo, F., & Vinciguerra, M. (2014). Motor resources in peripersonal space are intrinsic to spatial encoding: Evidence from motor interference. *Acta Psychologica, 153*, 20–27. https://doi.org/10.1016/j.actpsy.2014.09.001.

Iachini, T., Ruotolo, F., Vinciguerra, M., & Ruggiero, G. (2017). Manipulating time and space: Collision prediction in peripersonal and extrapersonal space. *Cognition, 166*, 107–117.
Jackson, G. B. (2014). Skillful action in peripersonal space. *Phenomenology and the Cognitive Science., 13*, 313–334. https://doi.org/10.1007/s11097-013-9301-7.
Kelly, S. P., & Brockmole, J. R. (2014). Hand proximity differentially affects visual working memory for color and orientation in a binding task. *Frontiers in Psychology, 5,* 318.
Matthen, M. (2005). *Seeing, doing and knowing: A philosophical theory of sense perception*. Oxford: Oxford University Press.
Matthen, M. (2010). Two visual systems and the feeling of presence. In N. Gangopadhyay, M. Madary, & F. Spencer (Eds.), *Perception, Action, and Consciousness: Sensorimotor Dynamics and the Two Visual Systems* (pp. 107–124). Oxford: Oxford University Press.
Milner, A., & Goodale, M. (1995/2006). *The visual brain in action* (2nd ed.). Oxford: Oxford University Press.
Milner, A. D., & Goodale, M. A. (2008). Two visual systems re-viewed. *Neuropsychologia, 46*(3), 774–785.
Nanay, B. (2011). Perceiving pictures. *Phenomenology and the Cognitive Sciences, 10*, 461–480.
Nanay, B. (2013). *Between perception and action*. Oxford: Oxford University Press.
Nijboer, T. C. W., Ten Brink, A. F., Kouwenhoven, M., & Visser-Meily, J. M. A. (2014). Functional assessment of region-specific neglect: Are there differential behavioural consequences of peripersonal versus extrapersonal neglect? *Behavioural Neurology, 2014,* 526407.
Noë, A. (2005). Against intellectualism. *Analysis, 65*, 278–290.
Noel, J.-P., Pfeiffer, C., Blanke, O., & Serino, A. (2015). Peripersonal space as the space of the bodily self. *Cognition, 144*, 49–57. https://doi.org/10.1016/j.cognition.2015.07.012.
Orioli, G. Santoni, A. Dragovic, D. and Farroni, T. (2019). Identifying peripersonal space boundaries in newborns. Scientific reports, *9:9370* | https://doi.org/10.1038/s41598-019-45084-4.
Quinlan, D. J., & Culham, J. C. (2007). fMRI reveals a preference for near viewing in the human parieto-occipital cortex. *NeuroImage, 36*(1), 167–187.
Ravenscroft, J. (2019). (Eds.) The Routledge handbook of visual impairment. Routledge.
Reed, C. L., Betz, R., Garza, J. P., & Roberts, R. J. (2010). Grab it! Biased attention in functional hand and tool space. *Attention, Perception, & Psychophysics, 72*(1), 236–245.
Reed, C. L., Grubb, J. D., & Steele, C. (2006). Hands up: Attentional prioritization of space near the hand. *Journal of Experimental Psychology: Human Perception and Performance, 32*(1), 166.
Rizzolatti, G., Fadiga, L., Fogassi, L., & Gallese, V. (1997). The space around us. *Science, 277*, 190–191.
Serino, A. (2019). Peripersonal space (PPS) as a multisensory interface between the individual and the environment, defining the space of the self. *Neuroscience and Biobehavioral Reviews, 99*, 138–159. https://doi.org/10.1016/j.neubiorev.2019.01.016.
Siegel, S. (2014). Affordances and the contents of perception. In B. Brogaard (Ed.), *Does perception have content?* (pp. 51–75). New York: Oxford University Press.
Svarverud, E., Gilson, S., & Glennerster, A. (2012). A demonstration of 'broken' visual space. *PLoS One, 7*(3), e33782. https://doi.org/10.1371/journal.pone.0033782.
Uji, M., Jentzsch, I., Redburn, J., & Vishwanath, D. (2019a). Dissociating neural activity associated with the subjective phenomenology of monocular stereopsis: An EEG study. *Neuropsychologia, 129,* 357–371.
Uji, M., Lingnau, A., Cavin, I., & Vishwanath, D. (2019b). Identifying Cortical Substrates Underlying the Phenomenology of Stereopsis and Realness: A Pilot fMRI Study. *Front Neurosci, 13,* 646. https://doi.org/10.3389/fnins.2019.00646.
Vishwanath, D. (2011). Information in surface and depth perception: Reconciling pictures and reality. In L. Albertazzi, G. J. van Tonder, & D. Vishwanath (Eds.), *Perception beyond inference. The information content of visual processes* (pp. 201–240). Cambridge: MIT Press.
Vishwanath, D. (2014). Toward a new theory of stereopsis. *Psychological Review, 121*(2), 151–178.
Vishwanath, D., & Hibbard, P. (2010). Quality in depth perception: The plastic effect. *Journal of Vision, 10.* https://doi.org/10.1167/10.7.42.
Vishwanath, D., & Hibbard, P. (2013). Seeing in 3D with just one eye: Stereopsis in the absence of binocular disparities. *Psychological Science, 24*, 1673–1685.
Zipoli Caiani, S., & Ferretti, G. (2017). Semantic and pragmatic integration in vision for action. *Consciousness and Cognition, 48*, 40–54. https://doi.org/10.1016/j.concog.2016.10.009.