Boundaries and Things. A Metaphysical Study of the Brentano-Chisholm Theory

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Abstract

The fact that boundaries are ontologically dependent entities is agreed by Franz Brentano and Roderick Chisholm. This article studies both authors as a single metaphysical account about boundaries. The Brentano-Chisholm theory understands that boundaries and the objects to which they belong hold a mutual relationship of ontological dependence: the existence of a boundary depends upon a *continuum* of higher spatial dimensionality, but also is a *conditio sine qua non* for the existence of a *continuum*. Although the view that ordinary material objects and their boundaries (or surfaces) ontologically depend on each other is correct, it does not grasp their asymmetric relationship: while the existence of a surface *rigidly* depends upon the existence of the very object it belongs to, the existence of a physical object *generically* depends upon having some surface. In modal terms, both are two kinds of *de re* ontological dependence that this article tries to distinguish.

Keywords: *Brentano-Chisholm, Physical Objects, Ontological Dependence, Boundaries, Surfaces*

Introduction

A boundary is always a 'boundary of ...', i.e., we cannot think of a boundary without thinking of the object it belongs to. This condition for a boundary entails a sort of ontological dependence. Boundaries are not substances in the strict metaphysical meaning of the word[1] since they do not exist by themselves: every time that a boundary exists, it does in virtue of the existence of something else. Ontological dependence is a form of ontological *non-self-sufficiency* [15] in which to say 'x depends upon y' means that x cannot exist by itself because x requires y to exist. By contrast, a self-sufficient entity does not require the existence of anything else to exist. Boundaries are non-self-sufficient entities.

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Existence and necessity are required every time something ontologically depends on something else. It is neither a merely causal relation nor a logical relation between objects. It is not just the case that something causes another thing, or that a proposition in which an object is involved entails the truth of another proposition. The relation is about the dependence between the being of one thing on the being of another as a metaphysical necessity. Philosophers such as Azzouni [2], Brentano [4, 3], Casati and Varzi [6], Chisholm [7, 8, 9, 11], Correia [15, 14], Koslicki [20], Jackendoff [18], Mulligan, Simons et al [24], Smid [27], Smith [29, 31], Smith and Varzi [32], Stroll [37], Varzi [39], Whitehead [40] have pointed out in different ways that a boundary is a sort of entity whose existence ontologically depends upon the object it belongs to.

This article specifically focuses on the ontological relationship between ordinary material beings and their boundaries, i.e., three-dimensional physical things (e.g., tables, apples, bowling balls, etc.) and their surfaces. This discussion takes the ontological account of boundaries adopted by Franz Brentano and Roderick Chisholm. I consider both as a single view about the mutual ontological dependence between boundaries and things (spatial objects or *continua*). However, I argue that the Brentano-Chisholm theory (for short, B-C theory) does not grasp the nature of the ontological dependence between ordinary physical objects and their boundaries (surfaces). Although the relationship held by both is a case of *de re* ontological dependence, there is still a metaphysical asymmetry: while the existence of a boundary *rigidly* depends on the existence of the very object it belongs to, the existence of a material object *generically* depends on the existence of boundaries.

The Brentano-Chisholm Account of Boundaries

The Brentanian view on boundaries is taken from two posthumously published works based on his late manuscripts on metaphysics: *Philosophical Investigations on Space, Time and the Continuum* [4] and *Theory of Categories* [3]. The concept of continuity (or *continuum*) is at the core of Brentano's metaphysics. This concept has been thought since Aristotle's theory of continuity in which the continuous change or alteration of quality, quantity, and location that things show in nature can be grasped through perception and intuition. Brentano [4] adopts this theory in which the concept of the *continuum* is not just some idealized mathematical object, but something acquired through an abstraction process from unitary sensible intuitions where "the concept of a boundary and possibility of a coincidence of boundaries is essential to the concept of what is continuous" [4, p. 7-8]. From the perception of objects connected with each other making up a whole, it can be derived the concept of a *continuum* having its boundary. Once we have accepted the idea that there is an object O where many objects xs continuously fill the region of space occupied by O, then both ideas (i) the xs connected in virtue of the coincidence of their boundaries and (ii) O as a bounded object having the xs as its parts are already presupposed.

The intuition of a *continuum* brings with it the intuition of a boundary. As Chisholm says: "Why assume, then, that there *are* boundaries? The concept is needed for the description of physical *continuity*" [9, p. 84]. Thinking of discrete objects x and y to be continuous with each other implies some ontological commitment to what a boundary is. According to Chisholm, a boundary can be defined in two ways: "a boundary is a dependent particular – a thing which is necessarily that it is a constituent of something or [. . .] a boundary is a thing that is capable of coinciding with something that is discrete from it" [9, p. 85]. In this respect, Chisholm accepts the controversial Brentanian theory of coincidence of boundaries, i.e., a boundary is such that it can wholly occupy the same place at the same time that another boundary of the same spatial dimensionality occupies. If x and y are continuous, then there is no empty space between them. Since Brentano labelled as a 'monstrous doctrine' Bolzano's distinction between closed objects that contain their boundaries among their constituents and open objects that do not, if x and y each have their own boundary, then x and y are continuous objects if and only if parts of x's boundary and y's boundaries are spatially co-located.

Contact between two objects (or parts of them) then occurs when two boundaries are co-located in space. As Brentano says, "if a red and blue surface are in contact with each other then a red and blue line coincide" [4, p. 41]. In a different passage Brentano writes again:

> Imagine the mid-point of a blue circular surface. This appears as the boundary of numberless straight and crooked blue lines and of arbitrarily many blue sectors in which the circular area can be thought of as having been divided. If, however, the surface is made up of four quadrants, of which the first is white, the second, blue, the third red, the fourth yellow, then we see the mid-point of the circle split apart in a certain way into a fourness of points. [4, p. 11]

Strictly speaking, there are four coinciding points in the middle of a surface divided into four coloured quadrants: one of each colour. But think of a simpler example such as the boundary-point where two segments of a line meet – one red and another green. In this case, Barry Smith explains the Brentano account of coinciding boundaries as follows: "This point is in a certain sense *both red and green*. More precisely, it is at one and the same time *a ceasing to be red* and *a beginning to be green*. More precisely still, it is a point where a red point and a green point *coincide*" [34, p. 2]. Thus, the two segments are in contact only if there are two co-located boundary-points in the line (one in the end of one segment and the other in the beginning of the other) which are precisely in the middle of it. Inspired by Brentano's ideas, Chisholm has adopted the account of spatial coinciding boundaries in a number of other writings [8, 9, 10, 11, 12]. He explains the idea of coinciding boundaries with the following example:

> We consider a ruler, so viewed that the first inch is the nearest inch. The farthest boundary of the first inch spatially coincides with the nearest boundary of the second inch. Therefore, the first inch is in *direct contact* with the second; the first inch is also in direct contact with the remainder of the ruler; it is in contact, but not in direct contact, with the third inch and with every spatial constituent beyond the third inch. Although the first inch is not itself in direct contact with the third, it is in direct contact with something that *is* in direct contact with the third. [12, p. 91]

By 'direct contact' is meant two objects (in Chisholm's example, two inches of a ruler) which are in immediate contact when their boundaries share a single location in space at the same time. If the ruler occupies a region of physical space without any gap or discontinuity on it, then, Chisholm says, the first inch is in contact but not direct contact with the third inch and every single part of the ruler beyond the third inch. The first inch is in contact with the third inch (and the remainder of the ruler) in virtue of being in *direct contact* with the second inch which in turn is in *direct contact* with the third inch.

Besides spatial coincidence, the most distinguishable characteristic that defines a boundary is, according to Chisholm's terminology, to be a dependent particular, i.e., a boundary is such that necessarily it is a constituent of something. This idea has been firmly addressed by Brentano in different passages. The following are taken from his *Philosophical Investigations*:

> If something continuous is a mere boundary then it can never exist except in connection with other boundaries and except as belonging to a continuum which possesses a larger number of dimensions. [4, p. 10]
> Something continuous which serves as boundary could exist only as belonging to something continuous of a greater number of dimensions and only in connection with other boundaries of the latter. Boundaries require such belongingness and such a connection in order to exist at all [4, p. 12]

Others are taken from the *Theory of Categories*:

> Boundaries do not exist in and for themselves and therefore no boundary can itself be an actual thing [ein Reales]. But boundaries stand in continuous relation with other boundaries and are real to the extent that they truly contribute to the reality of the continuum. [3, p. 55]
> Just as it is certain that there are boundaries and that they must be included among things, it is also certain that a boundary is not a thing existing in itself. The boundary could not exist unless it belonged as a boundary to a continuum. [3, p. 128]

Just as a knot cannot exist without the rope where it is located, a wave cannot exist without the media where it is spread out, and a hole[2] cannot exist without the pierced object where it can be found, a boundary cannot exist without the object it bounds. Just as those entities, boundaries are not substances since they are not "[. . .] entities in their own right; they are 'parasitical upon' other things" [7, p. 51]. By contrast "a substance is not a parasite, does not have borrowed reality; a substance is a being in its own right" [25]. So, necessarily, a boundary exists *in virtue of* the existence of something else. As Smith writes: "boundaries cannot exist in isolation: there are, in reality, no isolated points, lines or surfaces [. . .] they are located in space but do not take up space" [34, p. 109]. Although a boundary is not a substance able to take up space, it can be found in space when the spatial object it belongs to or at least *some* part of it exists.[3] The ontological dependence of a boundary upon the object it belongs to seems to be so strong according to Chisholm that even God cannot do anything about it:

> Could God preserve any of the boundaries of a thing apart from the thing? We could say that, for any thing having

> boundaries, God could destroy the thing and preserve the boundaries – by destroying some part of the thing such that the part did not contain any of those boundaries. But he couldn't preserve the boundaries except by retaining *some* part of the original thing. [9, p. 86][4]

Brentano distinguishes spatial boundaries having zero dimension (points), one-dimension (lines), and two-dimensions (surfaces) which can only be constituents of *continua* of higher dimensionality: points are boundaries of lines, lines are boundaries of surfaces, and surfaces are boundaries of bodies (or three-dimensional *continua*). According to the Austrian philosopher, boundaries can be also distinguished as *inner* and *outer* [17, p. 10-11][5]. Thus, any point between the two extremes of a line is an inner boundary, whilst the starting point and the final point of the line are both outer boundaries as well as the point on the top of cone. Inner boundaries can also be the line that divides a surface into two halves or the surface that divides a body into two halves. For instance, the Equator is a line that divides the earth's surface into two equal parts (or hemispheres). Since the Equator is a line throughout the earth's surface, then it is a part of the outer boundary of the earth. However, the Equator also is an inner boundary insofar as throughout it the earth's surface is divided into two halves. Furthermore, as long as the earth is a spherical body, the Equator is an inner boundary or surface area where the earth can be divided into two equal bodies. A boundary is an entity such that it exists as a boundary of a *continuum*, but also in connection (spatial coincidence) with other boundaries of the same *continuum*. In this regard, the outer/inner distinction of boundaries becomes more complex inasmuch as spatial dimensions are higher.

The outer/inner distinction of boundaries leads Brentano to describe boundaries as entities having differences of greater or lesser *plerosis* or *fullness* [4, p. 11]. The *plerosis* of a boundary is found in the possible directions of a boundary in relation to the object it belongs to. Brentano writes:

> One of the characteristic features of the relation which a boundary may bear to a bounded continuum is this – that the boundary can be a boundary in more or less directions. [...] This distinction along with the number of directions in which the boundary bounds the continuum yields differences in the *plerosis* of a boundary. [3, p. 128-29]

For instance, in the case of temporal boundaries, the initial instant and the final instant are both outer boundaries of an event. However, an instant that separates the event into two different moments is an inner boundary of that event, so it is a boundary having two directions insofar as it is both the end point of a part of the event and the starting point of another of it. On the other hand, in the case of spatial *continua*, one point, among the many other points that compose the surface of a three-dimensional object has a *greater* degree of *plerosis* than a temporal boundary at the beginning of an event (which only has one temporal direction) to the extent that a point may have a direction towards all the senses in which it can be a boundary. As Chisholm explains:

> The boundary of a spatial continuum is not thus restricted with respect to the number of directions in which it may be a boundary. It may be a boundary in all the directions in which it is capable of being a boundary, or it may be a boundary in only some of these directions [13, p. 115].[6]

The concept of *plerosis* is, therefore, what grounds the possibility of coinciding boundaries. The surface area where a body can be divided into parts is where spatially coincident boundaries have different *plerosis*. There is a topological change when a body is separated into two halves in which two surfaces with different *plerosis* appear once the cut is carried out. Nevertheless, Brentano rejects the distinction between open objects and closed objects when two objects are topologically connected. Instead, he supports the possibility of spatial coincidence. So, cutting a body that occupies a region of space R into two equal halves entails that there are two sub-regions of R and parts of their boundaries (R's inner boundaries) which were sharing a single spot in space at once, they do not anymore. Inner boundaries are therefore places where *continua* are things possible to divide. Thus, the concept of boundary is fundamental for what a *continuum* is: the existence of boundaries and the capability of either spatial or temporal coincidence with other boundaries entails the possibility of contact between different *continua*.

The *Theory of Categories* makes a critical study of the Aristotelian substance/accident theory. Basically, Aristotelian substances are entities which are 'beings in the strict sense', i.e., they can exist for themselves without depending on something else; by contrast, accidents just exist in a 'mere extended sense' in virtue of the bearers that instantiate them. The substance/accident relation illustrates what Brentano called the *one-sided separability*. Substances are *separable* entities which do not need anything else to exist; accidents are *inseparable* entities which do need something else to exist. According to Brentano, the substance/accident relation is in fact a whole/part relation. However, the Austrian philosopher turns it over: "every accident contains its substance as a part, but the accident is not itself a second, wholly different part that is added to the substance" [3, p. 19]. The traditional view would consider the whole as the substance and the parts it is composed of as accidents. By contrast, Brentano thinks of the substance as a proper part of the accident. How does he arrive at this idea?

Brentano accepts the traditional conception of the one-sided separability in which the accident requires the substance to exist. Nonetheless, the one-sided separability of the substance/accident relation would entail a mereological essentialism in the following way: an accident is a whole having a substance as a proper part, but the substance is the *only* proper part that the accident can have; the accident does not have more proper parts in addition to the substance. So, if the accident has a substance as its only proper part, then to destroy the substance involves destroying the accident. If every whole has the parts it has necessarily, then the accident cannot exist unless the substance exists. The Brentano view is that x depends on y means that x can only exist if y exists and y is a part of x. So, the accident A depends on the substance S insofar as (i) S is the only proper part that A can have and (ii) A may have another accident as a proper part, but every proper part of A is either identical with S or a part of S. Although Brentano defines a substance negatively, i.e., a substance is not an accident [3, p. 111], the difference between them is such that an accident has a substance as the only proper part *necessarily*, while a substance has an accident as a proper part *possibly*.

Boundaries are neither substances nor accidents. A Substance is a *separable* being that can exist for itself, while a boundary is an *inseparable* being that cannot exist without belonging to a *continuum*. An accident is a whole that needs a substance as a proper part, while a boundary is a kind of being that need to *be* part of something. Brentano thus distinguishes between parts and boundaries of *continua*: "the boundary is nothing by itself and therefore it cannot exist prior to the continuum; and any finite part of the continuum could exist prior to the continuum" [3, p. 56]. Chisholm also embraces a similar distinction: "[T]hings may have two types of constituents – parts and boundaries. And we will say that a part of a thing is a constituent which is not a boundary" [9, p. 83]. Any constituent of an object O that can only exist attached to any constituent of O having O's spatial dimensionality is a constituent of O's boundary; the remaining constituents of O are O's parts.

In this regard, Chisholm defines parthood as follows: "x is a proper part of $y =_{df} x$ is a (proper) constituent of y; and x is not a boundary" [11, p. 506]. The negative component of the definition is relevant to make clear what it means for a thing to be part of another thing. If being a boundary entails being an ontologically dependent constituent, then whatever exists as a part of a thing (without being a boundary) it might have existed without being part of that thing. Handles, for instance, can be proper parts of objects as mugs or suitcases, but handles themselves can be parts of no object at all. By contrast, boundaries are such that they cannot exist without being boundaries of three-dimensional objects such as mugs and suitcases.[7] The ontological dependence of boundaries upon *continua* has a particular characteristic:

> The boundary does not depend for its existence upon any particular one of the continua that may be specified. It depends only in a general way *upon some continuum or other* among the specifiable continua to which it belongs. [...] The boundary, then, depends, not upon any particular continuum, but only upon there being a continuum – indeed countless continua, which are alike in that the boundary belongs to them as a boundary. [3, p. 201]

The ontological dependence of a boundary is not upon the very object it belongs to, but upon *objects of some kind*. It is true that a boundary cannot exist unless something else exists, but it is not the case that a boundary *must* exist as the boundary of the object it *currently* belongs to. Boundaries do not depend upon *this* or *that* object, but upon *some* object of higher spatial dimensionality. According to the B-C theory, surfaces as boundaries of three-dimensional bodies do not exist in virtue of the existence of the particular object they currently bound; rather, they only exist in virtue of being the boundary of *some* object. Nonetheless, it is important to consider that the ontological dependence of a boundary upon the object it belongs to is not just a *one-side relation*. Just as boundaries depend upon the existence of *continua* (of higher dimensionality) to exist, the existence of *continua* depends upon the boundaries they have. This view is however clearer for Brentano than for Chisholm:

> No continuum can be conceived apart from the boundaries belonging to it, nor can any boundary be conceived apart from a continuum, indeed, apart from countless continua, to which it belongs as boundary [4, p. 201] [...] Every

> boundary is likewise a *conditio sine qua non* of the whole continuum. The boundary contributes to the existence of the continuum. [3, p. 56]

To be a *conditio sine qua non* seems to imply that, in some way, spatial (and temporal) objects are *conditioned* by having boundaries. In this case, 'conditioned' refers to some ontological relation between objects and boundaries in which the spatial existence of objects (or *continua*) depend on having a boundary. It is not clear what Brentano means by 'the boundary contributes to the existence of the continuum'. The term 'contributes' does not spell out the conditions under which an object ontologically depends upon the boundary it has. In another passage of *The Categories*, Brentano contends that "the boundary is a precondition of each of the continua to which it belongs, and so can truly be regarded as material cause of persistence" [3, p. 206]. By 'material cause of persistence' is meant, as I see it, that boundaries are a *conditio sine qua non* for objects insofar as they *contribute* to not only the spatial existence of objects capable of taking physical space (in the case of bodies), but also the conditions of their identity over time. That is, having a boundary allows an object both to take place in space and to survive changes across time. These considerations will be relevant to talk about boundaries and ordinary material beings which are the sort of things that seem to show temporal persistence. So far, the exposition of the B-C theory ends here.[8]

Surfaces as Boundaries of Ordinary Physical Things

This article focuses on the boundaries of ordinary physical things and the sort of ontological dependence between them. Ordinary physical things are traditionally seen as 3D bodies having physical properties and temporal persistent conditions (i.e., objects able to survive qualitative changes across time). As we saw, according to the B-C theory, a *continuum* can only have boundaries having lower spatial dimensions, so 3D bodies can only have boundaries of two dimensions or lower. For instance, by following a mathematical definition, a cube is a regular hexahedron bounded by six square faces, twelves edges where their faces meet, and eight vertices where their edges meet. Each of the faces, edges, and vertices are boundaries of two, one, and zero dimensions, respectively. However, if the cube undergoes a topological transformation such that it becomes a sphere, then the number of boundaries decrease to one single boundary (a surface). Given that no discontinuities are found along the surface of a sphere, there are no faces in the same way that a cube has its faces where its edges and vertices meet. So, the many boundaries had by the cube have become, after the topological transformation, a just one boundary or surface.

Avrum Stroll [36] raises the question 'How many surfaces do objects have?'. As we saw above, different answers can be said in relation to how we decide to count boundaries: someone can take a cube as an object having a single surface regardless of the six faces it has, while another one can argue that each of the faces is a boundary of the cube and, therefore, the cube has six surfaces. Thus, for the former, surfaces are the outermost layers or boundaries of 3D objects and there would thereby be one surface for each of them in the world; for the second, by contrast, each 3D object has as many surfaces as discontinuities (edges and vertices) and faces can be found along its outermost layer. In this latter respect, each of the faces, edges, and vertices is a boundary that a cube has of two, one, and zero spatial dimensions, respectively. Thus, the topological distortion of a cube into a sphere mentioned above or into any other 3D object will imply either an increase or decrease in the number of the outer boundaries it may have in virtue of the faces, edges, or vertices (corners) that can arise as a result of the distortion.

By following the B-C theory, ordinary material things, as instances of 3D *continua*, can have more than one boundary of different spatial dimensionality. From a *loose way of talking*, the die that I use to play board-games is an instance of a cube, i.e., a cube-shaped physical thing having six faces built by its edges and vertices. Nonetheless, the die's joints are soft curves which gradually bend the die into six faces shaped cube-wise, so that, *from a strict way of speaking*, the die has neither edges (1D boundaries) nor corners (0D boundaries). The die seems to only have one continuous surface that changes its orientation in such a way that six congruent square faces shape a cube-wise object. In this respect, the faces that an object may show are the result of the different changes of orientation that the object's surface undergoes. Thus, from this kind of perspective, ordinary physical things only have surfaces as their outermost or outer boundaries and faces, in this case, are just different parts of a single surface.

The distinction between faces and surfaces cannot be overlooked in a discussion about the boundaries of ordinary physical things.[9] However, this article does not aim to discuss this distinction, but to explore the kind of ontological dependence between those objects and their boundaries. For practical purposes, although the B-C theory is a general account of boundaries of any spatial dimension, I will take surfaces as the paradigmatic instances of the boundaries of ordinary physical objects. That is, I understand the surface of table not just as its top part, but its whole outer boundary that separates that table and all the matter it is composed of from the table's spatial environment. Put it differently, a physical object O is a three-dimensional entity having a surface as its external or exposed boundary that indicates where the matter that composes O reaches a limit in space before finding O's spatial environment. In this respect, Casati and Varzi define a surface as follows:

> The surface of an object x is the part of x that overlaps (i.e., is partly shared by) all those parts of x that are in contact with the geometrical complement of x – where the geometrical complement of an object x is simply defined as the entity wholly occupying the region of space that is not occupied by x. [5, p. 12]

This definition basically contends that a surface is the boundary of x insofar as it is the sum of all those parts of x which are in contact with x's *geometrical complement*, i.e., the unoccupied spatial environment immediately around x at one time that can be potentially occupied by (some part of) x or any other object at another time. This definition also includes physical objects with internal cavities such as tennis balls, Emmental cheese, or trumpets. Stroll's definition of surfaces as outer or upper aspects of things which are normally visible or not 'hidden' [37, p. 186] does not do justice to fact that hollowed out objects or things with internal cavities have surfaces which are hidden.[10] A French horn, for instance, is such that we can easily see the surfaces of each of its external parts (valves, levers, mouth piece, and bell pipe), but almost nothing can be seen from the inside of the bell and the rest of the tubing. In these cases, the adjectives 'upper' or 'outer' cannot be applied for every surface. However, Casati and Varzi's definition comprises both outer and inner surfaces of objects with internal cavities insofar as a surface is that boundary in direct contact with the surrounding empty space of an object. If so, even the inner surfaces of the internal cavities of trumpets, Emmental cheeses, or French horns are boundaries in direct contact with empty space inside them wherever they are located at some given time.

The following sections will address the ontological dependence between ordinary physical objects and their surfaces (i.e., those boundaries which demarcate the stopping place of the portion of space occupied by material things). As we saw with the B-C theory, boundaries and things hold a mutual ontological dependence. On the one hand, the existence of 2D boundaries or surfaces depends on their being the boundary of 3D *continua* (or, at least, on the remaining parts of it after the possible destruction of some of its parts). On the other hand, the existence of 3D *continua* such as ordinary physical things depends upon having boundaries of lower spatial dimensionality such as 2D *continua* or surfaces. According to a modal account, ordinary physical things and their boundaries (or surfaces) hold a mutual ontological relationship of *de re* dependence, but they differ in sort: while the existence of a surface *rigidly* depends on the material thing it belongs to, the existence of a material thing *generically* depends on having a surface. This asymmetry is, in fact, what the B-C theory does not allow us to grasp.

Surfaces and* de re/de dicto *Modality

Ontological dependence involves modal elements to the extent that the existence of something *necessitates* the existence of something else. This can be put in terms of *de re* and *de dicto* modality. A traditional example of the *de re/de dicto* distinction is this:

(De re) The number of planets is *necessarily* odd

(De dicto) *Necessarily*, the number of planets is odd

Let's say first that something is *necessary* if and only if it could not have been otherwise than it in fact is. The modal distinction between *de re* and *de dicto* statements rests on how the modal operator is taken: while in the former the property of being odd is what falls under the scope of the modal operator of necessity, in the latter it is the whole sentence 'the number of planets is odd' what does it. In this respect, the *de re* statement is true since the number of planets in the solar system is nine (so far) and the number nine is necessarily odd, whereas the *de dicto* statement is false since the number of planets could have been otherwise. How does the *de re/de dicto* distinction can apply to boundaries of material things? This point is suggested by Casati and Varzi:

> The dependence of a boundary on its host is a case of genuine ontological dependence [...]. It is not merely a case of conceptual or *de dicto* dependence, as when we say that there cannot exist a husband without a wife. Every husband, i.e., every man who is in fact married, could have been a bachelor

> (or so we may suppose). But the surface of a table can only exist as a *surface of* a table – perhaps only as a surface of *that* table. [6, p. 96]

Casati and Varzi contend that the ontological relation between a surface and the table it belongs to is not a case of *de dicto* dependence in terms of logical necessity, but a case of *de re* dependence in terms of ontological necessity. They think that a surface cannot exist without being the boundary of a table, which follows Simons' definition: "the ontological dependence of one object on another or others is one of *de re* necessity: the object itself could not exist if others did not exist" [26, p. 294-95]. However, Casati and Varzi also suggest that *maybe* a surface cannot exist unless the specific table it belongs to exists too. The B-C theory disagrees with that suggestion. According to it, a boundary ontologically depends in a general way upon *some continuum or another* rather than the specifiable continuum it currently belongs to. This view seems to be true for points and lines which are boundaries of abstract objects. However, it is not clear at all regarding boundaries of material things.

Unlike a point or a line, a surface is a particular case of boundary that directly depends upon bodies having physical existence and temporal persistence. This condition entails that a surface does not ontologically depend on objects of some kind (i.e., 3D *continua*), but on the very object it belongs to. However, material objects also need boundaries to exist in physical space, but it is not the same kind of ontological dependence that a surface requires. A material body needs a boundary, but not a specific one. The existential necessitation of surfaces with physical objects and physical objects with surfaces are both cases of *de re* ontological dependence, but of a different sort: while the former is a case of *rigid* ontological dependence, the latter is a case of *generic* ontological dependence. The *dependence of physical objects upon surfaces* (DOS) can be thus put as follows:

(DOS1) *De* re_{rigid} Dependence:
For every physical object, there is a surface that is **necessarily** the boundary of it.

(DOS2) *De* $re_{generic}$ Dependence:
For every physical object, there is **necessarily** a surface that is the boundary of it.

(DOS3) *De dicto* Dependence:
Necessarily, for every physical object, there is a surface that is the boundary of it.

Each of these have different ontological implications. First, for anything that happens to be a physical object, DOS1 rules out its existing without having the surface it in fact has. This can be formalized as $\forall x \exists y \Box (y \beta x)$ where β means 'a boundary of': for every x that is a physical object, there exists y that is a surface and y is necessarily the boundary of x. Since modality operates in the necessity of y as a boundary of x, DOS1 specifies that a physical object cannot have a different surface from that one it currently has. Thus, if DOS1 is a genuine case of *de re* modality, then a table can only have a surface and nothing else than *that* surface.

Second, DOS2 is a different case of *de re* modality. It implies that for anything that happens to be a physical object, DOS2 rules out its existing without having a surface at all or $\forall x \Box (\exists y) y \beta x$: for every x, there exists necessarily y and y is the boundary of x. Since modality is operating in the necessity of y's existence, DOS2 purports that a physical object cannot exist without *some* surface but does not tell us that it must have a particular surface. In this case, a table may exist without the surface it in fact has, but it is not possible for it to exist without a surface.

Third, DOS3 simply rules out anything as both being a physical object and also having no surface or $\Box(\forall x \exists \mathrm{y} y \beta x)$: necessarily, for every x there exists y and y is the boundary of x. Unlike DOS1 and DOS2, given that the modality is operating in the necessity of the entire sentence 'for every x there exists y and y is the boundary of x', DOS3 entails that if an object is said to be a physical object, that object cannot exist without having a surface. In this case, a table might exist without either being a physical object or having a surface, but in every world in which that table exists as a physical object it must exist having a surface.

On the other hand, the *dependence of surfaces upon physical objects* (DSO) can be put as follows:

(DSO4) *De re*$_{rigid}$ Dependence:
For every surface, there is a physical object it **necessarily** belongs to.

(DSO5) *De re*$_{generic}$ Dependence:
For every surface, there is **necessarily** a physical object it belongs to.

(DSO6) *De dicto* Dependence:
Necessarily, for every surface, there is a physical object it belongs to.

DSO claims have similar ontological consequences to DOS claims. First, for anything that happens to be a surface, DSO4 rules out its existing without belonging to the physical object it in fact belongs to. Given a surface x that belongs to a physical object y, x can only exist if y exists; so, in any world where the surface of a particular table exists, the surface only exists as the boundary of *that* table. Second, for anything that happens to be a surface, DSO5 rules out its existing without belonging to an ordinary physical object at all. In this case, a surface x can only exist as the boundary of some ordinary physical object y, but it does not entail that x is necessarily y's boundary; so, the current surface of a table might exist without belonging to *that* table, but it cannot exist without belonging to some physical object. Third, DSO5 simply rules out anything as both being a surface and not belonging to any physical object. In this case, DSO5 allows that a surface x that belongs to a physical object y might exist without being a surface at all, but insofar as x is a surface, x cannot exist without belonging to some y. So, in every world of physical objects where something is said to be a surface, it can only exist as a boundary of a physical object.

As regards DOS modal considerations, I consider DOS1 false while DOS3 true as a logical consequence of the truth of DOS2. DOS1 seems quite counterintuitive in our everyday talk of material objects: it is rather plausible to imagine a table (and any ordinary physical object) having a different surface from the one it currently has. If surfaces can bear physical properties, they might be removed from their bulks (e.g., by polishing every part of the old surface of a door would bring out a new surface). Nevertheless, DOS1 rules out that possibility since it asserts that every physical object could only have one surface throughout all its existence. Therefore, DOS1 would be false: it is not the case that an object has a surface that is necessarily its boundary because it could be otherwise.

Surfaces are also relevant in many physical features that we attribute to material objects (e.g., colours, shapes, textures, and so on), so it seems to be that having a surface is needed to instantiate physical properties. Nonetheless, if surfaces are where both physical properties are instantiated and physical events (e.g., light reflection or corrosion) occur, then a physical object does not need the specific surface it in fact has, but just having one at every time it exists in physical space. In that case, DOS2 describes better the sort of ontological dependence of ordinary physical objects upon surfaces. DOS2 is a different case of *de re* modality. Unlike DOS1, DOS2's modal dependence is not about a physical object upon the surface it in fact has, but upon having some surface throughout all its existence which may or may not be its current surface. Although an object may have different surfaces, it is not possible for it to exist in physical space without having any surface at all. Physical objects cannot go anywhere in space without having a boundary with them: in fact, they are spatially found, according to Casati and Varzi, where their boundaries (or surfaces) are found [6]. So, necessarily, for anything that is a physical object entails having a surface at any world it exists.

As regards DSO modal claims, all of them can be considered true, but only DSO4 expresses the genuine ontological status of boundaries of physical objects as dependent entities. DSO4 entails that for a surface there exists one and only one physical object to which that surface belongs. Although a table could have a different surface than it in fact has (as both DOS2 and DOS3 suggest), *that* surface cannot exist without *that* very table. This is for sure the most controversial claim. As we said in the introduction, a boundary is always a 'boundary of…'; in particular, surfaces are boundaries *of* ordinary physical things. Although surfaces are two-dimensional objects incapable of having physical powers by themselves, they are boundaries in contact with the spatial surroundings of material things showing many physical features. A surface has spatial location insofar as it exists as a boundary of a three-dimensional material substance. Following DSO4, although parts of a material body can survive the destruction of it, the surface (the boundar*y*'s body) is destroyed at the precise moment of the bod*y*'s destruction. If the body does not exist, the surface cannot be spatially located and show any physical property.

On the other hand, DSO5 is metaphysically weaker than DSO4. DSO5 just claims that a surface cannot exist without being the boundary of a physical object. DSO4 instead entails that if a surface exists as the boundary of a physical object, then it can only be found in space where *that* specific object is found. Given that material things have physical properties that points and lines lack, surfaces depend upon objects having identity and persisting conditions. Since surfaces are ontologically dependent boundaries upon objects that can survive qualitative changes across time, then they do not generically depend upon being the boundaries of one object or another, but rigidly upon being the boundaries of specific and well-identifiable physical objects. Hence, DSO4 describes this ontological condition better than DSO5 and DSO6. I will then focus only on DOS3 and DSO4 which explain more accurately the kind of ontological relationship that physical objects and boundaries hold between each other.

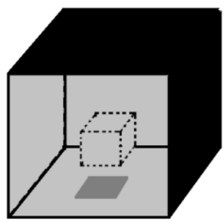
Rigid Ontological Dependence: *Surfaces upon Objects*

The B-C theory argues that boundaries are both ontologically dependent entities upon some *continua* and a *conditio sine qua non* for the existence of the *continua* they belong to. This thesis has been endorsed by Smith and Varzi in the following way: "the continuum is specifically dependent on its boundary, but the boundary is not in the same sense dependent on its continuum; it is only generically so" [32]. Although this view can be seen as correct regarding boundaries such as points and lines, it is not if we analyze boundaries of three-dimensional bodies capable of taking physical space. In this case, surfaces are both boundaries that specifically depend upon the physical object they belong to and *conditio sine qua non* for physical objects. That is, a surface ontologically depends upon the specific physical object it belongs to, while a physical object in a general way depends upon having boundaries throughout their existence. In the philosophical literature, these two different sort of ontological dependence are put in terms of *rigid existential dependence* and *generic existential dependence* [15, 38]. The former can be written down as follows:

(Def.1) x *rigidly* depends upon $y =_{df}$ Necessarily, (i) x exists only if y exists, and (ii) x is different from y.

The rigid existential dependence is not flexible: it is a very intimate ontological relation between the existence of an object with the existence of another. Some examples, according to Tahko and Lowe [38], can be a non-empty set that depends on the very members that it has, so any change in its members will change the set itself; or a particular person depends on the particular sperm and egg that generate him/her insofar as that if the original sperm and egg had been others, the person born from that ovulation would be different. Correia [15] also suggests other possible cases of rigid dependence: events or processes upon their participants, temporally extended objects upon their temporal parts, or veridical intentional states upon their objects. Other cases can be a hole that rigidly depends upon its host [5] or a trope as a particularized property that rigidly depends upon its bearer [15, 20]. Thus, rigid existential dependence is a strong ontological connexion between a thing that can only exist if another thing and only *that* very thing exists.

Boundaries of material beings are entities that rigidly depend upon the specific objects they belong to. A surface S of a material body x is such that S can neither exist without being the boundary of x nor exist if x does not exist. As Chisholm contends, boundaries and parts do not have the same ontological status: unlike the parts a material object is composed of, its boundary is a kind of constituent that cannot exist for itself. In this respect, boundaries –including surfaces of things– have the following two characteristics: first, if x is a boundary of y, then x is a boundary that encloses every part of y; second, if x is a boundary of y, then y is not a boundary of x. The first principle implies that the boundary of an object is a boundary of the *whole* object and not only of those parts that directly overlap with it. The second principle lays down that the relation between a boundary and the object it belongs to is *asymmetrical*: although every object has its boundary, an object is not itself a boundary for the boundary it has. In the case of boundaries of material bodies, a surface S of a compact wooden die (call it Woody) is a boundary that separates *all* the parts of Woody (the *ws*) from Woody's spatial surroundings, even those *ws* not directly connected with S. We can therefore think that if S rigidly depends for its existence upon Woody, then S rigidly depends upon each of the *ws*. However, this is not necessarily true. It is possible that some *ws* are destroyed and S will not be destroyed with them if and only if Woody survives the destruction of the *ws*. Look at Woody:



Imagine a very special tool capable of removing from Woody some of the *ws* (the little cube inside of Woody) without touching S. This piece (call it Piece) is exactly located at the centre of Woody and no part of Piece touches any part of S. Following the principles already said above, S is a boundary for every part of Woody including Piece and S is a boundary for Woody but not *vice versa*. In this case, the way S depends upon Woody is different from the way Woody depends upon S: while S cannot exist unless Woody exists, Woody cannot exist without having a surface like S. Even though S rigidly depends upon Woody, S does not depend upon each of the *ws*. In fact, S could still exist after the removal of Piece from Woody. If the existence of S rigidly depends upon the existence of Woody, then S exists every time that Woody keeps existing despite some of its parts can be destroyed. Put it differently, if the removal of Piece does not entail the annihilation of Woody, then S keeps existing. We can then make the following claim:

(C) If x is the surface of a physical thing y, then (i) x exists attached to y as a boundary where y is a physical object, (ii) x can exist only if y exists or some parts composing y exist, and (iii) y cannot be a boundary for x (given the difference in the way y ontologically depends upon x).

The above statement does not follow the principle of what Chisholm calls *mereological essentialism* (ME): "The principle may also be put by saying that every whole has the parts that it has necessarily, or by saying that if y is part of x then the property of having y as one of its parts is essential to x" [7, p. 145]. If an object is composed of the parts it has necessarily, then the destruction of any of them would entail its destruction. ME would therefore entail that if Piece is destroyed, then Woody is destroyed too. In that case, S cannot exist since the removal of Piece entails the destruction of Woody. If S is not destroyed when Woody is destroyed, then S would be the boundary of two different objects at different times: Woody (having Piece among its parts) at one time and some other object that comes into existence after Piece's removal. If Chisholm account is right, S (and any surface) does not rigidly depend upon Woody. Although ME agrees with the claim that boundaries cannot exist without the objects they belong to, this ontological relation would not be a rigid existential dependence as DSO4 demands, but a generic ontological dependence following DSO5.

In this regard, Chisholm (like Brentano) contends that a boundary is "a contingent individual which is necessarily such that it is a constituent of something" [11, p. 505] or that "every spatial boundary is necessarily such that there is some physical object that contains it as a constituent" [12, p. 96]. According to this view, boundaries are not necessary entities (they might have not existed) and their being do not depend on the specific objects they belong to, but in a general way on being the boundary of objects of some kind. That is, S does not depend on Woody, but on being the boundary of a kind of entity like Woody. Although the mereological change undergone by Woody entails the destruction of Woody, the destruction of Woody does not entail the destruction of S. Since S does not *rigidly* depend upon Woody, S does survive Woody's destruction and becomes the boundary of the object made of Woody minus Piece. Nonetheless, if the relation of a boundary and its object is a genuine case of ontological dependence, then it involves a *de re* modality as DSO4 demands. However, if ME is true, then the surface of a table would be destroyed every time that the table either gained or lost atoms. Thus, in order to both avoid this undesirable consequence and preserve a *de re* dependence of surfaces, I see three options:

i. Accepting ME and so accepting too that the same surface remains despite the series of mereological changes of the original object it belonged to as long as some parts of the original object still remain.

ii. Accepting ME and so accepting too that 'new' surfaces pop out with each of the different objects that come into existence in every series of mereological changes.

iii. Rejecting ME and so accepting too that a surface is the boundary of an object that may change its mereological composition without being destroyed.

Regarding (i), it looks byzantine. According to (C), a surface could survive throughout a series of mereological changes because at least some non-boundary constituents of the 'original' object remain in every change. ME entails that an object can be destroyed by any change of its mereological composition, but if some parts of the 'original' object remain, then the boundary may survive the object's destruction. So, if the table that you use for dinner undergoes series of mereological changes (perhaps either gaining or losing a few atoms), then your dinner would be on a different table at every change but on the same surface providing that parts of the 'original' table remain. We may then have this picture: an object x has a surface s_x at t_1; after a change in x's mereological composition, x is destroyed and a new object y comes into existence at t_2. Following (i), y's surface can still be s_x if some original parts of x are among the components of y; we thus have two different objects at t_1 and t_2 but having the same surface. The oddness of this picture is that an object y can both be composed of the 'original' parts of x and have s_x as its boundary. So, if y is composed by some parts that used to belong to x and therefore having s_x as its boundary, then what is the table on which you have dinner? It could be either on x insofar as you are still having dinner on s_x since some 'original' parts of x have survived x' mereological change, or on y that comes into existence after

x's destruction despite the fact that s_x still survives it. In some way, regardless of what may happen 'beneath that surface', you are always having dinner on the same surface but not the same table. Surfaces would be changeless boundaries throughout the continuous mereological destruction of different objects. In that sense, option (i) does not grasp the genuine ontological dependence of a surface on the object it belongs to that DSO4 demands. Therefore, it should be rejected.

Regarding (ii), it looks closer to *de re* dependence view of surfaces. In this case, every object in the series of mereological changes would have its specific surface: there exist different tables for every compositional change that your table might undergo and each of them having its own surface. We now have the following picture: x is an object having a surface s_x at t_1; after a change in x's mereological composition, x is destroyed and a new object y comes into existence at t_2; so, we have one object at t_1 and another object at t_2 but each one having a specific surface s_x and s_y respectively. This option does not lead us to the odd case of (i) in which the series of objects are continuously destroyed but a single surface survives. In the case of (ii), there exists one table for every series of mereological changes having its specific surface. However, (ii) has some puzzling consequences. Following (C), necessarily, s_x goes out of existence if either x is destroyed or s_x does not exist as a boundary of x (e.g., by detaching every part composing s_x from every non-boundary constituent of x overlapping directly with s_x). However, according to ME, to destroy x is only needed to change x's mereological composition. Thus, for every atom that your table may either gain or lose at different times, you will be having dinner on different tables, each with its own surface. A surface would *rigidly* depend upon each table that comes into existence in every mereological change as the genuine ontological dependence of boundaries of material beings demands. However, option (ii) would entail that there might exist countless tables, each one having its own surface, for every slightly mereological change. Since option (ii) implies such an odd consequence, it should be rejected too.

I rather sympathize with (iii). This option entails a *de re* dependence between a surface and the object it belongs to that DSO4 demands despite the mereological changes that *that* object may undergo. That is, notwithstanding your table can either gain or lose some of its atoms, there exists only one table at different times having the same surface. The picture is as follows: an object x is composed of the xs and it has s_x as its boundary; after a change in x's mereological composition, even though x might either gain or lose some of the xs, x is not necessarily destroyed and, therefore, s_x neither. Following S2, the only way to destroy s_x is by destroying x or at least those xs directly overlapping with s_x. Option (iii) does not contradict the common-sense view in which material objects have temporal persistence conditions.[11]

Regarding our previous example of Woody, option (iii) can be undermined by arguing that if we remove not only Piece but almost all the material from Woody's interior leaving only a thin shell, then the outcome would be the destruction of Woody and yet the outer boundary or surface would still be the same. To put it differently, after Woody's destruction a new object would pop out but having the same surface. This is quite close to the option (i) previously rejected, but it does not assume ME necessarily. Rather, it asserts that to destroy Woody is not enough either adding or taking out some atoms, but it would be needed to remove almost all the material from Woody's interior until leaving the thinnest possible amount of material attached to Woody's surface.[12]

First of all, the above situation entails settling how much material an object has to lose in order to go out of existence. It seems to be clear that losing few atoms does not entail Woody's destruction, while it is absolutely clear that losing all its atoms entails Woody's destruction. However, to determine a precise number of losing atoms seems to be a matter of vagueness. Thus, in order to leave Woody's surface unalterable, it is necessary to keep some of Woody's parts unalterable (the thinnest parts). If a surface is a two-dimensional boundary that can only be physically located by being the *boundary of* a three-dimensional body, then some parts or non-boundary constituents of Woody must remain if Woody's outer boundary (or surface) survives the removal of *almost* all the material form Woody's interior. That is, if we want to say that Woody has been destroyed but not its surface, we cannot remove *all* the matter that makes up Woody, but some of them (at least, we cannot remove the thinnest parts in direct contact with Woody's surface). However, if we have removed a *lot* of the material that composes Woody, but we cannot remove *all* of it (and still maintain that Woody's surface is the same), then it is vague whether Woody has lost enough matter or not in order to say that it is gone.

Furthermore, even though surfaces are abstract objects, it is clear that most of the perceptual information collected from physical objects (e.g., colours, textures, corrosivity, etc.) comes from their surfaces rather than the whole matter they are composed of. So, if surfaces are where many physical events and perceptual properties of material things appear to us, then surfaces play a relevant role to consider whether an object has changed or not or even whether an object is gone as result of the changes in its surface. In that sense, we can remove *almost* all the matter from Woody's interior, but if Woody's surface remains unalterable (i.e., having the same physical properties), then it is possible to considerer that Woody has survived the loss of the matter it was composed of. Of course, this point is more related to philosophy of perception than to ontology, but it tries to highlight the strong metaphysical relation between an ordinary physical thing and its outer boundary or surface. A surface cannot exist in the physical world unless the specific material object it belongs to exists too. This is not just the case of a *de dicto* dependence, but a genuine case of *de re* dependence where a surface rigidly depends on the object it bounds. That is, the existence of a surface necessarily depends on the existence of an object that can survive different series of mereological changes. Otherwise, there would be countless surfaces for every slightly change of the matter that composes an alleged single object. Now, the next and final task is to study the case of dependence of ordinary physical things on surfaces.

Generic Ontological Dependence*: Objects upon Surfaces*

According to (C), the ontological relation between surfaces and objects is asymmetric: whereas the existence of a surface rigidly depends upon the object it belongs to, an object might exist without having the surface it currently has. From *de re* dependence between a surface and the bulk it belongs to does not follow the same sort of dependence between the bulk and a surface. However, it can be noted that although material things do not need to have the surface they in fact have (DOS1), they cannot exist without having a surface (DOS2). The sort of ontological dependence of material objects upon surfaces is thus based on the idea that material objects cannot occupy physical space without having a boundary. The following claims support that idea:

(a) Material objects are three-dimensional occupants of physical space.

(b) The physical space occupied by material objects is finite.

(c) Surfaces are the outer boundaries of material objects.

Some requirements for something to exist in physical space are (i) to be a three-dimensional entity, (ii) to have some spatial location, and (iii) to bear physical causal powers. Objects such as tables, apples, and chairs cannot exist in physical space unless they have (at least) those characteristics. First, they are solids having volume, so they must have three-dimensions (length, width, and depth). Second, they occupy a portion of space where they can be found (they do not occupy the totality of physical space). Third, they have physical properties and can physically interact with other objects.

Surfaces play a relevant role in (i)-(iii). Material objects cannot be three-dimensional entities having a spatial location and physical features without a surface. Think again of Woody and its surface S. First, S determines the limit of Woody's spatial extension: S separates the portion of occupied space by Woody from the empty space in the Woody's surroundings; the total space occupied by Woody reaches S as its physical boundary. Second, spatial objects have boundaries of lower dimensionality. Woody is an object that occupies physical space spread out along the three spatial dimensions having a surface as a boundary of two spatial dimensions that indicates the point where Woody's spatial extension stops and no parts of Woody are found beyond it. Third, as we said, many of the physical properties (e.g., colours, shapes, or textures) and physical events (e.g., light reflection, contact, or corrosion) attributed to Woody occur on S. Woody therefore takes physical space insofar as S is both the boundary of the portion of space it occupies and where most of what physically characterizes Woody is perceived.

To be a material object entails being found somewhere in physical space: spatial entities must possess location or spatial address. Casati and Varzi [6, chpt. 5] distinguish between two pairs of notions about the concept of address: *permanent/temporary* and *minimal/broad*. According to the first pair, following their example, even though John lives in Manhattan and moves somewhere outside Manhattan, John keeps a *permanent address* where his house is located in Manhattan. On the other hand, John can change his own *temporary address* by walking from his job to the local pub. John maintains his house as a permanent address, but John himself can be in several places at different times. According to the second pair, John's *minimal address* is John's body's location at every moment it moves. By contrast, John's *broad address* is given by the fact that he may have a new house somewhere in Manhattan, but John still has a location in Manhattan. According to this distinction: "your present temporary minimal address gives your exact location at this time, the region of space presently taken up by your body" [6, p. 119]. This can be said about every physical object.

Woody's exact location is its *present temporary minimal address*, but how can Woody's exact location be easier to find? Actually, there is a way: we just need to look for Woody's boundary. According to Casati & Varzi, "[The notion of exact location] is closely related to the idea of a boundary, for the exactness of an object's location is determined by the location of the object's boundary" [6, p. 119]. Wherever Woody's exact location can be at some time, Woody may lose or gain some parts, but it cannot be the case that Woody can be exactly found in space without having a boundary or surface. Wherever Woody goes in space, a surface will go with it. In this respect, for every physical object O, having a surface entails: (i) a boundary that indicates where O's matter ends of filling space; (ii) the finding of O's exact location in three-dimensional space; and (iii) the instantiation of many of the physical properties and causal events attributed to O. Even though boundaries are non-substantial beings, they are fundamental entities for material substances. The following claim can be said:

(C2) Necessarily, anything existing in physical space has a surface throughout all its existence.

This claim expresses an ontological dependence between physical objects upon surfaces. However, unlike *de* re_{rigid} dependence of a surface upon its physical host, the ontological relation between a physical object and its surface is a case of *de* $re_{generic}$ dependence. That is, the dependence of a surface upon the object it belongs to is metaphysically stronger than the dependence of the object upon the surface it has. The existence of a surface in physical space depends upon the existence of the *specific* material object it belongs to, while the existence of a material object in physical space depends in a general way upon the existence of *some* surface. In this respect, (C2) can be put in terms of spatial dependence:

(Def.2) x *spatially* depends upon $y =_{df} x$ cannot exist in physical space unless y exists.

A surface cannot exist by itself in physical space unless it is the boundary of a material object, while an object can only exist in physical space if it has some boundary at every time of its existence. This difference of spatial dependence entails the modal distinction between surfaces as *de rerigid dependers* (DSO4) and physical objects as *de* $re_{generic}$ *dependers* (DOS2). The distinction between *rigid dependence* and *generic dependence* has been extensively studied in the literature about ontological dependence.[13] Following (Def.1), rigid dependence is a direct binary relation between the existence of something and the particular existence of something else. Generic dependence, on the other hand, is an ontological relation between the existence of something upon objects of some *kind*.

Correia [15, 14] explains generic dependence in terms of *essentialism*: *What does it make for something to be what it is*? For short, 'What is it F?' where F is a predicate like 'be human being' or 'be water'. In the Aristotelian tradition, to be a human being essentially depends upon being a rational animal, whereas to be water, in a Kripkean way, essentially depends upon being H_2O in every possible world. As Correia says, "a generic statement is one which states to be thus and thus is essentially to be so and so" [15, p. 754]. Generic dependence is therefore the ontological relation between the essence of an object x upon the existence of objects which fall under a specific kind. Let's say the following definition:

(Def.3) x *generically* depends upon objects of kind $K =_{df}$ necessarily, x exists only if y exists and y is such that y specifically falls under K.[14]

Following (Def.3), the fact that a boundary is a *conditio sine qua non* for a *continuum* – as the B-C theory suggests – is taken, in the case of physical objects, as follows: the existence of a physical object *generically* depends upon the existence of boundaries of a particular *kind*. Thus, the ontological dependence of physical objects upon boundaries is a *de re*$_{generic}$ modality to the extent that a physical object does not depend for its spatial existence upon the specific boundary it currently has, but upon boundaries which are surfaces. Without having a surface (whatever it can be), a physical object would lack a boundary to indicate: (i) where its physical occupation ends, (ii) where it can be spatially located, and (iii) where some physical properties and causal events are instantiated. Although a material object O does not need the surface S it currently has, O cannot exist without having a boundary of kind S in every possible world where O exists in physical space. Following (Def.3), we can make this claim:

(C3) If x is a physical object, then, necessarily, x *generically* depends for its spatial existence upon objects of a kind K only if what falls under K is a surface.

Think again of our cube Woody. Imagine now a surface-cutting machine capable of removing S from Woody (i.e., taking away from Woody the thinnest physical layer that makes contact with Woody's environment). Once we have removed S, a 'new' surface N_{s1} immediately comes out to be possessed by Woody; once N_{s1} is removed, N_{s2} will emerge as a surface, N_{s3} after N_{s2}, and so on. Woody can survive each of those surface removals, but it cannot survive as a physical object without having at least some surface. Indeed, if we remove every possible surface from Woody, then nothing of Woody is left. In this process, we can see that (i) S cannot survive without being the boundary of Woody, and (ii) Woody can exist without S, but cannot exist without having at least *some* surface. The ontological relation between Woody and its surface is a case of generic dependence: if Woody, and ordinary material being, fails in having a surface, then it also fails in existing in physical space.

Final Remarks

Boundaries are not self-sufficient entities: they cannot exist for themselves. However, as Brentano remarks, boundaries also are *conditio sine qua non* for *continua*: Although boundaries have no substance (i.e., they are *inseparable* beings), they are required by something to be a substantial being. As Smith puts it: something "becomes a substance only on becoming detached, when it acquires a boundary of its own" [29, p. 61]. In that sense, having a boundary is a metaphysical requirement for something to be a spatial substance. Nevertheless, this article has tried to explain the B-C theory, but also to argue that it does not grasp the asymmetric condition in the case of ordinary physical things and their boundaries (or surfaces). The metaphysical demand of a physical object for a surface is not like the metaphysical demand of a surface for a physical object: while the existence of a surface *rigidly* depends upon the *very* object it belongs to, a physical object *generically* depends upon there being some surface or other. In this respect, it can be said that boundaries are the sort of undesirable guests that never want to leave, but, paradoxically, they are necessary beings for the existence of their hosts.

Notes

1 In the metaphysical tradition, since Aristotle, a substance has been understood as a self-sufficient being and an accident as that which only exists as instantiated by a substance. In early modern metaphysics, Descartes understood by substance as "nothing other than a thing which exists in such a way as to depend on no other thing for its existence" [16, §51], so everything that is not a substance needs something else for its existence. The ideas of self-sufficient entities and non-self-sufficient entities are explained by Spinoza in his Ethics in terms of substances and modes respectively. So, while he defined 'substance' as "that which is in itself and is conceived through itself; that is, that the conception of which does not require the conception of another thing from which it has to be formed" [35, def. 3], by 'mode' he meant "the affections of substance, that is, that which is in something else and is conceived through something else" [35, def. 5]. For more details about the concept of substance see Hoffman and Rosenkrantz [17].

2 In particular, holes have been presented as a case of ontologically dependent entities by Lewis [21, chpt. 1] and largely studied by Casati & Varzi [5].

3 This idea will be addressed later in the article.

4 Barry Smith has a similar definition: "x is a boundary dependent on $y =_{df}$ (1) x is a proper part of y, and (2) x is necessarily such that either y exists or there exists some part of y properly including x, and (3) each individual part of x satisfies (2)" [29, p. 61]. According to it, a boundary is a part of an object such that necessarily it depends upon the existence of the object or some part of it. Unlike Chisholm, as we will see, this definition however does not distinguish between parts of an object and boundaries as constituents of objects of a different kind.

5 Thanks to the journal's reviewer for highlighting this point.

6 For more details about the Brentanian concept of plerosis see Smith [33].

7 Brentano says: "The conditioning of the continuum by its boundary is case of dependency. The difference between what we have here (a continuum having a boundary) and the usual cases where a part contributes to the whole is that, in the latter cases, the part is something for itself whereas, in the present case, the part exists only as belonging to something else" [3, p. 128].

8 For more details about the Brentanian view on boundaries, mereology, and the theory of substance see Smith [34, 33, 28]. For a complete study of Brentano's philosophy see Smith [30] and Jacquette [19].

9 See Stroll [37] for a detailed study about surfaces as boundaries of ordinary physical objects.

10 See Adams [1] for a critical review of Stroll's definition of surface.

11 Although the discussion whether things persist across time will not be specifically addressed in this article, the idea that things can survive qualitative changes at different times (or maybe be extended in time as much as they are extended in space) is taken as the preferable ontology of ordinary material beings.

12 Thanks to the journal's reviewer for this point.

13 See, for example, Correia [15, 14], E. J. Lowe [23, 22, chpt. 6], and Tahko & Lowe [38].

14 This definition is inspired by the Lowe's definition of generic ontological dependence: "x depends for its existence upon objects of type T $=_{df}$ Necessarily, x exists only if something y exists such that y is of type T" [23, p. 141].

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