



Space and perceptual boundaries

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Abstract

In consideration of the spatial structures of sensory experiences, an ‘Externality Thesis’ is commonly proposed, according to which awareness of sensory boundaries is also an awareness of the presence of a space beyond these boundaries. The paper evaluates the Externality Thesis in the context of vision and touch. More specifically, relying on mereotopological theories, it is shown that the notion of spatial boundaries is ambiguous as it encompasses various distinct ways in which entities may be connected by a boundary. It is argued that only some of these ways are able to support the Externality Thesis. In particular, it is claimed that while bodily boundaries of which one is aware in tactile sensations are such that the awareness of them provides support for the Externality Thesis, the analogous claim is not true about the boundaries of the visual field.

Keywords Vision · Touch · Spatial perception · Perceptual structures · Visual field · Bodily sense

A common idea proposed in the context of analyzing perceptual experiences is that perceptual experiences possess certain structures (Alsmith, 2017; Macpherson, 2015; Phillips, 2013; Richardson, 2010; Soteriou, 2013). In this context, the notion of structure regards the stable principles according to which the perceptually presented entities are organized. For example, no matter whether one perceives a red circle or a green triangle, these elements are presented as positioned in a topologically connected and bounded visual field (Martin, 1992; Richardson, 2010; Wilson, 2022).

This paper is concerned with particular types of spatial experiential structures, which I call ‘boundary structures.’ These are structures that demarcate the limits of

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perceptual space in which entities can be perceived. More precisely, I focus on one particular thesis regarding boundary structures. It is claimed that in virtue of the awareness of perceptual boundary structures, we are aware of perceived space as a part of a larger space (Cavedon-Taylor, 2018; Dokic, 2003; Laasik, 2019; Mac Cumhaill, 2015; Martin, 1992, 1993, 1998; Richardson, 2010, 2013; Serrahima, 2022, 2023; Soteriou, 2011, 2013; Wilson, 2022). In the case of vision, it is proposed that in being aware of a bounded visual field, one is also aware of the presence of space which extends beyond the visual field. In other words, by being aware of the boundaries of the visual field we are aware of a part of space in which objects can be seen (space inside the visual field) and of a space in which objects currently cannot be seen (space outside the visual field) (Cavedon-Taylor, 2018; Laasik, 2018; Richardson, 2010; Mac Cumhaill, 2015; Wilson, 2022).

A similar thesis has also been proposed in the case of bodily sensations. Some authors believe that when having bodily sensations—in particular related to touch—we are not only aware of something happening within the boundaries of our body, but also of the body as an object positioned in a larger space (Martin, 1992, 1993, 1998; Richardson, 2013; Serrahima, 2022, 2023). Similarly as in vision, certain bodily sensations seem to also involve a spatial boundary structure which demarcates a bodily space in which bodily sensations can be felt from a larger space outside the body.

More generally, in the case of both vision and some bodily sensations, an ‘Externality Thesis’ is proposed, according to which, an awareness of spatial boundary structures is also an awareness of the presence of a larger space. This larger space extends beyond the visual field and beyond the bodily space in which sensations can be felt. The aim of this paper is to evaluate the Externality Thesis in the context of vision and touch. In doing so, I assume that we have a perceptual awareness of the presence of a larger space, which is beyond the visual field and bodily boundaries. From this perspective, I will treat the Externality Thesis as a commonly accepted thesis that provides an explanation for the fact that we are aware of a space beyond visual or bodily boundaries. According to the Externality Thesis, we have such an awareness because an awareness of boundary structures is already an awareness of the presence of a larger space.

I will investigate whether the explanation provided by the Externality Thesis is correct by analyzing the awareness of boundary structures using mereotopological concepts (Casati & Varzi, 1999; Smith, 1997; Varzi, 2015). I believe that mereotopological notions associated with the concepts of parthood and connectedness are particularly useful in this context, as they show that the general idea of the awareness of boundary structures is ambiguous. This is because mereotopological considerations show that there are different kinds of boundary structures that are possible candidates for being the structures one is aware of in visual or bodily experiences. In other words, by using mereotopological notions, we can precisely describe possible experiential boundary structures and then analyze which of these structures are such that we are plausibly aware of them in visual or bodily experiences.

Drawing on certain distinct types of boundary structures, I argue that only the awareness of some of these structures is such that it is also an awareness of a larger space, as postulated by the Externality Thesis. In particular, I will argue that while the bodily boundaries that one is aware of in tactile experiences are such that the aware-

ness of them is as specified by the Externality Thesis, the analogous claim about the boundaries of the visual field is false.

The paper starts by a further explication of the Externality Thesis (Sect. 1). Subsequently (Sect. 2), I introduce a mereotopological framework which allows various boundary structures to be distinguished and their relation to the Externality Thesis to be established. Further, in Sects. 3 and 4, I argue that while the boundary structures present in usual tactile sensations are such that the bodily version of the Externality Thesis is true, the analogous claim is not justified in the case of visual boundaries. Finally, in Sect. 5, I show that the visual version of the Externality Thesis is not justified, even if we take into account the dynamic aspects of vision and that considerations about dynamic vision reveal a certain dependency between awareness of space beyond the visual space and the spatial bodily awareness.

1 Visual and bodily boundaries

In the context of vision, the Externality Thesis concerns the awareness of the boundaries of the visual field. The notion of visual field has been understood by philosophers of perception in several distinct ways (Clark, 1996; O’Sullivan, 2015; Richardson, 2010; Sorensen, 2011; Wilson, 2022). In discussion regarding the Externality Thesis, a structural notion of the visual field, originally proposed by Martin (1992, 1993), is usually utilized. According to this notion, the visual field is a roughly conical space such that entities located in this space may, in principle, be visually perceived. Beyond this space’s boundaries there is a larger space such that objects located in it cannot be currently perceived. As it is often claimed, boundaries of the visual field are experienced differently than the edges separating visible objects, as they constitute a spatial limitation structure of a visual experience (Dokic, 2003; Sorensen, 2011; Soteriou, 2011). Awareness of such structural boundaries is an awareness of the limits of our vision, namely, that the space in which objects can be visually perceived ends at these boundaries. The structurally understood visual field remains the same regardless of any entities that are currently perceived. For instance, even if the line of sight is partially blocked by an object, the visual field does not shrink, as places behind this object lie within the conical space demarcated by the structural boundaries of the visual field, so they are places in which entities, in principle, can be visually perceived (Richardson, 2010; Wilson, 2022).

The proponents of the Externality Thesis believe that awareness of the boundaries of the visual field is also an awareness of the presence of space beyond the visual field. For instance, a metaphor is used that being aware of boundaries of the visual field and being aware of the presence of a space beyond the visual field are ‘two sides of the same coin’ (Richardson, 2010, p. 238), because it is believed that the awareness of visual spatial limits is also an awareness of the presence of something beyond these limits. For instance, it is claimed that ‘In experiencing one’s visual field as bounded, one is aware of one’s sensory limitations in the sense that one is aware that there is more to be sensed than is currently being sensed’ (Mac Cumhaill, 2015, p. 690), or that ‘Your visual awareness of the region of space in front of you is in some

sense an awareness of the region as a sub-region of a region of space that has that sub-region as part' (Soteriou, 2011, p. 193).

It is important that the awareness being considered is meant to be perceptual, phenomenal, and complete. For example, it is not the case that an awareness of the presence of space beyond the visual field consists of having a belief about the way space is organized. The relevant awareness should be a perceptual, visual awareness of boundary structures. Furthermore, the relevant awareness is phenomenal, i.e., it is something like to experience the boundaries of a visual field as boundaries separating visual space from some larger space. Finally, the relevant awareness is complete, because in order to be aware of the presence of a space beyond the visual field, the awareness of boundary structures does not need to be supplemented by additional information provided by some perceptual or non-perceptual means. For example, the Externality Thesis is not satisfied if we are aware of the presence of space beyond the visual field by (a) being aware of visual boundaries, and (b) combining this awareness with background propositional knowledge about the external space. The truth of the Externality Thesis requires that an awareness of the boundaries of the visual field is sufficient for an awareness of the presence of space beyond the visual field.

Relying on the above remarks, a Visual Externality Thesis may be formulated in the following way:

(Visual Externality Thesis) *The awareness of visual boundary structures provided by visual experiences is also a perceptual, phenomenal, and complete awareness of the presence of a space beyond the visual field.*

It should be noted that the proposed version of the Visual Externality Thesis is purposively formulated in a weak way, such that it does not require that one is aware of any specific relation between visual and non-visual space (for instance, that the visual field is a part of the non-visual space). Similarly, the Visual Externality Thesis does not require any awareness of the internal structure or properties of the non-visual space. What is sufficient for the version of the Visual Externality Thesis I aim to discuss is merely an awareness of the presence of a space beyond the visual field.

The Externality Thesis is proposed not only in the context of vision, but also in regard to our bodily perception. More specifically, it is argued that certain bodily sensations are associated with awareness of the body as an object positioned in a larger space (Martin, 1992, 1993, 1998; Richardson, 2013; Serrahima, 2022, 2023). Similarly, as in the case of Visual Externality Thesis such awareness is believed to be closely connected to the awareness of spatial boundary structures. It is claimed that some bodily sensations, especially those related to touch, are such that when having them we are aware of a bounded bodily space, i.e. a space in which bodily sensations can occur. However, similarly as with the boundaries of the visual field, it is argued that in being aware of the boundaries of the bodily space, one is also aware of the presence of a non-bodily space, i.e. a space in which bodily sensations cannot occur. For instance, it is postulated that 'bodily sensations incorporate a sense of the space that extends beyond one's bodily boundaries, as a space in which it is not possible to feel any sensation' (Richardson, 2013, p. 13) or that 'touch qua bodily sensation involves the awareness of bodily boundaries, which in turn equates to the awareness of such boundaries standing out against a wider space.' (Serrahima, 2023). Like the visual case, such awareness of the presence of the non-bodily space is available

not due to some nonsensory means but is a perceptual, phenomenal, and complete awareness.

In an analogy to the Visual Externality Thesis, a Bodily Externality Thesis may be formulated as follows:

(Bodily Externality Thesis) *The awareness of bodily boundaries provided by certain bodily sensations is also a perceptual, phenomenal, and complete awareness of the presence of a space beyond bodily space.*

The above considerations show that philosophers often claim—by supporting the Externality Thesis—that an awareness of visual or bodily boundaries is an awareness of the presence of a space beyond those boundaries (Cavedon-Taylor, 2018; Mac Cumhaill, 2015; Richardson, 2010, 2013; Serrahima, 2023; Soteriou, 2011). As stated in the introduction, I interpret the Externality Thesis as an explanation of the fact that we have a perceptual awareness of the presence of space beyond visual and bodily boundaries: we have such an awareness because an awareness of boundary structures is already an awareness of the presence of a larger space. Proponents of the Externality Thesis usually argue for it by providing an analysis of awareness of boundary structures. This is particularly evident when the metaphor of ‘two sides of the same coin’ is used: intuitively, being aware of boundaries involves being aware of the contrast between what is within the boundaries and what is beyond them.

However, the issue is more complicated. There are different possible structures that can serve as boundary structures of the visual field or of bodily space. Only some of them are such that an awareness of them is also an awareness of the presence of something beyond the boundaries. Therefore, in order to evaluate whether the Externality Thesis is true, we need to analyze which boundary structures we are aware of in visual and bodily experiences, and whether an awareness of such structures is also an awareness of the presence of space beyond the boundaries.

I believe that whether an awareness of a boundary structure is also an awareness of the space beyond that boundary depends on the properties that the boundary structure possesses. It is quite intuitive that boundary structures have certain properties and that we are aware of at least some of those properties. For example, we are aware that visual boundaries are not triangular but approximately circular. Moreover, the Externality Thesis seems to presuppose that boundary structures have certain properties such that an awareness of a structure that has them is also an awareness of the extra space. In particular, an awareness of some other structural elements—such as the center of the visual field or its size—is not plausibly an awareness of the larger space required by the Externality Thesis. Consequently, if the Externality Thesis is true, boundary structures must have appropriate properties. However, not all possible boundary structures have the required properties. If a boundary structure has such properties that an awareness of it is also an awareness of the presence of space beyond the boundary, I will then claim that the awareness of that structure ‘supports’ the Externality Thesis. Consequently, my goal is to analyze whether our actual awareness of boundary structures supports the Externality Thesis.

Nevertheless, the characterization of boundary structures as having properties of which we are aware may seem to be in tension with the common claim that boundary structures are not objects presented in experiences. I do not believe, however, that the distinction between boundary structures and objects of experience is that

objects have properties we are aware of, while boundary structures do not. In order to make this distinction, two other factors seem to be crucial. The first concerns invariance: boundary structures are relatively invariant because, apart from serious disturbances, they are the same in every perceptual experience of a given modality (see Macpherson, 2015). On the other hand, the objects of experience usually change due to changes in the available stimuli. The second factor concerns accuracy conditions. Attributing properties to experiential objects determines the accuracy conditions of an experience, since the experience is accurate if the objects do actually possess the attributed properties. However, such a determination of accuracy conditions does not seem to be present in the case of boundary structures. The properties of spatial boundary structures determine the part of space in which objects can be experienced, but they do not characterize under what conditions this fragment of space, and the objects occupying it, are experienced accurately. Overall, while both boundary structures and experiential objects have properties one is aware of, boundary structures are not experiential objects. This is due to their invariance and the fact that their properties do not play the same role in determining the accuracy conditions of experiences.

Relying on the above remarks, let us consider an example of an analysis of an awareness of visual experiential structures. For example, let us assume that the spatial structure of a visual field is *the visual field is a continuous space bounded by a boundary that is part of the visual field*. An awareness of such a structure is an awareness of the visual field as being composed of certain places arranged in such a way as to form a continuous space bounded by a boundary. However, such an awareness is not an awareness of the presence of some space outside the boundary. This does not mean that the awareness of the structure under consideration is an awareness of the visual field as the only space. Rather, such an awareness is simply neutral as to whether or not there is anything beyond the visual boundary. Consequently, the awareness of such a spatial structure cannot be a perceptual, phenomenal, and complete awareness of the presence of space beyond the visual field. If visual experience has such a structure, then an awareness of such a structure does not support the Visual Externality Thesis.

However, this is not the only possibility. Let's consider a case where the spatial structure of the visual field is *the visual field is a continuous space bounded by a boundary that is part of the visual field and also part of a place that is not part of the visual field*. In this case, because the boundary is shared by the visual field and a place that does not belong to the visual field, the awareness of such a structure is an awareness of the presence of a space beyond the visual field. Unlike the previous example, visual awareness of such a spatial structure is also a perceptual, phenomenal, and complete awareness of the presence of a space outside the visual field. Consequently, such an awareness supports the Visual Externality Thesis.

In the following section, using mereotopological notions, I present the main types of boundary structures and discuss whether awareness of them might support the Externality Thesis. Then, in Sects. 3–5, I analyze the experiential boundary structures to see whether visual or bodily version of the Externality Thesis is justified.

2 Mereotopology of boundaries

Mereotopological theories characterize the notions of ‘parthood’ and ‘connectedness’ (see Casati & Varzi, 1999; Smith, 1997; Varzi, 1997; Varzi, 2015). According to a standard formulation, parthood is a (a) reflexive, (b) antisymmetric, and (c) transitive relation: (a) an entity O is part of itself, (b) if an entity O is a part of entity P , then P is not a part of O unless $P=O$, (c) if an entity O is a part of P and P is a part of S , then O is a part of S . A part of an entity which is not identical to this entity is named a *proper part*. If two entities share a part, they *overlap*.

The relation of connectedness possesses distinct characteristics as it is (a) reflexive, (b) symmetric, and (c) intransitive: (a) an entity O is connected to itself, (b) if an entity O is connected to P then P is also connected to O , (b) from the fact that O is connected to P and P is connected to S it does not follow that O and S are connected. If two entities are connected but they do not overlap, i.e., they do not share a part, they are *externally connected*.

Using the above notions, one may characterize an *internal proper part* and a *tangential proper part* of an entity (Casati & Varzi, 1999; Varzi, 1997). An internal proper part of an entity O is such proper part of O that if some entity P is connected to such part, then P overlaps with O . On the other hand, a tangential proper part of O is a proper part which is not internal, i.e., some P can be connected to such part without overlapping with O . In other words, tangential proper parts are positioned on the very edge of an entity O such that a connection with a tangential proper part may constitute an external connection with O , i.e., a connection with O without overlap.

Finally, by using the notion of tangential proper part we may define a boundary of an entity. A boundary of an entity O is its proper part which is composed only of its tangential proper parts. It should be noted that not all entities have to possess a boundary. Those who do not have a boundary as their part are called *open entities*, while those which include a boundary are *closed entities* (Smith, 1997, 2001; Varzi, 1998). For instance, an empty space surrounding an object may be, with some plausibility, interpreted as an open entity. Such space is separated from an object by a boundary, but this boundary belongs to the object and not to the empty space. An open entity may be limited in the sense that not everything is its part. The empty space from the above example is limited, as parts of the surrounded object are not its parts. However, it may not be possible to point out where exactly an open entity ends. If the empty space surrounding an object is continuous, then for each location L of this space, there will be another location belonging to this space which is closer to the boundary of the surrounded object than L . In other words, there is no ‘last’ location of an open entity after which a closed entity starts to be present.

Having characterized how boundaries are understood from the mereotopological perspective, the types of boundary structures that may occur when two entities are connected to each other may be considered. This will provide conceptual resources which will further allow the boundary structures of visual experiences and tactile sensations to be analyzed.

In this context, an important question regards whether a connection between two entities consists in them being externally connected, i.e., in being connected without overlap, or may also consist in some other relationship. In the mereotopological

literature, two main proposals have been developed, according to which connection between two entities is not an external connection (Smith & Varzi, 2000; Varzi, 1998):

- (1) *Overlap*: connection between O and P consists in the fact that there is a boundary B which is a proper part of both O and P .

According to this proposal, connected entities are closed entities which are connected due to the fact that they overlap by sharing a boundary. Of course, because of the presence of the overlap, their connection is not an external connection.

- (2) *Proximity*: connection between O and P consists in the fact that O and P stand in a relation of maximal proximity.

The relation of maximal proximity is characterized as such relations that if O and P stand in it, then nothing can be positioned between them (see Varzi, 1997). In other words, they are as close to each other as possible. In fact, such a solution does not entail that borders of the considered entities are connected—or even whether these entities are closed entities.

Nevertheless, usually in mereotopological works the connection between entities is interpreted as an external one. In the mereotopological literature, the following forms of external connection has gained the most attention:

- (3) *Open/close*: connection between O and P consists in the fact that there is a boundary B which is a proper part of a closed entity O that is externally connected to an open entity P .

According to this variant, connection occurs between a closed and an open entity. In consequence, connection involves a single boundary which belongs to the closed entity but not to the open one. This is one of the most influential mereotopological approaches to connection (see Casati & Varzi, 1999; Varzi, 1997, 1998).

- (4) *Coincidence*: connection between O and P consists in the fact that there is a boundary $B1$ which is a proper part of O , a distinct boundary $B2$ which is a proper part of P , and boundaries $B1$ and $B2$ spatially coincide.

In this case, O and P are two closed entities each having a distinct boundary, but, nevertheless, their boundaries are positioned in the same fragment of space. Despite this spatial coincidence, O and P are not overlapping, as they do not share any parts. This is the second of the most influential mereological accounts of connections (see Smith, 1997, 2001 for a contemporary formalization).

In order to combine the above variants of boundary structures with the considerations about the Externality Thesis, we can investigate whether these variants have such properties that awareness of them supports the Externality Thesis. Let's take the *open/closed* boundary structure and apply it to the boundaries of the visual field. In this case, when one is aware of the boundaries of the visual field, one is aware of (a) the visual field as a closed entity that has a boundary as part of it, and (b) the pres-

ence of an open entity that is externally connected to the visual field. Such an awareness supports the Visual Externality Thesis because it is an awareness of something spatially located beyond the boundary of the visual field. Note, however, that this support depends on awareness of the presence of three elements: a closed entity, its boundary, and an open entity. If the considered awareness were only the awareness of the closed entity and its boundary, the Externality Thesis would not be supported. In such a case, one would only be aware of the visual field as a closed entity with a boundary, without any information about whether there is anything beyond that boundary.

I propose to name such way of supporting the Externality Thesis the ‘external support,’ as it relies on being aware of an entity positioned beyond the boundary of the perceptual space. The external support is provided not only by the *open/closed* account but also by *proximity*. In these cases, awareness of the perceptual space and its boundary is not enough to support the Externality Thesis, as there is an additional requirement of the awareness of something located outside the boundary of a perceptual space.

However, external support is not the only type of support that can be provided for the Externality Thesis. To demonstrate this, let’s consider another important variant of boundary structures: coincidence. According to this variant, there is a connection between two closed entities by virtue of the fact that they have distinct boundaries that nevertheless coincide spatially. In the context of the visual field, this would mean that the structure of the visual field consists of a space that has a boundary as its proper part, and at the location of this boundary there is another boundary that is not part of the visual field but is a proper part of some distinct entity. Awareness of such a structure can support the Externality Thesis, because when one is aware of such a structure, one is aware that, in addition to the visual field and its boundary, there is a second boundary that belongs to something else. Consequently, there is something beyond the visual field to which the second boundary belongs.

This form of support for the Externality Thesis is distinct from the external support. In this case, the awareness of the presence of something beyond the visual field does not require an awareness of something that is positioned outside the boundaries of the visual field. An awareness of a boundary which is positioned in exactly the same location as the visual field boundary is sufficient. I name such support the ‘internal support.’ The internal support is provided not only by the *coincidence* approach but also by *overlap*. In this variant, the internal support is provided due to the fact that a single boundary is a proper part of two distinct entities. For instance, in the visual case, it would mean that in awareness of the boundary of the visual field, one is aware of this boundary as a part of another entity, distinct from the visual field.

In the subsequent sections, I use the above conceptual schema to investigate whether boundary structures of tactile sensations and visual experiences are able to provide external or internal support for the Externality Thesis.

3 Bodily boundaries and the externality thesis

In considering the validity of the Bodily Externality Thesis, I focus on cutaneous tactile sensations. I argue that typical tactile sensations involve such awareness of bodily boundaries that it supports the Bodily Externality Thesis. It should be noted that the thesis does not require that all bodily sensations are such that they provide an awareness of space beyond the bodily space. It is sufficient that the thesis is supported by some bodily sensations.

I believe that there is an important, intuitive characteristic of typical tactile sensations: When having such sensations, it does not seem to us that our body merges or spatially coincides with something that is not our body. For instance, when feeling pressure inflicted on a skin fragment, we may feel that our bodily boundaries change shape, but we do not feel that some bodily part is incorporated into something that does not belong to our body. Similarly, we do not feel that there is something that is not our body, yet we feel it is located in the same place as our bodily part. I do not claim that it is impossible to feel such things, but they are not felt in the case of usual tactile sensations.

This phenomenal fact has important consequences for considerations regarding the awareness of bodily boundaries. First, it is unlikely that awareness of bodily boundaries in usual tactile sensations is the awareness of structures described by the *overlap* account. If this were the case, then we would be aware that our bodily boundaries are also parts of something distinct from our body. Similarly, the *coincidence* account is implausible, as adopting it would mean that when having a tactile sensation, we are aware that in the location of bodily boundaries there are also boundaries of something that does not belong to the body.

The *overlap* and *coincidence* accounts are those that provide internal support for the Bodily Externality Thesis. If they are phenomenally implausible, then in order to justify the Bodily Externality Thesis it must be shown that tactile sensations involve such boundary structures as to provide external support, which requires that in the awareness of the boundary structure one is not only aware of the bodily space and its boundary, but also of something that is located outside the bodily boundary.

I believe that the strong reason in favor of the presence of external support for the Bodily Externality Thesis comes from the observation that tactile experiences are typically bipolar (e.g., Mattens, 2013, 2016; Ratcliffe, 2008; Richardson, 2013). This means that when having a usual tactile sensation, one is presented both with some bodily occurrence and with an object which causes this occurrence. This general idea has been developed by philosophers of perception in four main ways.

First, it has been proposed that a tactile sensation can present properties of an external object due to the fact that some spatial properties of a tactile sensation mirror the spatial properties of an external object (Martin, 1992, 1993). For instance, when a sensation occurs in a circular fragment of a skin, circularity is attributed to the object interacting with the bodily surface. Second, the bipolar character of touch can occur due to temporal summation (Matthen, 2021). A short-lasting tactile sensation may not allow any properties of an external object to be presented, but if such sensations occur in a sequence, it can be presented that, for instance, an object is moving along a certain path. Third, it has been proposed that tactile sensations are associated with

the feeling of resistance (Mac Cumhaill, 2017; Smith, 2002). Due to that feeling it is presented that there is something external to the body which impedes bodily movements. Finally, according to the so-called ‘simple theory,’ no additional step is required between presenting what happens to the body and presenting properties of an external object, as a tactile sensation is already a perceptual state presenting properties of an external element (Richardson, 2013). I do not want to argue in favor of one of these theories as they are not mutually exclusive. Instead, I believe the above approaches show that there are various plausible ways in which many of the ordinary tactile sensations present both that something happens to the body and that there is an external object possessing spatial properties.

In consequence, it seems likely to assume that in the case of many tactile sensations awareness of a boundary structure is an awareness of the boundary between a bodily space to which some property is attributed (e.g., that a circular fragment of bodily space is under pressure) and an object which also possesses some spatial property (e.g., a property of having a circular shape). Given that, it may be asked whether awareness of such boundary structure provides an external support for the Bodily Externality Thesis. I believe it is the case, as the awareness of the boundary structure in which a boundary separates bodily space from an object having spatial properties is an awareness of an object which is located somewhere, due to the fact that it has some spatial properties, and its location does not overlap with the bodily space. This means that beyond places which compose the bodily space, there is also at least one other place. Such support for the Bodily Externality Thesis is an external support, as it relies on the awareness of something positioned outside the bodily space.

Furthermore, such an awareness seems to be a perceptual, phenomenal awareness, since the boundary structure is experienced in virtue of sensory mechanisms that result in the occurrence of a phenomenally conscious, tactile sensation. Moreover, it is a complete awareness, since awareness of the boundary structure is sufficient to support the Bodily Externality Thesis. In particular, the awareness under consideration is an awareness of a structure in which the location of the presented object does not overlap with bodily space.

However, given that many ordinary tactile sensations have a bipolar character, one might doubt whether the awareness of a boundary is really necessary to support the Bodily Externality Thesis. It may seem that if a tactile experience attributes some property to bodily space and some spatial property to an external object, then this is already justification for some space beyond bodily space. However, without the awareness of a boundary, it is difficult to establish that the presented object is actually ‘external.’ The mere attribution of a property to a bodily space and a property to an object does not in itself establish the relationship between the location of the object and the locations that constitute the bodily space. This gap is filled by the awareness of the boundary structure, since it is an awareness of the mereotopological relations between experienced locations. In particular, such an awareness is one of locations that are internal parts of the bodily space by being inside a boundary, locations that overlap with the bodily boundary, and locations that are—at most—externally connected to the boundary of the bodily space.

While the above considerations show why it is plausible that boundary structures of ordinary tactile sensations provide external support for the Bodily Externality The-

sis, they do not establish the specific form of such structures. I do not aim to answer this question comprehensively as my goal is merely to consider the Bodily Externality Thesis. However, relying on considerations from the previous section, it may be shown that some boundary structures are more plausible candidates for boundary structures of ordinary tactile sensations. In particular, as specified in Sect. 2, the external support may be provided by the following boundary structures: *proximity* and *open/closed*.

The *open/closed* account has a certain plausibility, especially when a tactile sensation involves an experience of an empty space. For instance, when feeling a comb-like object touching the skin we may feel that there are some points in which an object touches our body but also that there are empty spaces between the object's parts (see Scott, 2001). This seems to be adequately grasped by proposing that the awareness of a boundary structure is an awareness that the body is a closed entity which is connected with an open entity, i.e., an empty space. However, in most cases, the *proximity* account seems to be the most plausible. In this case, when having a tactile sensation we are aware that there is a bodily space having a boundary and an external object having its own boundary which stands in some form of maximal proximity to the bodily boundary.

4 Visual boundaries and the externality thesis

I have started the previous section by stating that, in the case of typical tactile sensations, we have a strong phenomenal intuition that awareness of the bodily boundaries can give only external, and not internal, support for the Bodily Externality Thesis. I believe that the situation is reversed in the context of boundaries of the visual field. We are not visually aware of anything that lies beyond the boundaries of the visual field, so there is no element of the visual boundary structure whose awareness could provide an external support for the Visual Externality Thesis. In consequence, if awareness of visual boundary structure provides support for the Visual Externality Thesis, then such support must be internal.

As characterized in Sect. 2, there are two boundary structures suitable for providing internal support: *overlap* and *coincidence*. In the visual context, the first may provide internal support in virtue of the fact that a boundary of the visual field is also a proper part of something distinct from the visual field. The *coincidence* account may provide internal support because the boundary structure spatially coincides with another boundary that is a proper part of something that is not the visual field.

Relying on these observations, we may ask whether the perceptual awareness of visual boundary structure is such that it may be plausibly interpreted as an awareness of some form of overlap or coincidence between the visual boundary and something distinct from the visual field. As we know from Sect. 2, the boundary of the visual field is its proper part composed only of tangential parts, i.e., something can be connected to them without overlapping with the visual field. Even if visual field boundaries are not experienced as typical visual edges between visible objects (Dokic, 2003; Sorensen, 2011; Soteriou, 2011), if we are visually aware of them, then the character of this awareness must be determined by some visual mechanisms. Since the frag-

ments of visual space that make up the visual boundary must be located at the very edges of the visual field, the perceptual awareness of them occurs through the mechanisms of peripheral rather than central vision. Consequently, any visual awareness of visual boundary structures is limited by the capabilities of peripheral vision. If peripheral awareness cannot be an awareness of certain properties, then we cannot be perceptually aware of visual boundaries that have those properties.

In consideration of the above, before evaluating the possible internal support for the Visual Externality Thesis, it will be useful to consider certain facts about the functioning of peripheral vision. There is no doubt that perceptual abilities decrease as the distance from the center of the visual field increases. Nevertheless, it is more complicated to establish the factors that are responsible for this decrease. According to the contemporary state of the art, a major limitation of peripheral vision's performance is its susceptibility to crowding (see Strasburger et al., 2011 for a review), which occurs when visual stimuli are in proximity and the perceptual system has to distinguish the presented elements from each other and properly assign features to objects and places. In comparison to the central vision, peripheral vision requires larger distances between stimuli to effectively function in the case of crowding. The difficulties with crowding suggest that peripheral vision has less-developed abilities to recognize the structure of space and spatial entities. For instance, while central vision may recognize that places P_1 and P_2 are distinct, such that in each a different property can be instantiated, peripheral vision may treat them both as a single place P . In consequence, when crowding occurs in a situation in which one visual object is positioned in P_1 and second in P_2 , peripheral vision may fail to attribute distinct sets of features to each of the objects.

Having identified the major limitation of peripheral vision, we may ask whether it is plausible to postulate that the awareness of the visual boundary structure is also an awareness of this structure as belonging to something or coinciding with something distinct from the visual field. I believe that there are two reasons why this is unlikely. First, being aware of boundary overlap or coincidence requires making a precise recognition of relations in which fragments of the visual field stand. In particular, it requires recognition that a tangential part of the visual field stands in a certain part-hood relation to something distinct from the visual field, or that there is something distinct from the visual field which is co-located with this tangential part. Such recognition is difficult in the case of peripheral vision, which is not able to precisely discriminate relations between places and spatially instantiated features.

Second, the difference between awareness of the space in the center of the visual field and the awareness of space at the edges of the visual field does not seem to be distinct in any positive way. Rather, it is merely a negative difference consisting in the fact that at the edges the awareness of the structure of visual space is less detailed. Hence, it is unlikely that, in the awareness of the edges of the visual field, we are aware of some additional relation regarding overlap or coincidence. In comparison to the awareness of central space, the awareness of peripheral space is diminished and not enriched by some additional element indicating the presence of something distinct from visual space.

The above observations suggest that in visual experience we do not have an awareness of boundary structures that is able to provide internal support for the Visual

Externality Thesis. Nevertheless, I believe that there is, in fact, a deeper problem regarding the visual boundary structures. Up to this point, I was assuming that the visual field has a boundary, i.e., it is a closed entity which has a proper part composed only of tangential, and not internal, parts. However, the awareness of edges of the visual field does not seem to be an awareness of any special fragment of visual space which is not composed of internal parts but is constituted solely of tangential parts. It is more plausible that we are simply aware of the structure of visual space becoming less and less detailed with increasing distance from the center of the visual field, such that making spatial discriminations is increasingly difficult, without any clearly defined place in which the boundary of the visual space is located.

Furthermore, internal parts are such that if something is connected to an internal part of entity E , then it overlaps with E . On the other hand, a tangential part of E is such that something can be connected to it without overlapping with E . However, in the case of the visual field there are no examples of situations in which we are aware of something that is connected to a part of visual space without overlapping the visual field. If something is merely externally connected to the visual field, it is simply not visible. In consequence, the way we are aware of visual space does not provide a reason for postulating that in addition to internal parts, the visual field also has some tangential parts.

Consequently, it is likely that not only does the visual field not have a boundary structure that can be characterized according to overlap or coincidence accounts, but it is an open entity that does not have a boundary as its proper part at all. Note that treating the visual field as an open entity is consistent with the claim that the visual field is bounded in the sense of being limited in size and having a particular shape. Openness simply means that there is no determined place where the visual field ends. Such a particular boundary structure cannot support the Visual Externality Thesis, because the awareness of it is only an awareness of the visual field as composed of certain locations standing in some mereological and topological relations. There is no awareness of any space beyond the visual field.

5 Dynamic vision and dependency

While awareness of visual boundary structures does not seem to provide external or internal support for the Visual Externality Thesis, it may be proposed that the situation changes if we consider the dynamic aspects of vision. In fact, it has been proposed that experiencing visual changes leads to an awareness of the presence of space beyond the visual field (Cavedon-Taylor, 2018; Laasik, 2019; Textor, 2019). Below, I argue that awareness of visual boundary structures in dynamic cases do not provide a support for the Visual Externality Thesis. Furthermore, considerations regarding dynamic vision reveal a certain dependency between visual and bodily awareness of space.

A common visual change associated with visual field boundaries concerns objects coming into or out of view. However, as observed by Cavedon-Taylor (2018), awareness of such events is unlikely to be the kind of awareness that supports the Visual Externality Thesis. Consider a simple situation in which an object appears near the

edge of the visual field during a temporal interval, $T1-T2$. Awareness of such a situation, however, does not involve awareness of the presence of space beyond visual space. It is only an awareness of a visual location P that was not occupied by the considered object at $T1$, but at $T2$ this object is located in P .

Nevertheless, the visual changes associated with boundaries of the visual field are not restricted to changes concerning objects entering or exiting the visual space. In particular, there seems to be a phenomenal difference between experiencing that a moving object enters the visual field and experiencing that an object is stationary but we are moving—or the visual field itself is moving. An interesting demonstration of such phenomenal differences is provided by the rotating drum illusion (Schwenkler, 2014). When a stationary person is positioned in a rotating drum, at first, she experiences the walls of the drum as moving around, but after a while the experience changes and what a person perceives is her own movement in a stationary drum. Such transition from a veridical to an illusory experience suggests that the same pattern of objects moving through the visual field may be experienced as motion of objects in front of the stationary subject or as a motion of the subject against stationary objects.

When an experience of self-motion occurs, the awareness of visual boundary structure is distinct compared to an experience of object-motion. In the case of object-motion, one is aware of a place near the edge of the visual field in which, at some moment T , an object A appears. When a self-motion is experienced, for instance from right to left during the interval $T1-T2$, one is aware of something that concerns not only the location of objects but also the composition of the visual space itself. For instance, at $T1$ one is aware of the presence of a place $PL1$ near the left edge of the visual field and a place $PR1$ near the right edge of the visual field. However, at the subsequent moment $T2$, the location $PL1$ is a little closer to the center of the visual field and a new location, $PL2$, is present which is near the left edge. Analogously, at $T2$ the location $PR1$ is no longer within the visual space and some other place, $PR2$, is close to the right edge. In other words, at $T2$ one is aware of the visual field as composed of distinct places compared to $T1$.

Nevertheless, the presence of such awareness still does not support the Visual Externality Thesis. An awareness of the visual changes under consideration is an awareness of the visual field as composed of distinct places at distinct moments. However, such an awareness does not involve an awareness of some places that are outside the visual field. To reach this conclusion, one must additionally be aware of the place that began to compose the visual field at some moment T as having existed earlier outside the visual field, or of the place that ceased to compose the visual field at T as still existing outside the visual field. The mere awareness of the visual field as composed of distinct places at subsequent moments is consistent with a scenario in which there is no space beyond the visual field, but some parts of the visual field simply come and go out of existence.

At this point, one might ask why many authors have supported the Visual Externality Thesis, if awareness of boundary structures is not awareness of the presence of space beyond the visual field. In particular, if the Visual Externality Thesis is often justified by phenomenological analysis, then some explanation is needed for why philosophers have often been wrong about the source of our awareness of larger space. One plausible explanation is that we rarely have a unimodal, purely visual awareness

of boundary structures. It is more likely that our visual awareness of boundary structures is combined with other forms of spatial awareness. Introspectively, however, it may not be clear what the composition of such multimodal spatial awareness is. Consequently, it may seem that a visual awareness of boundary structures is sufficient for an awareness of the presence of space beyond the visual field, when in fact it is the combination of visual awareness with other forms of awareness that is sufficient.

Below, I outline a proposal that shows how an awareness of the presence of space beyond the visual field can arise from the combination of a visual awareness of boundary structures and a bodily awareness of the presence of space beyond bodily boundaries. Earlier, I argued that an awareness of a visual field—composed of distinct places at subsequent moments—is not sufficient for an awareness of the presence of space beyond the visual field. What is additionally needed is an awareness of a place—that began to compose the visual field at some moment T—as having previously existed outside the visual field. A plausible way to fill this gap is to postulate that in an ordinary experience of self-motion, a person is not only aware of changes in visual space, but also that she—the subject of the visual experience—is moving through space. In particular, such an awareness may be an awareness that (a) the subject is embedded in a space composed of particular locations, (b) the subject is moving and thus changing its spatial relations to parts of space, and (c) the locations in space in which the subject is positioned correspond to locations in visual space. If this is the case, then during self-motion, a new place present in the visual field can be experienced as existing even before it is seen, because it is part of the space in which the subject is embedded.

It seems that in many commonplace situations of self-motion, such additional spatial awareness is provided by bodily awareness. When having a visual experience of self-motion, one is usually not only aware of some changes occurring in the visual field but also of one's body changing position in space. Furthermore, in virtue of mechanisms translating spatial information between visual and bodily egocentric frames of reference, one may be aware of the visual field as a part of the space in which the body is positioned (see Alsmith, 2017; Briscoe, 2021). In consequence, it seems that while the Visual Externality Thesis is not justified, i.e., awareness of visual boundary structures is not a perceptual, phenomenal, and complete awareness of the presence of space beyond visual field, one may be aware of the presence of space beyond the visual field by combining visual awareness of boundary structures with the bodily awareness.

This observation leads to the conclusion that there is a certain dependency between the awareness of space beyond the visual field and the awareness of space beyond the bodily space provided by bodily sensations such as tactile sensations. As argued above, a major source of awareness of the presence of a space beyond the visual field is bodily awareness. This is because bodily awareness is, among other things, an awareness of the presence of space that extends outside of bodily space. One of the reasons why bodily awareness is awareness of space beyond bodily space is that certain bodily experiences, such as tactile sensation, have such boundary structures that awareness of them supports the Bodily Externality Thesis. Thus, awareness of space beyond visual space depends in part on spatial aspects of bodily awareness, which in

turn depend in part on spatial awareness provided by the boundary structures present in tactile sensations.

However, one should be careful not to overstate this dependency. First, while the bodily awareness, in combination with the visual awareness of visual boundary structures, seem to be a major source of awareness of the presence of a space beyond the visual field, it is not necessarily the only such source. It is possible that one may obtain awareness of the space beyond the visual field also by other means. Second, bodily awareness is shaped by a variety of sensory and nonsensory factors (de Vignemont, 2014). Hence, while the awareness of tactile boundary structures is likely to contribute to the fact that bodily awareness presents our body as positioned in a larger space, such a character of bodily awareness may also be determined by other factors, unrelated to the bodily sensations and their boundary structures. Nevertheless, despite these constraints, a certain dependency between awareness of space beyond the visual field and awareness of space beyond bodily space provided by bodily sensations is likely to be present. Such dependency occurs because (a) bodily awareness is an important factor leading to awareness of space beyond the visual field and (b) awareness of space beyond bodily space provided by bodily sensations is an important factor shaping the spatial aspects of bodily awareness.

6 Conclusions

The thesis that awareness of sensory boundaries is also an awareness of the space beyond sensory space has been proposed in the context of both visual experiences and bodily sensations. I have argued that the truth of this thesis depends on the presence of specific boundary structures awareness of which provides support for the Externality Thesis. The conducted analyses have shown that there are good reasons to accept the Bodily Externality Thesis, but not the Visual Externality Thesis. In fact, it is likely that the visual field is an open entity which does not have a boundary as its part.

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Declarations

Ethical approval I comply with the Ethical Standards of Philosophical Studies.

Informed consent and animal welfare The research did not involve human participants or animals.

Conflict of interest The author declares that he has no conflict of interest.

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