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Carving the World at its *Boundaries*
A Metaphysical Study

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*La pregunta filosófica por el límite cobra fuerza,
a tal punto que incluso se vuelve inquietante,
al sospechar cierto carácter ilusorio, virtual, artificial
que conlleva todo límite.*

*The philosophical question for boundaries gains strength
–in such a way that it becomes disturbing–
once we suspect certain illusory, virtual, and artificial features
held by any boundary.*

Cristóbal Holzapfel, “De Cara al Límite”

Abstract

According to common-sense beliefs, there is a mind-independent world consisting of many mid-sized physical objects which can survive qualitative changes and have all their parts at every time they exist. This thesis is a metaphysical study of the boundaries of such things.

The metaphysical feature of boundaries is that they are ontologically dependent entities. Following the work carried out by Franz Brentano and Roderick Chisholm, the existence of a boundary depends upon the existence of something else. However, regarding boundaries of physical objects (surfaces), they hold a mutual ontological dependence but asymmetrical: surfaces rigidly depend upon physical objects, whereas physical objects generically depend upon surfaces. Although a surface is a two-dimensional boundary (without thickness) which cannot take up physical space, it can be found in space where the physical object it belongs to is found; physical objects cannot take physical space unless they have a surface at every time they exist.

Once the ontological nature of boundaries is explained, the thesis discusses some boundary-puzzles such as the belongingness of a boundary, vagueness/sharpness, and the *bona fide/fiat* distinction. It is thus discussed the problem of contact between physical objects, material co-location of objects and their boundaries, temporal persistence, and composition. The last two chapters focus on composition and vagueness. Universalism and nihilism are explained in terms of the boundary they set to determine when composition occurs and when it does not. According to nihilism, there are neither ordinary physical objects nor their surfaces, but only simples. I suggest that if there is any boundary in a nihilist ontology, it must be a sharp one. However, I defend the idea that if we carve in the world enough, we will find some vagueness at its boundaries.

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INTRODUCTION

Why Boundaries?

We are all familiar with boundaries. Everyone has some idea of what boundaries are because we face them every day. Our first experience of boundaries is birth and our last experience is death: life begins at some point and ends at another. In the meantime, in the everyday life, we can find a broad range of boundaries everywhere: borders between countries, shores of rivers and lakes, edges of objects, summits of mountains, the final whistle of a football match, walls to separate nations, fences between the garden of your house and the neighbour's, the skin of your body, and so on. In a metaphorical way, we also talk about other things having boundaries or limits such as cultures, our knowledge, the universe, the mind, the power, ethics, among others. Since everyone knows what is meant by a boundary, why do a philosophical research on the topic?

Sometimes the most familiar things to us are the hardest to explain, though. In philosophy, a well-known example is what Saint Augustine said about time in his *Confessions*: “What then is time? If no one asks me, I know what it is. If I wish to explain it to him who asks, I do not know”. Asking ‘What is a boundary?’ is like asking ‘What is time?’. We certainly know what a boundary is in everyday life and where they can be found. However, if we try to define what is for something to be the boundary of something else, then the everyday idea of a boundary can become puzzling.

However, this research is not about boundaries in general, but the boundaries of the physical objects that common-sense beliefs consist of, i.e., the boundaries of tables, chairs, mugs, snooker balls, chairs, apples, and every physical object that could be seen with naked eye. In fact, by seeing carefully around us, we will realize that most of what we can really see and touch are boundaries (parts of them) rather than the whole of the objects: we only see the surfaces of things rather than things themselves. Physical objects fill with matter portions of three-dimensional space. A boundary indicates both where a physical object stops filling with matter the region of space it occupies at some given time and where the object's surroundings begin. Chapter One will introduce how philosophy and common-sense differ in their ontological accounts about physical objects and their boundaries.

I will take ‘surface’ as the term that is often used to refer to the boundaries, top physical layers, or outermost parts of ordinary physical objects. Euclid defines a boundary as “that which is the extremity of anything”(1962: Bk I Df.13). A surface is found in the extremity of a physical object. Go instance, the surface of an apple is the only part in contact with the apple's surroundings and, therefore, the only part that we see

from the apple. The surface is thus the extremity of the apple insofar as nothing of what composes the apple can be found beyond it. This follows Aristotle definition of an extremity as the “first point beyond which it is not possible to find any part [of x], and the first point within which every part [of x] is” (1984a: 1022a4-5). The surface of a physical object x is that point between x and x 's surroundings; or, let's say, between x and the remaining space where nothing of x is found. Thus, boundaries are always found in the extremity of things what entails being *between* things. In particular, surfaces are boundaries in the *extremities* of physical objects *laying* between objects and space.

The features said above characterizes the ontology of any boundary: a boundary is such that it is always ‘a boundary of...’. This basically means that boundaries are ontologically dependent entities, i.e., the existence of a boundary depends upon the existence of something else: every time that you find a boundary, you will also find an object what *that* boundary belongs to. This topic will be addressed in Chapter Two. The main thesis is that boundaries and physical objects hold a mutual but asymmetrical *de re* ontological dependence: boundaries *rigidly* depends upon physical objects, whereas physical objects *generically* depend upon boundaries. Once this distinction has been spelled out, the following chapters will address four puzzles:

- i. *Boundary-Belongingness*. If a boundary separates two objects or parts of one object, what does the boundary belong to? Think of the Equatorial line: it may belong to either the south hemisphere or the north hemisphere; it may belong to both; it may belong to neither; or maybe there are two co-located boundaries sharing one place at once (in that case, if two boundaries are entirely co-located, can the physical objects they belong to being co-located as well?).
- ii. *Boundary-Thickness*. Physical objects are material bulky things spread out in the three-dimension of space. However, surfaces are, by definition, boundaries of only two-spatial dimensions (length and height). Given that surfaces lack depth, they are entirely thin boundaries having no thickness at all and, therefore, cannot take up any physical space. Nonetheless, many physical properties (e.g., colours, sounds, or textures) and physical events (e.g., light reflection or corrosion) are said to happen on the objects' surfaces. How does something that is not a physical object instantiate physical properties or causal powers?
- iii. *Boundary-Vagueness*. A snooker ball has a smooth and sharp surface. However, not every physical object seems to have a boundary like that. Objects like clouds, mountains, or trees have vague boundaries where it is indeterminate when the boundary ends and when the object's surroundings begins. Actually, from a microscopic scale, any smooth and perfectly sharp ordinary object becomes a fuzzy swarm of tiny particles. Are there sharp boundaries at all? If there are, what features should have the objects they belong to? If there are vague boundaries, can vagueness be ontological or only the result of the imprecision of our language and knowledge?

iv. *Artificial/Natural Distinction.* Some boundaries seem to be natural or mind-independent *carvings* in the world; others artificial or mind-dependent drawings made by someone. The shore of Loch Ness can be an example of the former and the border between Spain and France an example of the latter. However, is this distinction clear at all? If the border between Spain and France is a boundary drawn by following the Pyrenees as a natural discontinuity on the earth's surface, is the border entirely artificial? Regarding surfaces, are they natural or artificial boundaries? Are those boundaries and the objects they belong to genuine denizens of reality?

Each of these puzzles will be addressed in different parts of the thesis in relation to topics such as composition, the nature of space, temporal persistence, modality, and vagueness in physical objects. If there is some way of *carving the world at its boundaries*, then will find out a world of physical objects made of *bona fide* vague boundaries which we attempt to make as sharp as possible by drawing our own boundaries on it.

Why then boundaries? Since ancient philosophy, philosophers have been largely discussed about things and the topic of material beings is among the favourite ones. However, much has been said about those things, but not much about their boundaries. This research is about boundaries. Perhaps, this topic has been often unattended by philosophers precisely because boundaries are too familiar to us. It is good to know, however, that by studying boundaries we are studying the objects they belong to as well.

CHAPTER ONE

Everyday Boundaries

Common-sense and Metaphysics

Introduction

This research is about boundaries, but not every boundary. It mainly aims at boundaries of physical objects of middle-sized physical world such as tables, marbles, books, mugs, stones and every object visible with naked eye around you now. In fact, those things seem to be unimaginable without having a boundary. As it was said in the introduction, every boundary is always ‘a boundary of...’, i.e., it cannot be conceived without being the extremity of something else. So, by understanding what ordinary physical things are, we also understand what their boundaries are.

This chapter has an introductory role of presenting most of the topics to be discussed in the following chapters about things and their boundaries. It focuses on common-sense ontology that seems to include a more less identifiable account of *what there is*. In this account, the world basically consists of mind-independent physical objects made of parts and capable of surviving changes across time. However, they also have another feature: things do have boundaries. How are these boundaries understood according to common-sense? How do metaphysics and common-sense say about physical things and their boundaries? This chapter is divided into two section A and B. The first section addresses the differences between metaphysics and common-sense ontology. The second part specifically addresses what common-sense thinks of what everyday boundaries are (i.e., the boundaries of ordinary physical objects) and how philosophy challenges it in some respects. Both parts are guided by two ontological questions: *how many things and boundaries are there* and *what kind of things and boundaries are there*.

A. The Ordinary Conception of the World

According to Quine (1964), the task of ontology is to answer the question ‘What is there?’. This is a metaphysical question about what exists in the world *out there*: it is not how the world is according to beliefs and desires, but how *everything* is by itself. Thus, ‘What is there?’ is the fundamental ontological question that requires an account of the genuine items of world. To determine *what there is*, our ontology must be committed to the best theory we have at hand, *viz.*, science: “What reality is like is the business of scientists, in the broadest sense, painstakingly to surmise; and what there is, what is real, is part of that

question” (Quine 1960: 20-21). To introduce an entity in an ontology entails adopting a theory and its domain of quantification: once we have accepted a theory, we are straightaway committed to the entities it quantifies. We can thus ask for the *reality* of entities such as numbers, properties, sets, four-dimensional objects, or even those things believed by common-sense, only if those entities are needed for the sake of our best theory. However, as Quine stresses, “the truths that can be said even in common-sense terms about ordinary things are themselves, in turn, far in excess of any available data” (1960: 20). The acceptance of a theory is not however of a set linguistic rules, but a theoretical system –the simplest and most efficient one– whose *conceptual scheme* can describe and unify “the disordered fragments of raw experience” (Quine 1964: 16). According to Quine, science (particularly physics) offers the best theoretical system to be ontologically committed to *what there is*: “Our ontology is determined once we have fixed upon the over-all conceptual scheme which is to accommodate science in the broadest sense”.

What could our everyday beliefs say about *what there is*? A common-sense ontology, we might say, is a folk theory based on the collection of proposition about how is the world that people mostly believe to be truth or false. As Descartes opens his *Discourse on Method*: “The power of judging well and distinguishing truth from falsehood, which is properly what is called common sense or reason, is naturally equal in all men [...]. It is the ordinary conception of the world” (1985: 111). Our opinions and practical behaviours about what physical objects are meant to be are based on the everyday experience with things such as tables, chairs, planets, and people showing properties such as being mind-independent entities made of parts, having persistent conditions, and causal powers. Scientists and philosophers both may object many of these aspects if we accept those physical objects and their properties studied by quantum theorists (e.g., electrons, quarks, or bosons) or what Plato thought about the physical world. Common-sense however becomes a serious business insofar as we use its most primitive beliefs in our daily decisions and life projects. We can indeed distinguish consistent pre-theoretical judgments about either *what there is* or *what there isn't*. According to Lewis, “common sense is a settled body of theory –unsystematic folk theory- which at any rate we do believe; and I presume that we are reasonable to believe it. Most of it” (1986: 134). Common-sense can therefore be a more less identifiable theoretical system consisting of beliefs and opinions about *what there is*.

Throughout its history, philosophy has had a strained relation with common-sense which has been used to reject too counterintuitive philosophical theories, but also accused of spreading misleading ideas that hinder ‘objective’ knowledge. As Coates puts it: “Common sense is like the loyal opposition in parliamentary democracies –annoying in its constant criticism and in the inertia it adds to the intellectual enterprise, yet important over the long haul in catching unnoticed error” (1996: 1). Common sense is the starting point of the search of the truth, but philosophy promptly moves toward the idea that common-sense beliefs must be under the scrutiny of rationality. Descartes’ scepticism is an example of how a philosophical investigation is thought to be a method of overcoming false ordinary opinions admitted as true without rational

examination. Although common-sense is the first approach to explain *what there is*, it is not the end of the explanations.

However, common-sense has been strongly upheld by philosophers too. G. E. Moore is likely the most prominent one in contemporary philosophy. In his well-known paper 'A Defence of Common Sense', he writes: "I am one of those philosophers who have held that the 'Common Sense view of the world' is, in certain fundamental features, *wholly true*" (1959: 118). Beliefs held by ordinary people about their own bodies, the existence of other material beings, their own minds, and other's minds are genuinely true in the way they are meant in everyday life: "*If we know that they are features in the 'Common Sense view of the world', it follows that they are true*: it is self-contradictory to maintain that *we* know them to be features in the Common Sense view, and that yet they are not true; since to say that *we* know this, is to say that they are true" (Moore 1959: 119). The basic claims about *what there is* are grounded on the most fundamental beliefs of common-sense. The philosophical task is the analysis of the main features of common-sense beliefs and their implications in our ontologies. Unlike logical positivism, Moore takes common-sense as the basic source of knowledge where philosophical theories must fit. Otherwise, philosophers will be imposing metaphysical truths on a view of the world whose ordinary truths are self-evident. As Wittgenstein claims in his late work: "What *we* do is to bring words back from their metaphysical to their everyday use" (2009: §116).

Common-sense seems to offer a reasonable account of what *there is*: we can identify a set of beliefs about *what there is* that can be systematized in a spontaneous theoretical body to be tested by sophisticated scientific or philosophical theories. Quine agrees that the preferable ontology is that one committed to science. If entities introduced by either philosophy or common-sense are committed to what is postulated by scientific theories as physics, they can be counted in the list of *what there is*. By contrast, Moore contends that whatever is believed by common-sense is the starting point of knowledge; so, ontological theories should be as close as possible to common-sense beliefs. Thus, philosophers permanently take a sideway look at common-sense: either to adjust their theories or to justify whether their theories need to fit with it.

As we said, an inquiry about boundaries cannot overlook the objects that such boundaries belong to. We cannot study what boundaries of ordinary physical things are (if there are any) without a picture of common-sense ontology or what Descartes calls *The Ordinary Conception of the World* (OCW). This can be put as follows:

The world is a long list of composite things (wholes made of parts) occupying some physical space at a given time which we directly perceive through our senses and it is not a mere fictional construction in our dreams or imagination.

Objects that fit with OCW such as tables, chairs, planets, trees or people can be considered as *individual* things –i.e., mind-independent things that can exist having their properties independently to other

individuals. According to Peter van Inwagen (2015), the idea of being an ‘individual’ is one of the main components of western metaphysics. I will briefly mention one negative way to explain it according to van Inwagen:

- (i) “*A thing is not an individual thing if it is a mere modification of something else*” (2015: 27). To be a modification entails bearing a dependent relation with something else. For instance, wrinkles are always wrinkles of something else, i.e., they only exist if something else to be wrinkled exists too. Although a wrinkle has some specific location and characteristics, the wrinkle’s location and each of its characteristics depends upon something else (e.g., a carpet). Thus, unlike wrinkles or knots, object as carpets and ropes are individual things insofar as they exist in ‘their own right’. A positive formulation of individuals is this: an object is an individual if it is an ontologically independent thing where modifications occur.

OCW thus consists of individuals having independence and persistence conditions among other features: your dinner table may exist if you do not see it or even floating isolated in space and it can also endure both qualitatively and mereologically by having all their parts at different parts. Boundaries of such individuals are not however individuals themselves or substantial beings insofar as they are not self-sufficient beings: the existence of a boundary ontologically depends upon the existence of the very object it belongs to. They cannot take neither space nor time by themselves unless they belong to an object capable of being in space or time (or both). However, both spatial and temporal objects seem to depend upon boundaries in such a way that they cannot have spatial extension or temporal duration without having a boundary. Although objects and boundaries seem to need each other, they do not ontologically depend in a similar way. This is the topic to be addressed in Chapter Two in details.

The boundaries we are interested of are those ones to be found in common-sense ontology. I will then call them the *everyday boundaries*, i.e., the boundaries of the objects to be the candidates to determine *what there is* according to OCW. Nevertheless, we will first sharp what OCW is by examining the answers to two metaphysical questions: *how many things are* and *what sort of things exist?*

How Many Things Are There?

This question can be answered by simply saying *one*, *many*, or *none*. According to OCW, the world consists of *many* individuals such as tables, chairs, books, or people. There are in fact so many things that we are not capable of imagining a precise number. You could find a precise number of the things inside your room, but as soon as you tilt your head to the sky, just the Milky Way is galaxy having more than 400 billion stars. Furthermore, we sometimes have problems determining whether something should be taken as single individual or more than one. For example, counting clouds in the sky is confusing due to the vagueness of boundaries: it can be indeterminate where one cloud ends and another cloud begins. OCW not only contends that there are *many* things, but also it is not possible sometimes to give an accurate number.

However, are there really *many* individuals in the world as OCW postulates? Instead of *many*, monism contends that there is *one* individual. For example, according to Spinoza's metaphysical system "all things that are, are either in themselves or in something else" (2006: Ax.1) that means that all things are either substances or modes respectively. For his monist theory, the only thing that is in itself, i.e., a substance, is God; everything else is a modification of it. From a contemporary version of monism, Shaffer (2010b) defines Existence Monism as the view that there is only one concrete object: the world. This position implies an eliminativist account in which literally individuals believed by OCW do not exist: "When we say that there is a table, the monist holds that what exists is *the world aspected table-ishly*. Here talk of tables is paraphrased in terms of the world and its modes" (Schaffer 2010b: 179). The only individual is the world; any other thing that the OCW can believe to be an individual is just a modification of the world itself.¹

Saying that there is only *one* individual is a radical answer, but to say *none* does not make it better. To say that there is nothing is a self-contradictory and absurd answer that neither scientists, nor metaphysicians, nor common-sense would support. Strictly speaking, it has been defended that there is nothing of what OCW believe to be. A view of this kind can be to argue that *nothing exists except you*. This thesis is called *solipsism*. It entails that everything –individuals believed by OCW (e.g., tables, chairs, stars, people, or your body) and individuals posited by scientists (e.g., electrons, quarks, and leptons)– are ideas in your mind. Regardless whether solipsism is a tenable theory, it implies that at least one individual must exist: yourself. Maybe you are the unique individual whose existence is simply justified by the Cartesian self-evidence of your own thoughts. Solipsism, in his own way, answers to 'Hoy many things are?' as monism does: there is *one* thinking individual.

Is there another way to argue that there is *nothing*? A more reasonable ontological position than solipsism but not less radical is *Mereological Nihilism*. The word 'nihilism' comes from a Latin word 'nihil' that means 'nothing'. Despite its etymological origin, nihilism does not postulate that there is *nothing* at all. Nihilists basically say that *nothing ever composes nothing*: given two or more objects, it never happens that a further object composed of them exists; the world consists only of simples or mereological atoms, i.e., individuals without proper parts. A nihilist account therefore does not argue that there is *nothing*. Rather, it argues that *there is nothing except simples*. There are therefore none of what OCW believes as tables, chairs, pyramids, houses, or planets. For instance, I can build a castle with sand in the beach. Following OCW, there are *many* individuals: the castle and every single grain composing the castle. According to nihilism, there is

¹ Another version of monism less radical than Existence Monism is what Schaffer calls *Priority Monism* which is based on the following idea: "The mereological structure of whole and parts is not the only structure to the world. There is also the metaphysical structure of prior and posterior, reflecting what depends on what [...]" (Schaffer 2010b: 35). The cosmos on this view has an ontological priority over its parts in terms of *well-foundedness*. This is a kind of *metaphysical foundationalism* in which the chain of ontological dependence has a fundamental limit. The cosmos is ontologically prior to its parts insofar as everything exists in virtue of being part of it: the cosmos is the only self-sufficient individual whose being does not depend on anything else and where the being of everything finally depends on. So, every individual believed by OCW only exist in a derived way as parts whose beings depend upon the being of the cosmos as the whole where everything is grounded.

nothing of what is said by OCW: there are neither castles nor grains of sand. There are only simples (subatomic particles) arranged *castle-wise* and *sand-grain-wise*. Strictly speaking, both nihilism and OCW contend that the world consists of many individuals, but they differ in the sort of individuals to exist: while OCW posits that there are *many* composite individuals, nihilism argues that there is nothing of what OCW posits except *many partless individuals*.

What Kind of Things Are There?

According to OCW, the world is not a fictional construction in our imagination or dreams: there is an *external world* that consists of mind-independent individuals; individual such as cars, tools, or people exist outside of our minds. Those individuals posited by OCW are found in different places in space at different times: a glass can be found on a shelf before dinner and be placed in some empty spot on the table at dinner time. Everyday individuals also have *physical features* (e.g., marbles have some weight, glasses are breakable, or hammers are compact) and *physical powers* (e.g., marbles *can* crush with other marbles, glasses *can* refract light through their surfaces, and hammers *can* brake marbles and glasses). The individuals believed by OCW are not therefore found in our minds but in *physical space at different times*.

OCW individuals can also survive qualitative changes across time. Even though individuals such as tables, books, or people can have different properties at different times, they do not go out of existence at every change. Moreover, physical objects can survive changes that involve bearing contradictory properties. Imagine, for instance, that you have poured a glass of water into your book: while the book is dried and stretched at the time of the accident, the book itself becomes wet and wrinkled after the accident. Despite the contradiction of the book's properties, the book is still the very same book before and after the accident. According to OWC, the kind of individuals the world consists of are physical objects that occupy different spots in space at different times having *temporal persistence* conditions.

However, philosophy has systematically suspected of the thesis of an external world. *Idealism* is probably one of the most radical theories: the kind of things to exist are only mental. George Berkeley supports this philosophical view. He rejects not only the thesis of an external material world, but also a representationalist theory of perception in which we indirectly perceive physical objects in virtue of the direct awareness of objects in our minds (or sense-data). According to Berkeley, material substances² are fictional entities made up by philosophers: everything that exists it does so as *ideas* perceived by some mind or soul. That explains Berkeley's motto: *esse est percipi*. As he writes in his *Principles*: "the choir of heaven and furniture of the earth, in a word all those bodies which compose the mighty frame of the world, have not any

² Berkeley argues against Locke's distinction between *primary* and *secondary* qualities about material objects. According to Locke, while the former are features such as extension, figure, motion, solidity and number, the latter are features which can be sensed such as colours, texture, taste, smell, and son. Matter would then be those mystery substances isolated from any mental property. Nonetheless, according to Berkeley's account: "[...] extension, figure and motion are only ideas existing in the mind [...] Hence it is plain, that the very notion of what is called *matter* or *corporeal substance*, involves a contradiction in it" (2009: 27).

subsistence without a mind, that their being is to be perceived [...]” (2009: 26). Whatever may exist, it does in virtue of being perceived in someone’s mind.

Other philosophers have also been sceptical with the thesis that the individuals believed by OCW have physical powers. Hume defends an empiricist account in which experience is the only source of knowledge and every belief that we have. Although the world seems to be a very well-organized place in which necessarily events are causally connected with each other, there is nothing like that in our experience of it. The source of this internal harmony is not the world itself, but our *association of ideas*. Causation is the strongest principle of association³ that takes us to raise metaphysical beliefs beyond the limits of experience. In particular, the belief that events are intrinsically tied with each other in virtue of an internal causal connection. Nonetheless, Hume argues that the source of this necessary connection is neither the world itself nor the reason, but *habits*. It is not a fact of the world that future events will happen in the same way as they happened in the past, but a psychological association that our imagination is accustomed to performing. This habit of associating ideas leads us a sophisticated and more complex idea. As Hume writes in his *Treatise*, “we have a distinct idea of an object, that remains invariable and uninterrupted thro’ a suppos’d variation of time; and this idea we call that of *identity or sameness*” (2009: 165). As we know, OCW believes in individuals capable of keeping identical with themselves that exist continuously across time despite the qualitative changes they undergo. For Hume, this idea of identity does not come from things themselves, but from our imagination and how it associates ideas. By the the association of ideas, we generate the habit of connecting and unifying ideas that ground our beliefs of mind-independent persisting objects. If Hume is right, there is nothing in nature having causal powers and spatiotemporal continuity, but rather a psychological habit of *associating perceptual contents*.

OCW answers ‘What kind of thing are there?’ saying that there are *many* spatiotemporal individuals capable of surviving several qualitative modifications throughout their existence regardless our minds and imagination. Philosophy has been suspicious with this answer. Some philosophers, as Berkeley, have contended that there are no spatiotemporal objects but only ideas in someone’s mind, while others, as Hume, have claimed that causal powers and the spatiotemporal continuity shown by OCW individuals do not come nature itself but from psychological habits. We said that if we want to understand what a boundary is, we need to understand what the object it belongs to is. Now that we have a clearer picture of what the world consists of according to OCW (*how many* things are and *what kind* of things) and its contrast with some philosophical views, we can then move to their boundaries.

³ Hume identifies three main associative principles: *resemblance*, *contiguity*, and *causation*. *Resemblance* refers when someone associate the picture of something with the pictured thing (e.g., the picture of a friend and the friend himself). *Contiguity* in space and time occurs when someone associate some event with another event that happened at the same time (e.g., the cold war and the fall of the Berlin Wall). *Causation* refers to the association in which, necessarily, the same causes trigger the same effects (e.g., touching fire always triggers pain).

B. The Everyday Boundaries

Everyday boundaries are things that commonly appear in our ordinary experience with physical objects. They are in a general way the first perceptual contact that we have from physical objects. If you see and touch those objects around you, you will first see and touch their boundaries rather than their *insides*. Languages use different terms to refer to everyday boundaries. Some of them in English can be as follows: *barks* refer to the boundaries of trunks, *shores* refer to the boundaries of rivers, *skins* refer to the boundaries of human bodies, or *surfaces* to the boundaries of marbles. Each one refers to that part in the object's *extremity* that *separates* it from the object's spatial surroundings. Abstract objects (e.g., properties, relations, or propositions) which are neither in space nor time are not individuals having boundaries in the literal sense that trunks, rivers, or human beings do have. In the case of the individuals believed by OCW which exist in physical space having persistent conditions, it however seems difficult to think of them without boundaries. This can be at least two main reasons:

- (i) *Having a boundary allows for an individual to exclude other individuals from the place that it occupies in space at some given time.* According to OCW, two individuals cannot occupy the same place at the same time. Locke called *solidity* or *impenetrability* that primary quality of bodies which are conceived to *fill space* by excluding each other. Unlike pure empty space, says Locke, impenetrability of a solid object involves a *resistance* that keeps other bodies out of the space that it fills: "All bodies in the world, pressing a drop of water on all sides, will never be able to overcome the Resistance, which it will make, as soft as it is, to their approaching one another, till it be removed out of their way" (2008: 67). Bodies cannot be penetrated by other bodies; they resist to share a single spot in physical space at the same time. This picture is related to boundaries: two bodies cannot share a physical place at once because they cannot go *through their boundaries*. Impenetrability occurs when the boundary of an object resists the boundary of another object. We cannot cross through a wall because our body's boundary and the wall's boundary will resist each other. However, some philosophers have reasonable accounts of the possibility of co-located objects (i.e., two different physical objects sharing all their parts at the same time). If co-located objects are metaphysically possible, then the idea of co-located boundaries are too. This is addressed in both Chapter Three about contact between boundaries and Chapter Four about material coincidence and temporal persistence.
- (ii) *Having a boundary allows for an individual to exist as an object having physical features.* Although there are features of physical objects not directly related to everyday boundaries (e.g., the weight of something), many other physical features are attributed to their boundaries or surfaces (e.g., hardness, softness, porosity, colors, shape, etc.). Physical events as light reflection or corrosion also seem to occur on surfaces of bodies. Our physical interaction with physical bodies is through their boundaries or at least begins with them. Actually, we can note that many of the physical operations that we do on ordinary objects occur on their boundaries rather than on the totality of them. We paint a wall in virtue of painting the wall's surface; a sculptor carves a stone in virtue of carving the stone's surface. We thus

do many physical things with objects in virtue of doing those things with the objects' surfaces. However, to take surfaces as the everyday boundaries entails what we called in the introduction the *thickness puzzle*. Surfaces show a tension between the concrete and the abstract: surfaces are the physical top layers of bodies but also two-dimensional boundaries without any thickness. This puzzle is addressed in Chapter Two about surfaces as the boundaries of ordinary physical objects and their ontological relation of mutual ontological dependence.

The OCW individuals are not imaginable without having a boundary or surface at each time they exist. As we shall see in Chapter Two, for a physical object *O*, having a boundary (or surface) entails both *O* occupying some portion of physical space where *O* is exactly located and *O* having an outermost part where many of the physical features and events that characterize *O* occurs. The task now is to analyze the contrast between ordinary boundaries and metaphysical views regarding two questions: *How many boundaries are there?* and *What kind of boundaries are there?*

How Many Boundaries Are There?

If the physical objects posited by OCW cannot exist without having boundaries at every time they exist, then we just need to know the number of individuals at a given time in order to find out the number of boundaries in the world at that time. This looks easy: if there are *many* individuals, there are *many* boundaries. However, individuals do not only have their outermost boundaries which separate them from their spatial surroundings, but they also have parts that can be detached and become individuals too having a boundary (e.g., a tyre is part of a car but it is an individual that can exist without being part of a car). Individuals can also have internal boundaries that separate their parts which can be also considered as individuals. If boundaries separate things or parts of things, to divide an object into parts entails the existence of boundaries between them (e.g., the equatorial line that separates the two halves of the earth). Hence, the number of boundaries becomes higher insofar as we also include the parts that individuals are composed of. However, monism and nihilism have different answers to 'How many boundaries are there?'

Existence Monism, as we saw, contends that there exists only *one* substance: the *world*. If there exists only one individual, then, we might say, there exists *one* boundary. The multiplicity of things and their boundaries disappears and get melted into the one and unique substance. Every object such as tables, chairs, planets, stars, or people are not individuals properly speaking but worldly shaped things and, therefore, there are none of the alleged boundaries of such kind of objects. If *everything* is worldly shaped, then there would not be more than one substance –the world– having its boundary. Following classic monists as Parmenides and Spinoza, if there is only one substance, it must be simple (i.e., indivisible). If an individual has parts, then each of them can potentially exist as *separable* substantial beings. This claim has an incompatible consequence for monism: if parts can be separable beings and become substantial beings, then there can be more than one substance and, therefore, monism would be wrong. If the one substance cannot be divided into parts, it cannot have internal boundaries to separate them (if we accept as true that boundaries separate

both things and parts of things). Thus, if there is only one simple substance, the multiplicity of objects posited by OCW and their boundaries are modifications of the world itself, but nothing for themselves. In this respect, Russell's objection to monism points out the reality of divisions: "I share the common-sense belief that there are many separate things; I do not regard the apparent multiplicity of the world as consisting merely in phases and unreal divisions of a single indivisible Reality" (1985: 36). Physical objects involved in common-sense beliefs are not substantial beings having boundaries insofar as everything is just a worldly way of being.⁴

Following monism, we may contend that if there exist boundaries belonging to substantial beings, it must be just one boundary that belongs to the one simple substantial being. Monism may however entail a boundaryless world. Spinoza argues that "Every substance is necessarily infinite. [...] [I]t cannot exist as finite, for it would have to be limited by another substance of the same nature, and that substance also would have to exist. And so there would exist two substances of the same attribute, which is absurd" (2006: 11). This argument entails that if the one substance had a boundary, then it is possible to conceive either other substantial being different form it or emptiness where nothing of the world is found beyond the world's boundaries. However, if whatever exists is just one substance that covers everything without gaps (i.e., without empty places where nothing of the world exists), then there is no room for another substance or the nothingness. Hence, the world must be a substance without boundaries insofar as it is possible to think that beyond its boundaries there might exist another substance or just the nothingness.

Nihilism, on the other hand, is the thesis that there only exist *partless* individuals which never compose anything. Since nihilism rejects composition, then ordinary things such as tables, glasses, or books do not exist and neither do their boundaries. If we want to investigate the everyday boundaries of OCW objects but none of them exists, then there is nothing to investigate. So how many boundaries are in the world? At least, in a world consisting of the physical objects posited by OCW, there are *none* of them. However, if there are only simples as nihilism argues, then there would only be boundaries for each of them.

Simples can be characterized as entities having sharp boundaries and exact location. On the one hand, if simples have no parts, then they have no borderline parts which it is indeterminate whether they belong to their boundaries or their surroundings. If they have no borderline parts, then they have very precise boundaries. On the other hand, if something is found in space where their parts are found, then simples have an exact location in space. If x has borderline parts, then x 's spatial location is inexact depending on what

⁴ Priority Monism is less radical than Existence Monism. Priority Monism assumes a whole-part relationship in which the world is the *only* being that is not a proper part of something else and where everything is a proper part of it. As Schaffer contends: "I will assume that there is a world and that it has proper parts. More precisely, I assume that there is a maximal actual concrete object –the cosmos– of which all actual concrete objects are parts" (2010b: 33). If parts ontologically depend upon being the part of a whole, the world is the only individual whose existence does not depend upon being part of something else. The world is where the chain of ontological dependence stops. Unlike Existence Monism, Priority Monism does not rule out that many things can compose a whole, but there must be one being –the world– as the only whole where everything is part of it. Thus, there can exist many individuals having boundaries composed of parts which are separated by internal boundaries, but each of these things ontologically depend upon the world where everything is a proper part of it.

objects are taken to be the x 's proper parts. Given that a simple has no proper parts, then it has no borderline parts that make indeterminate whether its location is *this* or *that*. The sharp boundaries of a simple therefore entails having a precise location in space. However, as we shall see in Chapter Five, this argument can be challenged by adopting a modal view in which a simple can be a vague object despite its lack of parthood.

Following the thesis that simples are the only existing beings having sharp boundaries, then we can think of a precise match between individuals and boundaries: there are as many boundaries as individuals are in the world. There are only simples having their boundaries. Simples have no internal boundaries between parts and, given that they never compose anything, there are no boundaries of composite objects. Common-sense beliefs such as 'The table has a soft surface' can be perfectly meaningful in the context of OCW, but they are loosely true; for nihilists, 'table' does not have reference at all since none of such kind of objects exist. Strictly speaking, the utterance 'The table has a soft surface' refers to simples arranged table-wise; so, there is nothing there having a soft surface. Philosophical puzzles such as co-location, the problem of many, persistence, or vagueness can be thrown away if composite objects do not exist at all. In this respect, nihilism and its metaphysical implication about boundaries will be addressed in both Chapter Five and Chapter Six.

What Kind of Boundaries Are There?

The everyday world has plenty of different kinds of boundaries: the edge of the screen of my laptop, barks of trunks, the skin of your body, surfaces of bodies, borders of countries, lines on the football pitches, fences separating plots, walls separating nations, and so on. According to the OCW, some of them are said to be manmade boundaries, whereas others are considered natural boundaries. For instance, border of countries, fences, walls, or lines on football pitches clearly depend on human decisions and preferences, but surfaces of bodies or the skin of your own body are natural joints of reality. Following Smith's distinction (1995, 2001): there are *bona fide* or mind-independent boundaries whose existence depends neither on human intentions, and *fiat* or mind-dependent boundaries whose existence would fully depend on human intentions. Common-sense objects themselves are *bona fide* individuals having natural boundaries. I can decide the colour to paint the surface of a door, but it is not my decision whether the door exists without a surface. By contrast, the lines of a football pitch are boundaries that can be drawn in different ways according to the rules decided by human beings at some given time in history.

Everyday boundaries can also be either vague or sharp: while the boundaries of clouds, deserts, mountains, constellations, or flocks are vague, boundaries (surfaces) of snooker balls, the Taj Mahal, or pebbles are sharp. According to OCW, there can be both vague boundaries and sharp boundaries in contexts of *fideness* and *fiatness*. For instance, the vagueness of the boundary of a cloud as well as the sharpness of the boundary of a pebble do not depend on human decisions, whereas both the vagueness or sharpness of the borders that some countries may have depend on human indecisions. However, as we shall see in Chapter

Six, the *bona fide/fiat* distinction of boundaries is not clear enough if we look at the world from a microphysical point of view. In fact, even the most sharply defined object would look a swarm of atoms where no clear boundary can be found. If there exist some boundary in the physical world, it would be a very vague area of borderline atoms where it is indeterminate whether they are part of some alleged object or part of the object's surroundings. Despite ontological vagueness is not acceptable for some philosophers, boundaries belonging to the objects posited by OCW would be *fiat* boundaries drawn over *bona fide* vague places. This is the thesis to discuss in Chapter Six.

Let's finally turn to another controversial issue: can two different boundaries occupy the same place at once? We saw in the introduction the puzzle of *belongingness* regarding boundaries: What does the boundary between two things in contact belong to? Different answers can be given to explain what contact is in terms of (parts of) the boundaries of things touching each other. However, can they even make contact if quantum physics teaches us that bodies never touch each other given the electromagnetic repulsion force between the sub-atomic particles they are composed of? A possible answer was Brentano's position in which boundaries can occupy the same place at once. However, this view would definitely overlook Locke's principle (shared by common sense too) of the impossibility of two bodies in one place at once. Borders of countries are *fiat* boundaries drawn by human conventions which can co-exist in the same place at once since they do not take physical space: by walking through the line that separates England and Scotland we are walking on English and British territories at once. What about boundaries of material bodies? Can they occupy the same place at once? If two different material bodies can occupy the same place at the same time as many philosophers think they do, then maybe two boundaries can be spatially co-located. Is that possible? The problem of contact between boundaries will be addressed in Chapter Three, while material coinciding objects and their boundaries in Chapter Four.

Final Remarks

This research is a metaphysical study about boundaries of the physical objects posited by common-sense or what Descartes called the *Ordinary Conception of the World* (OCW). The task of this chapter was to introduce a clearer picture of it. OCW is a more less identifiable body of theories about *what there is* in a Quinean sense. We saw that OCW and philosophy differ in many aspects in their answers regarding two ontological questions: *how many things and boundaries are there* and *what kind of things and boundaries are there*. Some answers given by philosophical theories actually challenge common-sense ontology and what everyday boundaries are supposed to be. The following chapters will thus discuss the different topics about boundaries that come out from this contrast between common-sense and metaphysics.

CHAPTER TWO

The Surfaces of Things

Boundaries as Ontological Parasites

Introduction

This chapter addresses the most relevant metaphysical condition of a boundary: a boundary is an ontologically dependent entity. That is, the being of a boundary depends upon the being of something else. Boundaries thus are ontological parasites that necessitate the existence of a host. However, what is the nature of the ontological dependence of boundaries upon objects? In particular, how do boundaries ontologically depend upon physical objects. But also, do physical objects depend upon boundaries in some way? If they do, do physical objects depend upon boundaries in a similar way as boundaries depend upon physical objects? Surfaces will be taken as the boundaries of material objects. However, surfaces show a tension between the abstract and the concrete: although surfaces are two-dimensional boundaries without thickness, they are the first part of material objects where many of their physical features and causal events occur. How are surfaces and physical objects ontologically related?

Ontological dependence between surfaces and physical objects is explained in terms of *de re* and *de dicto* modality. I will argue that the ontological dependence between surfaces and physical objects is a *de re* dependence, but two different sorts of *de re* dependence: while a boundary *rigidly* depends for its existence upon the material object it belongs to, a physical object *generically* depends for its spatial existence upon a boundary.

This Chapter has two sections A and B. The first section introduces what is understood by surfaces as boundaries of material objects and how they show the tension between being abstract being and concrete parts of physical objects. The second section addresses the topic of the ontological dependence between boundaries and objects in two main parts: first, an analysis of the Brentano-Chisholm account of boundaries; and second, the modal account of boundaries in terms of *rigid* and *generic* dependence.

A. Introducing Surfaces

Surfaces are not mysterious things if we think of them as the most exposed or ‘public’ parts of material objects. Most of what we perceive of ordinary physical things are their external boundaries. Although there are different words to refer to such boundaries depending on the objects they belong to (e.g.,

inanimate object such as tables, chairs, or statues have *surfaces*; people and some fruits as tomatoes have *skins*, or tree's trunks have bark) we will take 'surface' to refer to the boundaries of every physical object in everyday life. On this respect, a surface is that 'superficial' physical part of a material object or its boundary. However, surfaces become mysterious things once we realized that they are not good candidates to be physical things despite being part of physical things. Let's try to clarify what a surface is and then explain the puzzle involved with it.

The Boundaries of Material Bodies

Surfaces are taken as boundaries to the extent that they mark the spatial limit of ordinary material objects.⁵ According to the *Oxford English Dictionary*, the term 'surface' is defined as 'the outside part or uppermost layer of something', 'the level top of something' or 'the area of an outer part or uppermost layer of something'. To be defined in terms of being the *level top*, *uppermost layer*, or *outermost part* of a thing entails for a surface to be in the extremity of *that* thing. If a boundary, as Euclid defines it, is the extremity of anything, then surfaces are boundaries of ordinary material objects such as tables, chairs, planets, stars. Stroll has contended that "surfaces are thin spreads that form the upper or outer boundaries of embodiments" (1988: 209). Surfaces can be thus considered as boundaries or those thin layers in the extremities of ordinary material bodies.⁶ Things such as tables, chairs, or stars fill with matter delimited regions of three-dimensional space at every time they exist. According to what we called in Chapter One the *Ordinary Conception of the World*, surfaces are often said to be the boundaries of physical objects, i.e., that part of a physical object *x* that indicates the point where *x* ends of filling with matter the three-dimensional space. Or following Aristotle definition of a boundary seen in the introduction, a surface is the first point beyond which it is not possible to find any part of a table and the first point within which every part of it is.

A surface is a sort of 'mantel covering' thing (1979: 289): just like a mantle placed on a table, a surface would be the top or the outermost physical layer covering an object everywhere from its surroundings. A Surface is, therefore, that external or exposed boundary of a material thing.⁷ Galton explains a similar idea about the surface of a solid sphere:

Consider now all the possible portions of gold that can be identified within the sphere, i.e., all the possible sub-volumes. We can distinguish *interior* sub-volumes, which are entirely surrounded by other parts of the sphere and which therefore do not include any part of the

⁵ I will use interchangeably the terms 'physical objects', 'material body', or 'material object' to refer to things such as tables, chairs, or billiard balls found in the everyday life.

⁶ There are some cases of physical things in which to talk about 'surfaces' does not seem to be appropriate. According to Stroll, depending on linguistic contexts, 'surface' may not refer to the external boundary of an object: "[...] that are circumstances in which surface-talk is withheld from the objects being spoken about. What is surprising is that some objects which one, preanalytically, might have expected to be susceptible to such talk (i.e., to have surfaces) are not" (1988: 36). This semantic discussion will not be however considered here.

⁷ See Adam (1988: 552) for some objections to Stroll's view on surfaces. He contends that surfaces cannot be generalized as upper or outer layer of material things since there are many surfaces which are not visible for an accessible visual perception and, therefore, they are neither upper nor outer. That is the cases of hollow objects.

surface of the sphere, and *exposed* sub-volumes, which are not thus entirely surrounded and therefore do extend to the surface of the sphere. (2007: 380)

On this view, the sphere's surface is that exposed sub-volume of the sphere that is not entirely surrounded by other sub-volumes since it is in contact with the sphere's spatial surroundings. This is the part that we can *easily* see from every perspective that we may have from the sphere: "Because surfaces and faces are generally outer or upper aspects of things, they are normally easily visible. [...] Surfaces and faces are not 'hidden' in the way that what lies under the surface or behind the face may be" (Stroll 1988: 186). According to this 'public' or perceptually accessible condition of surfaces, we can note that a surface (and every boundary in general) implies contrasts such as outer/inner or exterior/interior. Boundaries are things that usually exist between other things. Thus, the surface of a sphere made of gold is that *exposed sub-volume* that exists *between* the interior of the sphere (the sum of the sub-volumes that composes it) and its exterior or the spatial environment where that sphere is located. 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. On 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*. (1994: 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. Peter Simons gives the following notion of 'complement': "For every individual there is a unique individual comprising the rest of the universe outside it. If *x* is the individual, this *complement*, *U-x* [...] exists and is unique, providing *U* exists and *x* is not identical with *U*" (1987: 16). Following this principle, every individual has an *outside* and, therefore, an *inside*. A boundary, we may argue, distinguishes outsides from insides: once you have crossed the threshold of a house, you can note whether you are inside or outside of that house. A similar thing can be said about surfaces as boundaries (or 'thresholds') of bodies. The surface of the snooker ball, for instance, separates the dense and compact matter that composes it and the remaining unoccupied along the ball's spatial surroundings.⁸ Thus, every individual has a complement defined as the subtraction between the universe and the individual itself. The surface of *x* would then be the boundary between *x* and *x*'s complement. Following Casati and Varzi surface's definition, a surface of an object *x* is the part of *x* that overlaps all those parts of *x* which are in immediate contact with *x*'s geometrical complement. In this case, the 'geometrical complement' of *x* at time *t* is the sum of

⁸ I will use 'geometrical complement', 'surroundings', or 'spatial environment' interchangeably.

unoccupied space in the x 's surroundings that compresses x from its *outside* following the shape of x 's boundary. For instance, take figure 2.1 as a three-dimensional cube (Cube, for short) that occupies some specific region of space at some given time, whereas figure 2.2 highlights the geometrical complement of Cube or the subtraction between the universe and Cube itself. The geometrical complement is thus found in the unoccupied space along Cube's three-dimensional spatial environment that follows the geometrical shape given by Cube's surface.

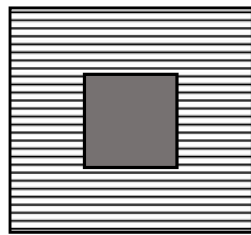


Figure 2.1

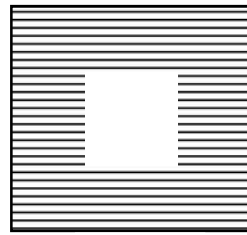


Figure 2.2

Cube therefore has a surface S that is the outermost part of it where S is the sum of every part of Cube connected with Cube's spatial complement; S is then extended in the contrast between Cube's location and Cube's spatial surroundings. According to Casati and Varzi, "the number of surfaces is defined by the number of maximally connected parts of the complement" (1994: 12). Cube has a sum of discontinuities or joints (corners and edges) spread out in S having six different connected parts which geometrically shape the unoccupied spatial environment around Cube. Either discontinuities (e.g., joints or edges) or changes of directions (i.e., the different spatial orientations of a boundary) make a surface to have distinguishable parts connected with the geometrical complement of the object that surface belongs to. Unlike Cube having six parts (given bit its twelve edges and eight vertices) facing six different directions in space, a snooker ball has a continuous round surface (having neither edges nor vertices) facing to every direction in space connected with the ball's spatial surrounding having the same geometrical pattern. This story, of course, becomes more complicated with three-dimensional objects having more discontinuities on their surfaces, irregular forms, or holes such as pipes, French Horns, cheeses, or mugs.

Something however seems to be missing in the definition given by Casati and Varzi. If a surface is that part of a bulky object that overlaps all those parts in contact with the object's geometrical complement (i.e., the unoccupied space in the object's surroundings), then such part may have any thickness and shape. A Surface is represented as an entirely thin physical layer of a material body; so, we might say, it should be as thin as possible and each of its parts having the same minimal thickness. See Cube-A in figure 2.3, take the black area as the surface of a three-dimensional bulky cube. The surface of Cube-A perfectly fits Casati and Varzi view of what a surface is to the extent that it overlaps all those parts which are in contact with Cube-A's geometrical complement (the grey area). Regardless the shape of the surface and the different

thickness in some parts of it, every part of Cube-A's surface is in contact with Cube-A's spatial surroundings. Nevertheless, the surface of Cube-A does not fit our intuitive representation of what a surface is; by contrast, Cube-B in figure 2.4 seems to fit better with that representation.

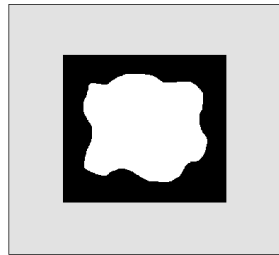


Figure 2.3 Cube-A

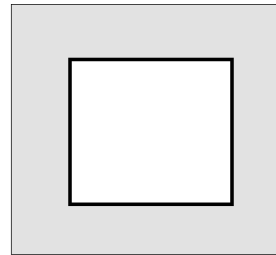


Figure 2.4 Cube-B

The surface in figure 2.4 is defined as the part of Cube-B that overlaps all those thinnest parts which are in contact with Cube-B's geometrical complement. The only way to make sure that a surface of Cube-B is composed of the thinnest parts is that such parts are the smallest possible parts which are simples. In Mereology, simples are those parts of an object having no proper parts.⁹ Since simples have no proper parts, they cannot be divided into further smaller parts (we can take these simple objects as those particles studied by physicists). Thus, the boundary of a physical object overlaps all those simples which are in contact with the object's surroundings. This definition of a boundary is quite closed to Hudson's definition in which "the boundary of a material object is just the region which is the set of all and only its boundary points"(2005: 69). On this view, the boundary of a physical object O that exactly fills with matter a region of space R is just the set of those matter-filled points within R in contact with O 's spatial surroundings. By adopting simples in our definition of what the surface of a physical object is, we can avoid odd surfaces as in case of Cube-A and we instead have a most natural representation as Cube-B's surface. As far as I am concerned, a surface therefore is *the outermost boundary or top physical layer of any ordinary material object that overlap all those simples which are in contact with the object's spatial surroundings geometrical complement.*¹⁰

Physical or Non-Physical Boundaries?

Material objects have been broadly considered as first-order entities that deserve most of the metaphysical concerns. Boundaries however are *minor* entities or non-substantial material things: whereas physical objects fill space with matter, boundaries are such that "they are located in space, yet do not take up any space (just as temporal boundaries do not take any time)" (Casati and Varzi 1999: 71). The Equator

⁹ See Chapter Five for more details on what simples are.

¹⁰ This definition entails problems of vagueness which will be addressed in more details in Chapter Five.

Line, for instance, can be spatially found between the two halves on the earth's surface, but it cannot take up any physical space at all. Although the spatial address of boundaries can be traced insofar as we find the spatial location of the material objects they belong to, boundaries themselves do not fill with the space matter.

The lack of substantial materiality of boundaries entails their lack of bulkiness. This feature of boundaries leads us to what was called in the introduction the *thickness puzzle*. In particular, surfaces are boundaries of bulky objects that occupy matter-filled regions of three-dimensional space. However, surfaces are by definition two-dimensional entities, i.e., they only have two spatial dimensions: length and height. We may believe that by a clear-cut process of the top physical layers of an object (like cutting a very thin slice of a cheese) we could finally arrive at the thinnest physical object that our process allows us which corresponds to what is meant by the term 'surface'. Nonetheless, there cannot be any physical surface regardless how thin it can be. If for anything that fills a region of space with matter it does spread out in three spatial dimensions, then it must have not only length and height but also depth. For anything to be a physical object, it must have a *minimal* depth or thickness. If a surface is a boundary having no depth and therefore no thickness at all, then it cannot be a physical object. So, if surfaces are bodiless boundaries, they can be called *abstract objects*. This is the view that Stroll (1979, 1988) attributes to Leonardo da Vinci, who writes in his Notebooks:

[...] The surface of water does not form part of the water nor does it form part of the air. What is it therefore that divides the air from the water? There must be a common boundary which is neither air nor narrow but is without substance [...] A surface is the common boundary of two bodies, and it does not form part of either; for if it did it would have divisible bulk. But since the surface is indivisible, nothingness separates these bodies the one from the other (1952: 120)

The *Leonardo Conception* of surfaces is as follows. There are two contiguous media in contact (water and air). The intersection where both media make contact is a surface which is a common boundary. However, by 'common boundary' is not meant a shared boundary where the air and the water overlap. According to this view, the boundary is an interface that separates two media (air and water) without taking part of either. That boundary cannot have a thickness or some divisible bulk. Otherwise, the two contiguous media could not make contact since there would be 'something' (a material thing) between them. If both media are really making contact, then the interface should be some abstract entity that does not belong to any physical thing at all. Boundaries therefore are not material objects in the extremities of bodies. Otherwise, physical contact between bodies would be impossible to the extent that boundaries are substantial entities having some divisible bulk between them. Thus, the boundary or surface of a table is part of neither the table nor the table's surroundings. According to this view, such boundary is said to be a mere 'conceptual entity' or 'abstract thing' but nothing concrete that could prevent physical contact between bodies or between physical media.

The Leonardo Conception seems to be based on the idea that a surface is a bodiless object insofar as it has no divisible bulk. A surface occupies space by having only length and height, so it can be divided into two-dimensional parts. Since a surface has no depth in space, it cannot be divided into three-dimensional parts. Therefore, a surface is just an abstract entity as much as the Equator is an abstract line without taking any physical space between two halves of the earth. If both parts of a material body make contact, then there cannot be a bulky boundary between them –only some sort of abstract thing. This view seems to be correct: surfaces should not have bulk. However, it seems odd to say that a surface does belong to any of the objects it separates. Boundaries, as we will see soon, are always entities which cannot exist without being part of something else in every world where they exist. If this is right, then a surface cannot be some entity existing by itself even at some abstract level. Maybe surfaces are not abstract things, but nothing: surfaces do not exist at all. Nonetheless, Leonardo Conception does not seem to entail this sort of eliminativist view of boundaries. Instead, it entails that surfaces as physical boundaries of material bodies would just a mere *façon de parler*¹¹, i.e., a loosely way of talking about boundaries as physical parts of things such as tables or golden spheres; but, strictly speaking, surfaces are nothing physical at all. If boundaries of material things or surfaces are something, they would be a sort of *abstract objects*.

Roughly speaking, unlike concrete material objects, abstract objects (e.g., numbers, propositions, or relations) can be understood as entities having the following two features. First, they do not exist in either space or time. An abstract object takes neither physical space to the extent that it has no bulkiness nor time to the extent that it has no duration. Second, it follows from the lack of spatiotemporal existence the fact that abstract objects are incapable of being involved in causal interactions.¹² Material objects can both take action in different physical phenomena (e.g., chemical reactions, biological mutations, electromagnetic radiation, and so on) and instantiate several properties accessible through our senses (e.g., colours, shapes, smells, tastes, or textures). On this respect, even though surfaces can be geometrically seen as abstract objects without taking physical space, it is equally clear that they do not satisfy some other relevant requirements of abstraction such as spatial location, perception, and physical causality. As Casati says:

Surfaces exemplify a tension between the abstract and the concrete. They are intrinsically spatial entities as they mark the limits of a material object. At the same time the notion of a surface goes beyond a pure geometrical characterization, as it is also importantly *causal*, precisely because surfaces mark the outermost limits of objects. Surfaces are where action is first exerted on an object, and where the object first reacts. As a special case perceptual contact with an object is first and foremost perceptual contact with its surface: we see bodies, in the room, by seeing their surfaces. (2012: 383)

¹¹ This expression is borrowed from Varzi (1997).

¹² For more details about abstract objects see E. J. Lowe (2002: Chap. 20).

We can distinguish two types of *surface activity*, viz., how surfaces are involved in some physical interaction: first, *perception activity* that includes our sensorial approach to surfaces; second, *causal activity* that includes all those possible physical things that surfaces can do. Most of our perception of physical objects is about their boundaries or surfaces. Every time we taste an ice-cream, the first contact occurs with the outermost part of it (i.e., its surface). We touch things by touching first (and sometimes only) their surfaces. Sounds coming from physical objects are commonly produced by the vibration when we strike their surfaces as the first point of contact (and different surfaces seems to produce different sounds). Visual perception is the clearest example of how surfaces play a relevant role in our sensing of physical things. Surfaces seem to be the only part of an opaque object that is exposed to be seen by perceivers. Although we only see the surface of a thing, we see the object itself entirely: we see objects in virtue of seeing their surfaces. Strictly speaking, by seeing an apple we only see its red surface, but we see a red apple in virtue of seeing just its surface.

Surfaces are also involved in causal activities. Many physical events occur only on the surfaces of things. Surfaces can be painted, polished, carved, scratched among other physical operations. Despite their alleged abstract nature, many physical things can be done on the surfaces of things. Stroll points out this as follows: “If you O (where O is an operation of some sort) X (where X is *the* surface of Y –and Y is a marble [...]), then you $O Y$ ” (1988: 21-22). What Stroll expresses is whatever the physical operation that we could do on the surface of a physical object seems to be done on the entire object rather than just on its surface: when Neil Armstrong is walking on the moon’s surface he is really walking on the moon itself. Either sensing the surface of a thing or doing some physical operation on it implies either sensing or doing something on that very thing.

Nevertheless, there are cases in which physical objects and their boundaries can be distinguished, viz., cases in which they do not have the same properties. For example, we can measure the area where the surface of a table is extended without measuring the entire space occupied by the table itself. Surfaces can be removed from their bulks according to some ordinary talk of material things. For instance, if I want to restyle the old door of my house, the first thing to do is to scrape its surface and remove every part of it until a new soft surface appears to be painted. It is possible to say that the old surface of the door was destroyed and replaced by a new one without destroying the door itself.

In some given context, both science and common sense may consider surfaces as physical boundaries or outermost parts of bodies which can be distinguished from the bulks they belong to. Galton (2007) differentiates two ways of approaching to surfaces: *naïve physics* and *scientific physics*. According to the former, the surface of your desk is a continuous and homogeneous layer of matter that is completely compact and dense. Nonetheless, from a microphysical approach to the same surface, scientists observe something different: instead of a smooth continuous layer of dense matter, a microphysical approach reveals that a surface is a discontinuous and irregular layer of atomic structures having diverse chemical processes

and electrical charges. Boundaries of material objects would not look as we are used to glancing them in everyday life:

If the solid bodies of common sense are replaced by intricate systems of subatomic particles, speaking of a body's continuous boundary is like speaking of the 'flat top' of a fakir's bed of nails, to borrow Peter Simons' phrase.¹³ Boundaries become merely imaginary entities enveloping smudgy bunches of hadrons and leptons, and their exact shape and properties involve the same degree of arbitrariness as those of any mathematical graph smoothed out of scattered and inexact data. (Casati and Varzi 1999: 72)

In opposition to *The Leonardo Conception*, Stroll (1979, 1988) calls *The Somorjai Conception* this scientific approach to surfaces as physical things having particular properties that their bulks lack. There is nothing abstract or merely imaginary to be considered on surfaces of solids, but specific empirical phenomena studied by physicists. The scientific field focused on surfaces of materials is called 'Surface Physics' that studies the electro-chemical phenomena which can be microscopically observed on the interfaces formed between the three different states of matter (solid, gas, and liquid) and their interaction with the vacuum. From the Surface Physics view, a body is understood as an object made of matter that can be microscopically analyzed in different atomic levels or layers and its surface is the top, ultimate, or outermost of those layers (Prupton 1983). Although the scientific view and the naïve view agree that surfaces are physical boundaries rather than abstract things, there is a disagreement regarding the following question raised by Stroll (1988): Can the properties of the x's surface be attributed to x? According to the naïve approach of surface activity, surfaces and the bulks they belong to may differ in one property or another at some contexts, while both may entirely share the same properties in other contexts. By contrast, for Surface Physics (1983) there exist certain microphysical phenomena that only occur on the complex subatomic systems of the surface of a solid and not in their remaining bulks (e.g., thermionic emissions, chemical reactions, or atomic vibrations).

Surfaces can be thus defined as boundaries or top physical layer of ordinary material objects which overlap all those simples (or atomic particles) in contact with material objects' surroundings or geometrical complements. However, there are good reasons to think of surfaces as either abstract objects which do not take physical space or proper physical things. This puzzling condition of surfaces of material objects is explained by the ontological dependence found between boundaries and objects.

¹³ Simons' reference is as follows: "At the best we have the bounding surfaces of the Democritean atoms, but these are spatially separated and do not form a connected whole. A connected boundary would need to bridge the gaps between the atoms, and thus would be an 'imaginary'; rather a real entity (like saying a fakir's bed of nails has a flat top), and to some extent arbitrary (like the curves scientists draw through the scattered and inexact data to give a smooth graph)" (1991: 91).

B. Boundaries as Ontological Dependent Entities

As we said in the introduction, we cannot think of a boundary without thinking of the object such boundary belongs to. This condition of existence for every boundary entails a sort of ontological dependence. Boundaries are not substances in the strict metaphysical meaning of the word, i.e., they do not exist by themselves, so every time that a boundary exists, it does because of the existence of something else. Ontological dependence is a form of ontological *non-self-sufficiency* (Correia 2008). Something ontologically depends upon something else if and only if the former cannot exist unless the latter does. Therefore, to say ‘*x* depends upon *y*’ means that *x* cannot exist by itself because *x* requires *y* to exist. By contrast, something that is self-sufficient is something that does not require the existence of anything else to exist.¹⁴ If boundaries are some kind of being, their being will always ontologically depend upon another being.

Ontological dependence entails existential and modal elements. Existence and necessity are required every time something ontologically depends on something else. Ontological dependence is neither a merely causal relation nor a logical relation between objects. It is not just the case that something causes another thing as its effect, or that a proposition in which an object is involved entails the truth of another proposition. The relation is a deep metaphysical sense of dependence between the being of one thing on the being of another as a metaphysical necessity. What sort of ontological dependence is involved in boundaries? Many philosophers have pointed out the ontological dependence of boundaries on the entities to which they belong.¹⁵ However, I will first focus on the ontological account of boundaries argued by Franz Brentano and Roderick Chisholm. Both are considered as a single view on boundaries as ontologically dependent entities. I will analyze such ontological dependence of boundaries in terms of *de re* and *de dicto* modality and how this distinction applies to surfaces or boundaries of ordinary material objects.

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* (1988) and *Theory of Categories* (1981). The concept of continuity (or *continuum*) is at the core of Brentano’s

¹⁴ In the metaphysical tradition, since Aristotle’s *Categories*, a *substance* is understood as a self-sufficient being and an accident as a thing that only exists 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” (1985: §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” (2006: Def. 3), by ‘mode’ he meant “the affections of substance, that is, that which is in something else and is conceived through something else” (2006: Def. 5). For more details about the concept of substance see Robb (2012) and Hoffman & Rosenkrantz (1997).

¹⁵ See Azzouni (2014); Brentano (1988, 1981); Casati and Varzi (1999); Chisholm (1976, 1983, 1989 1994); Correia (2006; 2008); Koslicki (2014); Jackendoff (1991); Mulligan, Simons & Simth (1984); Smid (2015); Smith (1992; 1996); Smith and Varzi (1997); Stroll (1988); Varzi (1996, 1997); Whitehead (1919).

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 found through perception and intuition. Brentano (1988) adopts this theory in which the concept of the *continuum* is not just some idealized mathematical objects but it is acquired through abstraction 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" (1988: 7-8). From our perception of objects connected with each other making up a whole, we are able to derive the concept of a boundary. The experience in the world of many objects continuous with each other composing a single larger object that can survive changes in composition, qualities, and location leads us to postulate the existence of boundaries. Once we have the concept of boundary, the conditions for the concept of a continuous object having either spatial boundaries or temporal boundaries are already given.

As Chisholm says: "Why assume, then, that there *are* boundaries? The concept is needed for the description of physical *continuity*" (1989: 84). To think 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" (1989: 85). On 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 same spatial dimensionality occupies. If x and y are continuous with each other, then there is no empty space between them. Since Brentano rejects Bolzano's distinction between closed objects having boundaries among their constituents and open objects which do not have them, if x and y have each one a 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.¹⁶

The most distinguishable characteristic that defines a boundary is, as Chisholm above says, to be 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. Some of them 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. (1988: 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

¹⁶ For more details about this idea and, in general, the problem of contact between boundaries see Chapter Three.

the latter. Boundaries require such belongingness and such a connection in order to exist at all (1988: 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. (1981: 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. (1981: 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, or a hole¹⁷ 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: “a substance is not a parasite, does not have borrowed reality; a substance is a being in its own right” (Robb 2012: 258). By contrast, boundaries are entities which can be understood as *ontological parasites*, i.e., “they are not entities in their own right; they are ‘parasitical upon’ other things” (Chisholm 1976: 51). A boundary is a case of ontological dependence, i.e., necessarily, a boundary exists *in virtue of* the existence of something else. As Smith writes: “Boundaries are full-fledged denizens of reality. They serve as objects of perception (and are perhaps the only objects of perception). But 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” (Smith 1998/99: 109). The ontological dependence of a boundary upon the object it belongs to seems to be so strong that even God could not do it otherwise. Although a boundary is not a material substance able to fill physical space, it can be found in space when the object it belongs to or at least *some* part of it exists:

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. (Chisholm 1989: 86)¹⁸

¹⁷ Holes, in particular, have been presented as a case of ontologically dependent entities by Lewis (1983: Chap. 1) and largely studied by Casati & Varzi (1994).

¹⁸ 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)” (1992: 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.

Brentano distinguishes spatial boundaries having zero dimension (points), one-dimension (lines), and two-dimensions (surfaces). Each one can be connected with other boundaries of different dimensionality and bounding *continua* of higher dimensionality. Points can be connected with other points to make a line and lines can be connected with other lines to make a surface; points are boundaries of lines, lines are boundaries of surfaces and surfaces boundaries of bodies (or three-dimensional *continua*). Regarding the ontological dependence of boundary upon the object it belongs to, a surface *S* is a two-dimensional boundary whose existence (spatial occupation) is such that necessarily *S* depends on a body or a three-dimensional object *O* or at least those parts kept by *O* in case of some parts are destroyed or detached from *O* where *S* is the boundary. Brentano also describes boundaries as entities having differences of greater or lesser *plerosis* or fullness (1988: 11). The *plerosis* of a boundary is found in the possible directions of a boundary in relation to the object it belongs to. In the *Categories*, 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. (1981: 128-129)

In the case of temporal boundaries, the first moment of an event is, for example, a boundary that exists as an initial part of it but not at the end, while the last moment of that event is a boundary that exists as final part of it but not at the beginning. However, an internal boundary separates an event into two moments can have two directions insofar as it is the start point of one moment and the end point of the other moment. But, 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” (2008: 115). One point, for instance, among the many other points that composes the surface of a three-dimensional object (e.g., a cube) has a *greater* degree of *plerosis* or different directions toward the interior of the cube than a temporal boundary either at the beginning or the end of an event that only has one temporal direction.¹⁹

The concept of *plerosis* is, therefore, what grounds the possibility of coinciding boundaries. Two surfaces (or any boundaries of same spatial dimensionality) of two bodies can be spatially co-located to the extent that –in the same place and at the same time– there are two boundaries having different *plerosis*. In temporal terms, there is a single instant in time that is both a starting point and an ending point between two moments.²⁰ 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 *continua* of different spatial dimensionalities. And although boundaries make

¹⁹ For more details about the Brentanian concept of *plerosis* see Smith (1997).

²⁰ The possibility of coinciding boundaries is addressed in Chapter Three, while the problem of spatially co-located physical objects is addressed in Chapter Four.

possible the contact between either temporal or spatial *continua*, boundaries are such that they ontologically depend on some *continua* to exist somewhere in space or time –in particular, *where* that *continuum* exists.

The *Theory of Categories* consists of the late metaphysical thoughts by Brentano that makes a critical study of the Aristotelian theory of substance and accident. Basically, Aristotelian substances are entities which are ‘beings in the strict sense’, i.e., they can exist for itself 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 somethings else to exist. According to Brentano, the substance/accident relation is in fact a whole/part relation. However, the Austrian philosopher turns it in a different way: “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” (1981: 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.

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 mereological essentialism²¹ 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. As Chisholm says: “The principle of mereological essentialism –the principle that parts are essential to their wholes– is basic to Brentano’s theory of substance and accident” (2008: 8). Unlike the Aristotelian view of the one-sided separability in which *x* depends on *y* means that *x* can only exist if *y* exists and *y* is not a part of *x*, the Brentano’s view is that *x* depends on *y* means that *x* can only exist if *y* exists and *y* is a part of *x* (Smith 1987). On this respect, 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 (1981: 111), the difference between substances and accidents is such that the accident has the substance as the only proper part necessarily, while a substance is such that it possibly has an accident as a proper part.

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 the *continuum* it belongs to. An accident, according to Brentano’s theory, is a whole that needs to *have* a substance as a proper part, while a boundary is a kind of being that need to *be* part of something. Boundaries therefore are such that are incapable of existing in itself without being part of a *continuum* of higher dimensionality (in case of spatial boundaries).

²¹ Mereological Essentialism entails that every whole has its parts necessarily. See Chisholm (1976, Appendix B).

Brentano also 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” (1981: 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” (1989: 83). Any part of an object *O* that can only exist attached to *O* is a part of *O*’s boundary; the remaining parts of *O* which could exist detached from *O* cannot be boundaries. On this respect, 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” (1994: 506). The negative element of the definition is relevant to have a clear idea of what for a thing means to be part of another thing. If being a boundary entails being an ontologically dependent constituent, then whatever it exists as a part of something else (without being a boundary) it does but it could have been otherwise. Handles, for instance, can be proper parts of objects as mugs or suitcases but handles themselves could either stop being parts of such objects or have been parts of no objects at all. On the other hand, surfaces are such that they neither could have existed without being boundaries of three-dimensional objects as mugs and suitcases nor can stop being boundaries of alike objects.²² The ontological dependence of boundaries upon *continua* thus 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. (Brentano 1981: 201)

The ontological dependence of a boundary is not upon the very object it belongs to, but upon *some* object. That is, 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. Points therefore are ontologically dependent entities because they are boundaries of lines, while lines are ontologically dependent entities because they are boundaries of surfaces. Nevertheless, neither points or lines are boundaries of a particular and unique line or surface respectively. Boundaries do not depend upon *this* or *that* particular object but upon *some* object of higher spatial dimensionality. On this respect, a surface –e.g., that one belonging to the moon– is an ontologically dependent entity insofar as it is a two-dimensional boundary whose existence does not depend on a particular object (the moon, in this case), but upon any three-dimensional body where it is instantiated. Brentano however contends that “the nature of the boundary is conditioned and determined by the distinctive properties of the continuum” (1981: 56). Instants, for instance, are boundaries whose durationless nature is determined by the sort of object they belong to, *viz.*, events. In the case of surfaces,

²² 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” (1981: 128).

since they are boundaries that *directly*²³ depend upon three-dimensional physical objects, they can have a spatial location and some physical attributes which can be held by them despite their tension between the abstract and the concrete. Surfaces can be found in space in the extremities of physical objects where bodies make contact with their surroundings (or geometrical complements) and show most of their physical features. Nonetheless, according to the Brentano-Chisholm account of boundaries, surfaces do not exist in virtue of the existence of the particular material object they currently bound. Rather, they do only exist in virtue of being the boundary of some material being.

It is important to regard 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 (1981: 201) [...] Every boundary is likewise a *conditio sine qua non* of the whole continuum. The boundary contributes to the existence of the continuum. (1981: 56)

To be a *conditio sine qua non* seems to imply that, in some way, objects are *conditioned* by having boundaries. In this case, ‘conditioned’ refers to some ontological relation between spatial objects and boundaries in which the spatial existence of objects (or *continua*) would depend on having a boundary. It is not clear at all what Brentano means when he claims that ‘the boundary contributes to the existence of the continuum’; in particular, the term ‘contributes’ does not spell out the conditions in which an object ontologically depends upon the boundary it has to exist. 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” (1981: 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 identity over time they can show. That is, having a boundary allows an object both to take place in space and to survive changes across time. This will however be considered in the following sections. So, the exposition of the Brentano-Chisholm account of boundaries ends here.²⁴

²³ By ‘directly’ is meant what follows. Like surfaces, either points (corners) or lines (edges) can be found in three-dimensional physical objects. However, unlike points and lines, surfaces *directly* depend upon such objects to the extent that points and lines could only be part of three-dimensional objects every time that surfaces show that sort of discontinuities. In fact, three-dimensional objects can have surfaces without corners and edges (e.g., spheres such as snooker balls, cannon balls, or marbles), but not the other way around.

²⁴ For more details about the Brentanian view on boundaries, mereology, and the theory of substance see Smith (1987, 1988/99, 1997), Baungartner & Simons (1994), and Chisholm (2008: Chap. I and IX). For a complete study of Brentano’s philosophy see Smith (1994) and Jacquette (2004).

Boundaries and objects have a mutual ontological dependence that needs to be well explained. In the particular case of surfaces of material objects, I will take this two-sided ontological dependence between boundaries and objects in modal terms. First, unlike what is implied by the Brentano-Chisholm account, I take the ontological relation of a surface with the object it belongs to as a case of *de re* dependence. Second, regarding the idea of boundaries as a *conditio sine qua non* of objects suggested by Brentano, I take the ontological relation of a physical object with the surface it has as a case of *de dicto* dependence. Both will be understood as instances of *rigid* ontological dependence and *generic* ontological dependence, respectively.

Boundaries 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. On this regard, ontological dependence 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 cannot have been otherwise than it in fact is. The first statement takes 'The number of planets' to denote a single object that necessarily bears the property of being odd; the second statement takes the proposition 'The number of planets is odd' as necessarily true. While 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, the *de dicto* statement is false since the number of planets could have been otherwise. The modal distinction between *de re* and *de dicto* statements rests on how the modal operator is taken: while for the former 'the number of planets is odd' is subordinate to the scope of the modal operator of necessity, for the latter the property of being odd is what is subordinate to the modal operator. How does the *de re/de dicto* distinction can apply to boundaries (or surfaces) of material beings? 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. (1999: 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 what follows Simons' definition in which 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" (2003, 294-95). However, Casati and Varzi also suggest that a surface cannot exist unless the specific table it belongs to exists. The Brentano-Chisholm account of boundaries disagrees with that suggestion in particular. 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. However, since surfaces are boundaries of material bodies capable of having location in physical space, they cannot be boundaries whose existence depends upon the existence of *some* material being. Unlike points and lines, a surface is a particular case of boundary that directly depends upon bodies having physical existence. This condition, I contend, entails that a surface does not ontologically depend upon some material being, but upon the very object it belongs to. However, material objects also need a boundary to exist in physical space but it is not the same kind of ontological dependence that a surface has upon the very object it belongs to. A material body needs a boundary, but not a specific one. The dependence of surfaces upon physical objects and the dependence of physical objects upon surfaces are both cases of *de re* ontological dependence but of 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) in terms of a *de re/de dicto* distinction can be 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 one has different ontological implications. First, for anything that happens to be a physical object, OS1 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 other 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 $\Box(\forall x \exists y y\beta x)$: necessarily, for every x there exists y and y is the boundary of x . That is, 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 other hand, *de re/de dicto* 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, DSO6 simply rules out anything as both being a surface and belonging to any physical object. In this case, DSO6 allows that a surface x is 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 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: 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 can be for example removed from their bulks. Nevertheless, DOS1 does not leave room for that possibility since every physical object could have only one surface throughout all its existence. Therefore, DOS1 would be false: it is not the case that an object necessarily has a surface because it could be otherwise. Surfaces are also relevant, as we saw before, in many physical features that we attribute to physical objects (e.g., colours, shapes, textures, and so on), so such objects need to have a surface in order to instantiate some physical properties. Nonetheless, if surfaces are where both physical properties are perceived and physical events occur, then a physical object does not need to have the specific surface it in fact has, but just to have some at every time that exists in physical space. In that case, DOS2 describes better the sort of ontological dependence of physical objects upon boundaries. DOS2 is a different case of *de re* modality. Unlike DOS1, DOS2's modal dependence is not of 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 seems difficult 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: they are in fact spatially found where their boundaries (or surfaces) are found. 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 does express 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 object incapable of having physical powers, they are the most exposed boundaries showing many of the physical features and physical phenomena that characterize material bodies. 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 boundary's body) is destroyed at the precise moment of the body's destruction. If the body does not exist, the surface can neither be spatially located nor show physical properties. 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 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, as boundaries of such things, depend upon objects having identity and persisting conditions.²⁵ Thus, given that surfaces are ontologically dependent boundaries upon objects that can survive qualitative changes across time, then they do not generically depend upon being the

²⁵ For more details about this topic see Chapter Four.

boundaries of physical objects, 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 DSO3 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 Brentano-Chisholm account is such that boundaries are both ontologically dependent entities upon some *continua* and *conditio sine qua non* for the existence of the particular *continuum* they belong to. Thus, while a boundary ontologically depends upon some *continua*, a *continuum* ontologically depends upon the particular boundary it has. This thesis is also endorsed by Smith and Varzi: “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” (1997: 12). Although this view can be correct regarding boundaries 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 depends 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 literature, these two different manners of how something depends upon something else is put in terms of *rigid existential dependence* and *generic existential dependence* (Correia 2008; Tahko and Lowe 2015). The former can be put 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 that makes possible the existence of another. Two possible examples according to Tahko and Lowe (2015): first, a non-empty set depends on the very members that it has, so any change in its members will change the set itself; so, a set exists insofar as the very members that constitute it exist; second, a particular person depends on the sperm and egg which generate that person; so it can be said that if the original sperm and egg had been others, then the person generated from that ovulation would be different. Correia (2008) also suggests other possible cases of rigid dependence: events or processes upon their participants; temporally extended objects upon their temporal parts; veridical intentional states upon their objects. Other cases can be a hole that rigidly depends upon its host (Casati and Varzi 1994) or a trope as a particularized property that rigidly depends upon its bearer (Correia 2008; Koslicki 2014). Rigid existential dependence is a strong ontological connexion between the existence of a thing that is only possible only if some other thing and only *that* very thing exists.

Boundaries of material beings, in particular, are entities that rigidly depend upon the specific objects they belong to. A surface S of a material body x is such that, necessarily, S can neither exist without being the boundary of x nor exist if x does not exist. Following how a surface was defined in section A of this chapter, a surface is that outermost part of an object that overlaps all those simples which are in contact with the object's spatial surroundings. However, as Chisholm suggests, a surface (and any sort of boundary) does not have the same ontological status of those parts of an object which are not overlapped by the surface. Unlike parts of an object which are not parts of the object's surface, the surface is a different kind of constituent of an object whose parts do not exist for themselves. As regard (Def.1), we can raise the following statement:

- (S1) The surface S of a physical object x is the set of simple parts of x in contact with x 's spatial surroundings which cannot exist as members of S unless x exists.

Following S1, a surface is a collection of parts which must fulfill two different requirements: first, being simples, i.e., cannot be divided into further proper parts; second, being in contact with the spatial surroundings of the object they belong to. These parts differ from any other parts of an object insofar as they can only exist as constituents of the boundary of a physical object wherever *that* very object exists. On the other hand, boundaries –including surfaces– 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 physical 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 thus think that if S rigidly depends for its existence upon Woody, then, necessarily, 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 Figure 2.5:

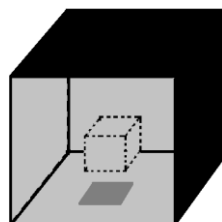


Figure 2.5 Woody

Imagine a very special tool capable of removing from Woody some of the *ws* (the little cube in Figure 2.5) 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, *S* depends upon Woody in a different way than 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 statement:

- (S2)** If *x* is a surface of *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*).

This statement however 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*” (1976: 145). If an object is composed of the parts it has necessarily, then the destruction of one of them would entail the destruction of that object. 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 at the time that Piece is destroyed. If Chisholm account is right, *S* (and any surface) does not rigidly depend upon Woody. ME agrees with the claim that boundaries cannot exist without objects the objects they belong to. However, this ontological relation would not be a rigid existential dependence as DSO4 demands, but a generic ontological dependence following DSO5.

On this respect, Chisholm (like Brentano) contends that a boundary is “a contingent individual which is necessarily such that it is a constituent of something” (1994: 505) or that “every spatial boundary is necessarily such that there is some physical object that contains it as a constituent” (1996: 96). According to this view, boundaries are entities whose being is not necessary (they might have not existed) and does not depend upon the specific objects they belong to, but in a general way upon being the boundary of *some* object. That is, *S* does not depend upon Woody, but upon being the boundary of some physical object 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 DSO3 demands. However, if ME is true, then the surface of a table would be destroyed every time that the table either gain or lose 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 a surface remains despite the series of mereological changes of the original object it belonged to as long as parts of the original object also 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 S2, 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 different tables 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 y that comes into existence after x ’s destruction or x insofar as s_x exists due to original parts of x still exist. However, the distinction between ‘original’ parts and ‘non-original’ parts is confusing: it generates this odd picture in which a surface is a changeless boundary throughout the continuous destruction of different objects in series of mereological changes. Option (i) does not catch the genuine ontological dependence of a surface upon the object it belongs to that DOS4 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: for every compositional change that your table might undergo, there exist different tables and each of them having a different 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 we are not certainly sure about the table on which we have dinner. In the case of (ii), there exists one table for every series of mereological changes having its specific surface. However, (ii) has some restrictions. Following S2, 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 in different tables having each one its 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 having each one its surface for every slightly mereological change. Since option (ii) implies such an odd consequence, then it should be rejected.

I sympathize with (iii). This option entails a *de re* dependence between a surface and the object it belongs to that DOS4 demands despite the mereological changes *that* object can 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 x s 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 x s, 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 x s directly overlapping with s_x . This view requires discussion of the persistence condition of material objects that will be addressed in detail in Chapter Four.

A boundary is then characterized by always being 'a boundary of...', i.e., they cannot exist for themselves. In the case of boundaries of material beings (surfaces), it is not just the case that being a boundary and being part of something else is an analytical truth. Rather, such a boundary is a genuine case of *de re* dependence: unlike the Brentano-Chisholm account of boundaries, a surface necessarily is the boundary of the specific physical object it belongs to; that is, a surface is a boundary whose existence *rigidly* requires the existence of the physical object it belongs to. Although surfaces are abstract things of only two spatial dimensions, we do many physical things with them insofar as they are the boundary of physical objects. A surface cannot therefore exist in the physical world unless the material object it belongs to exists (even though such object undergoes mereological changes). The next task is to study the case of dependence of ordinary physical things on surfaces.

Generic Ontological Dependence: Objects upon Surfaces

According to S2, 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 kind of dependence between the bulk and a specific surface. However, it can be noted this: although

physical objects need not have the surface they in fact have (DOS1), they cannot exist without having a surface (DOS2). Unlike surfaces, physical objects are instances of a *de re_{generic}* dependence upon their boundaries: while a table can exist without one of its legs, it cannot exist in a general way without having a surface.

We said in the introduction that boundaries are entities that exist in the extremity of something and between things. In case of surfaces, they both are in the extremity of physical objects and separate those objects from their spatial surroundings. The sort of ontological dependence of material objects upon surfaces is thus based on the intuition that they cannot occupy physical space without having a surface. The core ideas for this argument are the following:

- (a) Material objects are three-dimensional occupants of physical space.
- (b) The physical space occupied by material objects is finite.
- (c) Surfaces are the 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, wide, and depth). Second, they occupy some determined portion 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. Following our definition of a surface in Section A, *S* separates the portion of occupied space by Woody from the empty space in Woody's surroundings: the total space occupied by Woody reaches *S* as its physical boundary. Following (i), Woody takes up a finite portion of physical space insofar as Woody has a surface that sets the boundary of its spatial occupation. Secondly, regarding (ii), 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 ends and no parts of Woody are found beyond it. Third, regarding (iii), Woody has physical properties and causal interactions. As we saw, many of the physical features and causal interactions of material objects occur on their surfaces according to both common-sense and science. Thus, most of the either physical properties (e.g., colours, shapes, or textures) or physical events (e.g., light reflection, contact, or corrosion) attributed to Woody occur on *S*. Woody 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 seen.

To be a material object entails being found somewhere in physical space: spatial entities must possess location or spatial address. Casati & Varzi (1999) 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 someone (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" (1999: 119). This can be said about every physical object.

Woody's exact location is its *present temporary minimal address*. How can however Woody's exact location be easier to find? There is a way: we just need to look for Woody's boundary. According to Casati & Varzi, "This notion of exact location is the notion we are interested in here. It 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" (1999: 119). Wherever Woody's exact location can be, Woody can lose some parts which were not parts of it at some later exact location. However, 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. On 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*. Despite they are minor entities or non-substantial beings, boundaries are fundamental entities for material beings or first order entities. The following statement can be therefore claimed:

(S3) Necessarily, anything existing in physical space, it has a boundary (i.e., 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. This ontological dependence suggested by S3 in terms of spatial dependence:

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

On this respect, 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 (including the requirements already seen) if it has some boundary at every time of its existence. This difference of spatial dependence entails the modal distinction between surfaces as *de re_{rigid} dependens* (DSO4) and physical objects as *de re_{generic} dependens* (DOS2). This distinction is taken by two kinds of existential dependence: a surface *rigidly* depends upon the physical object it belongs to; a physical object *generically* depends for its spatial existence upon a surface. The distinction between *rigid dependence* and *generic dependence* has been largely studied in the literature about ontological dependence.²⁶ 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 (2006, 2008) explains generic dependence in terms of *essentialism*. A traditional metaphysical question is as follows: *What does it make for something to be what it is?* For short, this can be put as ‘What is it to 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 H₂O 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” (2006: 754). Generic dependence is therefore the ontological relation between the existence of an object *x* upon the existence of objects which fall under a specific kind *K*. 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*.²⁷

Following (Def.3), the existence of *x* does not depend upon the particular existence of *y*; instead, the existence of *y* depends upon the existence of *y* only if *y* is an object of a kind *K* such that *x* ontologically depends upon any object falling under *K*. The fact that a boundary is a *conditio sine qua non* for a *continuum* –as the Brentano-Chisholm account 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 object 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. A physical object depends for its spatial existence upon *having a surface* throughout its existence. Without having a surface (whatever it can be) throughout its existence, a physical object would lack a boundary to indicate both (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

²⁶ See, for example, Correia (2006; 2008), E. J. Lowe (1994: Chap. 6, 1998), and Tahko & E.J. Lowe (2016).

²⁷ 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*” (1998, 141).

a material object O does not need the surface S it currently has, O cannot exist without having an S in every possible world where O exists in physical space. Following Def.3, we can make this statement:

(S4) 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 are surfaces.

Think again of our cube Woody. Imagine now a surface-cutting machine capable of removing S from Woody (i.e., taking away all those simple parts that compose S). Once we have removed S , a ‘new’ surface N_{S_1} immediately comes out to be possessed by Woody; once N_{S_1} is removed, N_{S_2} will emerge as a surface, N_{S_3} after N_{S_2} , 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 fails in having a surface, then it also fails in existing in physical space.

Boundaries are not self-sufficient entities: they cannot exist for themselves. Regarding surfaces, they directly depend upon three-dimensional objects. Although surfaces can be considered abstract things, they take part of the physical world since they are the boundaries of material beings where we can do physical activities such as painting, piercing, scratching or sanding. Physical objects can be distinguished from other physical objects by being red, soft, perforated, dirty, stained, or any other property, but all of them are instantiated on their surfaces. So, many of the physical features that individualize a material object are on its surface. Unlike the Brentano-Chisholm account of boundaries, surfaces do not depend in a general way upon some continuum or another. Rather, a surface becomes a concrete boundary given that its existence in physical space *rigidly* depends upon the specific material object it belongs to.

On the other hand, as Brentano remarks, boundaries also are *conditio sine qua non* for *continua*: being bounded is a metaphysical requirement to occupy some particular portion of space. To be a substance –i.e., a *separable* being having a self-sufficient existence– seems to necessitate a boundary to make it separable from other beings. As Smith puts it: something “becomes a substance only on becoming detached, when it acquires a boundary of its own” (1992: 61). Although boundaries have no substance (i.e., they are *inseparable* beings), they are required for substantial beings. However, 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. This therefore is a fundamental metaphysical distinction to study the boundaries of ordinary material beings.

Final Remarks

Surfaces have been taken as the boundaries of physical objects despite their abstractness. They are in the outermost parts or top layer of physical objects that overlap all those simple parts in contact with the objects' spatial surroundings. The fact that boundaries are entities that cannot exist in isolation seems to be a philosophical agreement expressed by the Brentano-Chisholm account. However, we found an asymmetric metaphysical relation between surfaces and objects: the existence of surfaces *rigidly* depends upon the specific objects they belong to, whereas the existence of physical objects *generically* depends upon having a surface as long as they exist in space. In modal terms, the ontological relation between surfaces and physical object is a case of *de re_{rigid}* dependence; the ontological relation between physical objects and surfaces is a case of *de re_{generic}* dependence. There is a mutual metaphysical necessitation between surfaces and material objects: surfaces can be located physical space insofar as they exist as boundaries of a *specific* material object, whereas material objects can take up three-dimensional physical space insofar as they have *some* surface at any time of their existence. Surfaces are the sort of undesirable guests that never want to leave, but, paradoxically, they are necessary beings for the existence of their hosts.

CHAPTER THREE

On Contact and Continuity *The Boundaries between Things*

Introduction

This chapter addresses a natural and intuitive idea related to boundaries of everyday material beings: boundaries are where objects make contact. Actually, to think of boundaries entails not only thinking of boundaries separating objects or parts of objects, but also boundaries touching each other when objects or parts composing objects are in contact. A feature of boundaries is not only, as we saw in Chapter Two, that they are ontologically dependent entities, but also that they seem to exist *between things*. If boundaries separate objects or parts of objects, then whenever a boundary can be found, it is found between things. Contact thus occurs when the boundaries of two objects meet in space and nothing else can be placed *between* them. That is, contact occurs when boundaries are so close to each other that only they and nothing else prevents two things from going through each other.

However, if two objects in contact fill a continuous region of space (i.e., a region such that you can uninterruptedly travel from place to place within it without ever leaving it) could the existence of boundaries entail a discontinuity of some kind in that region of space? In fact, boundaries are discontinuities insofar as they indicate *where* or *when* something stops and something else starts (that's why boundaries are always between two things). So, if two things (or parts of a thing) are in contact through their boundaries, can this entail that the space occupied by both things is cut in such a way that it becomes discontinuous? How should contact between things be understood to make compatible the existence of boundaries and continuous space?

This chapter has four main parts. First, two different accounts about how contact occurs in space in terms of objects' boundaries and whether the idea of contact itself is possible or not. Second, the incompatibility of the following statements (i) boundaries exist, (ii) contact between objects is possible, and (iii) space is continuous. Third, four views about how such incompatibility can be resolved. Finally, fourth, the advantages of one of these views over the others, viz., the *Coincident View*.

Contact Through Boundaries

Thinking of everyday boundaries leads us to think of the possibility of *contact* between things. Contact between objects is often said to happen when their boundaries touch each other. By shaking hands,

the first contact occurs when the hands' boundaries (their skins) are touching, whereas the first point of contact when two snooker balls collide with each other occurs on their surfaces. Thus, 'boundary' and 'contact' seem to be concepts difficult to think of separately; or, at least, thinking of things making contact intuitively entails thinking of the boundaries of those things.

As the *ordinary conception of the world* (OCW) tells us, the world consists of solid and compact objects such as tables, marbles, or statues located in physical space at some given time are. A physical object then occupies an empty region of space by filling it up with matter without leaving empty space within its boundaries. Antony Galton (2007) calls this view *naïve physics* in which an object such as a gold sphere is a material substance taken to be a homogeneous *filler of space*: “[o]ur gold sphere, on this view, is gold *all the way through*, by which is meant that there exists gold at every point within the sphere’s volume” (2007: 379). A snooker ball, for instance, is another ‘filler of space’ made of different types of polymers (phenolic resins, polyester, and acrylic) characterized by the hardness and compactness of its material composition. If you look at the region of space filled by this object, you would look a portion of space continuously filled by matter: there are no unoccupied sub-regions within the region of space filled up by the billiard ball. By looking at the space occupied by the snooker ball, *everything is matter all over the place*.

In this picture, physical objects continuously fill up delimited portions of space with matter without leaving empty space. The snooker ball does not take up physical space entirely, but rather a portion of space (not occupied by another object) entirely filled with the matter that composes the snooker ball. The matter composing the snooker ball reaches a boundary (a surface) where nothing of the snooker ball can be found beyond it. As Simon defines a body: “For a *body* is something like a maximal connected mass of matter, separated from its surroundings by a discontinuity at its surface” (1985: 75). A compact material body x is then an object that continuously fills with matter a portion of three-dimensional space having a boundary (or surface) that separate x from x 's spatial surroundings (or geometrical complement).²⁸ Boundaries thus indicate where the physical extension of the spatial portion taken by material objects ends: nothing of the matter that continuously fills the portion of space occupied by an object can be found beyond the object's boundary. There might be nonetheless cases of unclear or vague boundaries. Think of boundaries of the regions of space occupied by clouds, the smoke coming from a cigarette, constellations, the sun, or trees: it is indeterminate where the space filled by those objects ends. However, despite the vagueness, we certainly know that objects do not take up the entire physical space but only portions of it, so there must be boundaries there regardless of whether they are sharp or vague.²⁹

The idea of contact between boundaries fits naturally in this common-sense story of material beings. It is an everyday fact that objects make contact with each other. However, the contact between two objects does not occur between *all* the matter that composes one object and *all* the matter that composes the other,

²⁸ See Chapter Two for more details about the definition of a surface.

²⁹ I will assume in this chapter that physical objects have sharp boundaries and, therefore, the region of space occupied by them can be clearly delimited. The discussion about vague boundaries will be addressed in Chapters Five and Six.

but only through their boundaries or surfaces. A tennis ball bounces on the tennis court and books are on a shelf when parts of their surfaces make contact. An Olympic diver goes through the water in the pool when the skin of her fingers makes the first contact with the surface of the water. Boundaries are the first part (maybe the only part) that comes into contact when objects make touch each other.

Contact could be explained in terms of overlapping and gaps. Two objects overlap if they have some common parts. The overlapping might occur between larger parts of objects or those parts composing objects' boundaries. In the first case, think of two round-shape lights of equal size projected on a wall –one red and one green– which overlap just in the half of each one. As a result of the overlapping, the total yellow area between the two lights would indicate the parts shared by them. In the second case, think of two halves of a square separated by a boundary. The overlap here occurs in a shared boundary: there is one boundary that is a common part between both halves. Unlike the first case where the yellow area can be divided into further parts, the boundary between the two halves of the square is a line that cannot be divided into further parts. (At least, not in the same way a square in a plane can be divided. While a square has two spatial dimensions, a line has only one dimension. So, the line between the two halves cannot be divided into two-dimensional parts, but only into one-dimensional segments or zero-dimensional points). Intuitively, contact between things seems to be a different story. First, contact specifically occurs between boundaries. Second, when two things make contact, there are two boundaries touching each other instead of one shared boundary. Third, contact occurs when two boundaries touch one another without leaving gaps or empty space between them. The idea of no empty space between boundaries to explain the idea of contact can be confusing. Think of a doughnut cut into two halves which are in contact with each other:

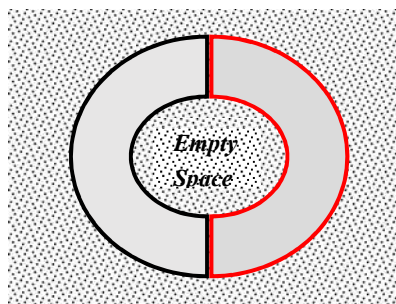


Figure 3.1

It is not accurate to say that the contact between two objects occurs when there are no gaps or empty space between them. In the case of figure 4.1, although both halves are in contact, there is an empty space between them. It is necessary to specify that contact between objects is said to occur when no gaps or empty space can be found between at least *parts of their boundaries*. We can try the following principle:

(Contact) Two objects x and y make contact if and only if (i) x and y do not overlap, and (ii) at least one part of x 's boundary touches one part of y 's boundary without leaving empty space in between.

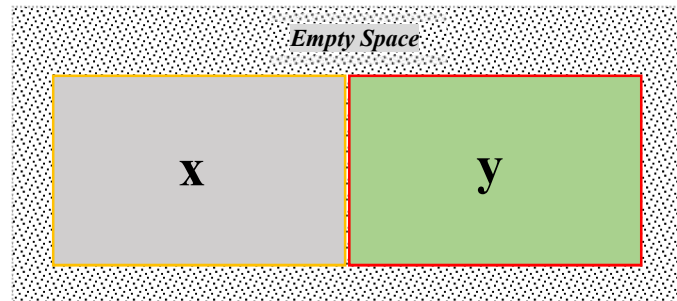


Figure 3.2 Contact

This is a very intuitive principle about how contact occurs between macroscopic physical objects in everyday life: x and y are in contact insofar as there is no empty space to be occupied between (parts of) x 's boundary and y 's boundary (see Fig. 4.2). Thus, if x and y are two objects in contact, then they are next to each other without gaps between (parts of) their boundaries and without sharing parts. Thus, in order to go from x to y neither *jumping* an empty area nor *passing through* something else between x 's boundary and y 's boundary is needed; we can *pass directly* from one to another.

We can also try a similar principle of contact but this time focused on the place in space where two boundaries make contact:

(Contact*) Two objects x and y are in contact if and only if there is a region of space R that (i) R is divided into two sub-regions R_1 and R_2 , (ii) R_1 is entirely filled by some of x 's boundary-points and R_2 is entirely filled by some of y 's boundary-points,³⁰ and (iii) R cannot be divided into more sub-regions.

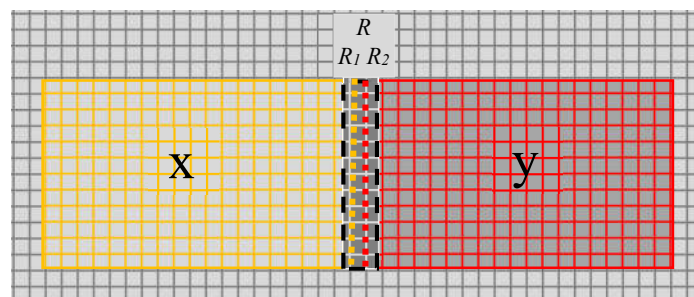


Figure 3.3 Contact*

³⁰ By 'boundary-point' is simply meant all those points within a region of space R which are in contact with those points in R 's spatial surroundings. Hence, R 's boundary would then be the set of each of R 's boundary-points.

*Contact** is more sophisticated than *Contact*. Fig. 3.3 shows where x and y make contact in space, R is a spatial region where nothing except x 's boundary-points and y 's boundary-points can be found. So, R is, let's say, a saturated region, i.e., it has no points unfilled. If R is where x and y make contact, then R cannot be divided into more than the two sub-regions entirely occupied by the boundary points of x and y . Otherwise, it may happen either (i) R_3 , a further sub-region of R between R_1 and R_2 , could be filled by some object different from x and y or (ii) R_3 could be an empty sub-region of R between R_1 and R_2 . Both (i) and (ii) entail that x and y are not in contact: while (i) entails that there is some other object between x and y , (ii) entails that there is a gap between x and y . Like *Contact*, in *Contact** we do not need *jumping* or *passing through* something else in order to go from x to y because 'throughout the travel' we find neither gaps nor other objects in the region of space where x 's boundary and y ' boundary meet. We *pass directly* from one to another without overlapping and gaps.

The Space Between Boundaries

This is an everyday fact: contact occurs when the boundaries of two objects bump into in space, i.e., when one object cannot continue its travel in space because the boundaries of another object intercept it (and *vice versa*). The idea of contact can entail two different ontological commitment to space: (i) being in contact can imply the existence of some region of space where objects' boundaries meet; (ii) being in contact can imply a spatial relationship between objects' boundaries such that they are so close to each other that nothing can found between them. In the case of (i), space is a substantial being for itself that exists independently of the object can occupy it. In the case of (ii), space is not a substantial being but just the spatial relations held between objects (e.g., being in contact).

The views above about the ontological status of space have divided philosophers into two main accounts: *substantivalism* and *relationism*. In general terms, a substantivalist account of space contends that *there exists* a being that is the space in addition to material beings such as planets, stars, tables, chairs, persons, or atoms. Space itself has an intrinsic structure whose features and existence do not depend upon the features and existence of the material beings that occupy it. On the other hand, a relationalist account of space contends that space is nothing in itself, but just the spatial relations that material objects can hold. In negative terms, "the heart of relationism is the rejection of absolute or substantival space(time), understood as a separate basic element of the correct ontology of the world" (Hoefler 1998: 463). Unlike substantivalism that contends that there are space-things as well as matter-things, relationalism contends that there is only matter, and space emerges from the spatial relations had by material beings.³¹

Regarding the idea of contact, while *Contact* is consistent with relationalism, *Contact** is consistent with substantivalism. *Contact* focuses on the idea that x and y are in a spatial relation such that x 's boundaries

³¹ For more details about the discussion between relationalism and substantivalism see Maudalin (2012), Teller (1991), Rynasiewicz (1996), Nerlich (1994: Chap. 1-2), Hoefler (1998), Dainton (2001: Chap. 9), or Hugget & Hoefler (2016).

and y 's boundaries are close enough that nothing is found in between. On this view, space itself is not needed to determine whether x and y are in contact; what is just needed is to determine that there is some spatial relation between x and y that entails for both being in contact through their boundaries. On the other hand, *Contact** focuses on specifying *that* region of space where two objects are in contact. So, x and y are in contact insofar as there is a region of space in which x 's boundary and y 's boundary meet. On this view, space itself does not exist in virtue of how x and y are related, but it is an entity that can be filled with matter and have a parthood structure. This entails that when x and y are in contact, then there exists a sub-region of space divided into two sub-regions entirely filled by some x 's boundary-points and some y 's boundary points. Insofar as space can be divided into parts and filled by stuff, x and y are in contact only if there is a region of space R where parts of the boundaries of x and y touch one another and no further sub-region of space is found in R (either empty or filled by another thing) between x 's boundary and y 's boundary.

Common-sense seems to adopt a non-substantialist view on space. Material objects are spatial beings which can move from place to place and cannot be in the same place at the same time. The place where a material object can be at one time and the place where it can be at another time are not entities of some kind: there are only objects that occupy space, but space itself does not exist as a separable being. Actually, it seems odd to say that the portion of space that your body occupies literally exists as a separable being from your body. Space is therefore seen as merely emptiness or vacuum: there is nothing where material beings are not found. Barry Dainton calls this intuitive view as *The Void Conception*: "Space in itself is nothing at all; it has no intrinsic features of its own, it is mere absence. [...] [W]e cannot directly measure magnitudes of space, since space is itself featureless void" (2001: 132). This conception comes naturally if it were imaginable to remove all the stuff from the universe: stars, planets, stellar dust and every single atomic particle. What would it be then left? We would naturally say 'nothing'.³² What would the *Void Conception* imply? The distance between Buenos Aires and Montevideo in a straight beeline is 129 miles. A substantialist would say that while Buenos Aires occupies a region of space R_1 Montevideo occupies a region of space R_2 , and R_1 and R_2 are 129 miles away. By contrast, the relationalist rejects that we can know the distance between both cities by measuring the distance between portions of space because measurements can be only done on something but space is nothing in itself. Being close or being away are relations that exclusively applies to material things but no to space.

What problems can the *Void Conception* have? If space is 'nothing', then, we might say, there cannot be spatial *paths*, *tracks*, or *trajectories* to link spatial objects. How can I travel from Buenos Aires to Montevideo if there are no *spatial paths* to be tracked between them? How could a bullet reach its target if there are no *spatial trajectories* connecting the starting point of the bullet and the endpoint where the bullet meets its target? We can have an absurd conclusion in which material objects would be isolated spatial things

³² Although common-sense beliefs do not include the idea that space is a substantial being, there some everyday contexts in which we seem to imply that there exist parts of space when no material thing occupies it (e.g., when we say that there is some empty space where a car can be parked). In that case, if no material object existed at all, instead of nothing, we could say that there is space, but empty.

without ever bumping into each other. If space is nothing at all or completely featureless, i.e., it has no for itself paths or trajectories to link the objects it hosts, then material things would remain contactless in this picture. As Dainton puts it:

Any two material objects are properly viewed as distinct and independent spatial world in their own right. Since there are no spatial paths or distances between two distinct objects, *it is impossible for one object ever to collide with another*.³³ If an object breaks into two parts, these parts would not drift gradually away from one another, they would each immediately come to constitute isolated worlds in their own right. (2001: 138)

According to this view, if being in contact is a physical possibility of material beings that mainly occurs between their boundaries, then space cannot be anything or merely void. Insofar as physical objects fill space with matter and can travel *through* it and stop where their boundaries meet, then space cannot exist only in virtue of the relations held by physical objects. According to substantialism, if two objects can make contact, then there exists a portion of space covered by the two objects traveling until finding each other in a region of space where their boundaries meet without leaving more space in between. This is the option expressed by *Contact**. According to it, *there is* a region of space R where two things x and y *spatially* meet. In this case, R is divided into two sub-regions R_1 and R_2 , so while R_1 is fully occupied by some x 's boundary-points, R_2 is fully occupied by some y 's boundary-points. Thus, the contact between x and y occurs only if R is entirely occupied by parts of the boundaries of x and y and R cannot have further divisions. If so, there are no portions of space between x and y (either empty or occupied by other than x and y). *Contact** thus assumes that space is not a simply nothingness, but *something* that things can *fill* and *move through* it until their boundaries come across.

However, if space is an entity of some kind, then the idea of contact between material bodies, we might say, becomes impossible to the extent that there exists something else between them that prevents boundaries from meeting one another. If space is nothing at all, then nothing would prevent the contact of objects' boundaries. Nonetheless, if space is such that, among its features, it can be divided into parts infinitely, then the boundaries of two object could never be in contact because there would always exist a minimal portion of space between them. This indeed is the core of Zeno's paradox of Achilles and Tortoise race in which Achilles will never reach the tortoise regardless how fast he moves. The paradox arises if we think that during the time that Achilles travels the distance in space to reach tortoise's actual position at t_1 , the tortoise will be ahead in space some shorter distance; during the time that Achilles travels the distance in space to reach tortoise's actual position at t_2 , the tortoise will be ahead some shorter distance; the same at t_3 , t_4 , and so on. Hence, every time that Achilles *goes through space* to reach the place where the tortoise has been, he still has a shorter and shorter distance to travel. Thus, if two things travel in space to make contact,

³³ The emphasis is mine.

their boundaries can be very close but they will never meet because space itself is divided into an infinite number of smaller and smaller pieces.

Contact makes the closest statement to OCW insofar as it assumes a non-substantialist view. According to common-sense, there are no regions of space in the same way as there are tables, chairs, or snooker balls; or, at least, there is *nothing* where material objects are not found. As *Contact* suggests, two objects x and y are in contact if there is no empty space between their boundaries. By claiming this, it can be inferred that portions of space can be *found* between x 's boundaries and y 's boundaries when x and y are apart. This however is a misleading idea if the 'nothingness' is not something *findable*. How could we find something having no features, magnitudes, parts, or structures? Although we do not believe that there exists something when a material object is not found in some place, we may take space as something that can be measured in different metric units of length (e.g., inches, centimeters, kilometers, or miles), divided into regions, or structured in dimensions. These features cannot be believed about anything; there must be *something* where physical objects are found and *something* between them when they move away from each other. However, unlike *Contact**, *Contact* is not consistent with some substantial view of space. *Contact* is not committed to the existence of a region of space where the contact of two boundaries occurs. *Contact* is not committed to the idea that contact occurs between the boundaries of two regions of space filled by two material objects neither. *Contact* rather is a spatial relation of some kind between two objects x and y such that some part of x 's boundaries and some part of y 's boundaries are so close with each other that nothing between them can be placed. This idea may not faithfully represent what relationalism intends to say about space, but at least is not committed to what substantialism says.

As it is remarked by Dainton (2001: 143), the attitude toward empty space is one of the points that makes the difference between substantialists and relationalists. *Contact** assumes a substantialist view in which there *exists* some point in space where two things touch each other through their boundaries. On the other hand, *Contact* need not be interpreted as a relationalist thesis at all, but it is a non-substantialist view insofar as it assumes contact as a spatial relation between two things which are so close that nothing is between their boundaries. According to these views, contact can be either an event that happens somewhere in space where boundaries come across or a spatial relation held between the two objects and their boundaries. Both seem to be reasonable: How could objects make contact if there were not exist a path in space where they travel through and a place in space where their boundaries meet? How could objects make contact if they do not hold a kind of spatial relationship in which they are so close that nothing can be between their boundaries? Nonetheless, can things' boundaries really touch each other?

Boundaries: Close but Not Enough

The everyday picture of material objects making contact through their boundaries is so natural that seems hard to reject it. As we saw, the substantialist may say that two things are in contact only if there is

a region of space filled by the boundary-points of two objects and there no no other sub-regions of space between them. On the other hand, the relationalist may say that given that there is no such being as space but only spatial relations between material objects such as 'being close' or 'being far', contact is a relation between two objects spatially related such that their boundaries are so close that nothing can be placed between them. The controversial issue on this view is that it is committed to universals and not a few philosophers have argued against their existence. In particular, relationalism is committed to the existence of *relations*; in this case: contact, i.e., a *spatial relationship held between object's boundaries*. Relationalism could argue that the relational account of space is more economical than a substantialist account because it assumes that there are no space-things in addition to matter-things. However, the relationalist ontological commitment to 'spatial relations' can be even more controversial than the substantialist's commitment to space.

According to substantialism, instead of merely void, space(time) is a substantial being whose existence does not depend upon the existence of the objects that occupy it. However, think of two balls x and y moving toward each other. If contact is possible between x and y , then there should be nothing (nothing substantial, let's say) separating (parts of) x 's boundary from (parts of) y 's boundary. If x and y travel through space until coming into contact, then nothing should exist between x and y that could prevent the contact of their boundaries. But, if there exist portions of space between x and y in their travel to make contact and space itself is a kind of substantial being, then x and y cannot make contact because *there would be something else* between their boundaries. (This is what we described before with the Zeno's paradox example). Taking Dainton's words, "a substantialist holds that space and time 'contain' objects in the way that an ocean contains the solid things that float within it" (Dainton 2001: 2-3). Hence, two objects could be very close to each other, but they cannot make contact insofar as there would always exist small portions of space between their boundaries as well as small portions of water between two objects close to each other floating within the ocean.

Empty space actually is what you mostly find in the entire universe. The inside of the atoms composing planets, stars, animals, people, and every macroscopic object consists of practically nothing. Your body is composed of scattered particles spread out over a vast empty space. However, quantum physicists have discovered that empty space is not really empty at all. Although the universe is sprinkled with dispersed sub-atomic stuff, the vacuum between fundamental particles is full of quantum field fluctuations. In this story, as Cox & Forshaw describes in their book *The Quantum Universe* (2011: Chap. 11), the origin of mass is due to particles that move according to hopping and branching rules. Higgs particles play a fundamental role in how the matter would emerge in the universe. Subatomic particles do not move straight in a vacuum, but rather they do in a zig-zag traveling. This behavior of the sub-atomic particles triggers the idea there must exist a field energy (called the *Higgs Field*) that permeates the entire universe. The Higgs Field interacts with the sub-atomic particles and give them their mass: the more a particle interacts with the Higgs Field, more the mass it has. In fact, if the Higgs Field did not exist, particles would have any

mass at all. Higgs particles (bosons) are the smallest bits of this energy field. If there were no Higgs particles, low-mass particles would not be ‘hopping’ from one side to another and the energy would not increase enough to make possible the emergence of mass to form complex things such as atoms, planets, stars, people, and the whole universe. Physical space cannot just be simply void; if matter exists, then the vacuum where elemental particles move *through* must be plenty of Higgs particles.

How do these interesting scientific facts affect our conception of boundaries of ordinary material beings? In different ways, but at least one: contact through the boundaries of things is not possible at all. A common-sense view is that two objects can move in empty space in a straight line one against the other and they hit each other when (parts of) their boundaries make contact. Space however is not an empty place at all where nothing happens when material objects do not occupy it. If space is a substantial being between objects, then, we may think, there would always be some tiny portion of it between objects no matter how close they can be. *Contact* contends that two objects are said to be in contact when *nothing* can be placed between (parts of) their boundaries. However, we can think that if space is some kind of substantial being having, for instance, an energy field made of tiny bits (or any kind of structure and features to be determined by scientists and philosophers), material objects can be really close, but some little space can still be found between them.

There is still another convincing physical reason why contact between objects’ boundaries never happens. According to quantum theory, no two identical fermions (e.g., electrons) can share the same quantum state. This is called the *Pauli Exclusion Principle* that says that electrons cannot all fall down to the same energy level (same spin) on the same shell. Since electrons repel each other insofar as they try to occupy the same quantum state, the idea of contact becomes a macroscopic illusion. When you hold a cup of tea, the skin of your hand is not really touching any hot and soft surface. Actually, there is an atomic gap between both boundaries. The atoms composing one thing never reach the atoms composing the other because they repel each other. The texture, heat and every feature that you might feel is nothing about the surface of the cup, but rather the electromagnetic repulsive force between atoms. Although you cannot touch any part of the boundary of the cup, you can still ‘grasp’ it because surfaces are not entirely flat at an atomic level and there is friction between my hand’s skin and the cup’s surface. The boundaries of such things can be really close to each other, but not enough to be in contact: there is either a substantial space separating them or a rejection of their atomic electromagnetic forces. Touching something on a fundamental level is thereby not physically possible: *nothing touches anything* ever.

Boundaries and Continuous Space

The following three principles seem to be incompatible with each other if they are all accepted (Casati and Varzi 1999; Varzi 1997; Weber and Cotnoir 2014):

- (a) Boundaries exist
- (b) Objects occupy continuous space (or topologically connected)
- (c) Objects can be in contact

The idea of a continuous space is broadly accepted by common sense. We can travel through space uninterrupted: there are no gaps in space if we move from one place to another place. Contact is a common picture too: things make contact through their boundaries (or parts of them). The existence of Boundaries is a quite natural and intuitive thought too: since material objects occupy portions of physical space, then there should be a boundary demarcating it. The contact between two discrete objects intuitively needs the idea of boundaries touching each other. However, as we saw, according to quantum physics, for instance, contact never occurs due to the electromagnetic forces keeping particles away from each other. So, even though (c) presupposes (a), (c) would be a loose way of talking of things and their boundaries, but not a fact in the world. Moreover, if (b) is true, then two objects in contact x and y (if contact is possible) fill two continuous regions of space which compose a larger region of space R . It follows that we must be able to pass from x to y without ever leaving R at any time, i.e., there is at least one continuous path from x to y that is entirely within R . However, if boundaries exist and separate things or divide them into parts, then they could interrupt or ‘cut’ the continuity or topological connectedness of space. That is, if the continuous path to go from x to y is interrupted in the place where x ’s boundary and y ’s boundary meet, then R is not composed of two continuous regions of space.

Hence, if (b) is true, then (a) should be false; or, at least, (a) should be thought without contradicting (b). If (b) and (c) both are true, then (a) cannot be true at all; or, at least, it cannot be true that there is a boundary for every object in space; (a) cannot be true (at least in the literal sense of our daily talk of boundaries). We could therefore adopt the topological distinction between closed objects and open objects: while a topologically closed object occupies a region that, among its members, contains its boundary-points, a topological open object occupies a region that, among its members, does not contain any boundary-point. Thus, contact and the continuity of space could be possible if between two objects in contact one of them has its boundary while the other does not. The acceptance of both (b) and (c) leads to give up (a) or at least the everyday way of talking about boundaries and contact.

According to common-sense ontology, the idea that two or more objects compose a further single object can be explained in terms the contact of their boundaries: x and y compose an object only if (some part of) x ’s boundary and (some part of) y ’s boundary are in contact (as it is suggested by either *Contact* or *Contact**).³⁴ This can be put in two ways: (i) by the contact between the *outer boundaries* of many things which are put together; (ii) by the contact of *internal boundaries* which separate different parts of a single object. For example:

³⁴ We will see in Chapter Five that contact between objects’ boundaries, according to van Inwagen (1990), is not sufficient to answer when two or more objects compose one further single object.

- (i) Imagine a pyramid made of bricks placed on top of each other. The pyramid is the sum of all the bricks arranged in a pyramid-shape. Every single brick has a boundary (surface) and taken collectively they shape the boundary (surface) of the pyramid.
- (ii) Imagine a cat (or Cat) divided into two parts: tail (or Tail) and the rest of his body (or Tailless). Tail and Tailless do not make contact as the bricks' boundaries in (i) do: Cat is separated into parts by a boundary drawn following Cat's anatomy rather than piling up many objects. Cat then is a sum of continuous parts including Tail and Tailless.

Regarding (i), according to quantum physics, we know that boundaries of ordinary material objects (if there is any) –e.g., surfaces of bricks and pyramids– cannot make contact since the particles composing them repel each other. We can say ‘the boundaries of the bricks are in contact with each other shaping together the pyramid and so its boundary too’, but this would only be a loose way of talking about contact through boundaries. They can be close, but never enough to make ‘real’ contact. We can therefore rule out that bricks compose a pyramid through the contact of their boundaries since they never touch each other (and perhaps, for the same reason, atoms do not compose any brick or those physical objects that we everyday talk about). If so, then the only way that two things can be in ‘real’ contact would be the case of (ii).

If the everyday notion of contact is the event of two boundaries touching each other, case (ii) is not an example of contact but a traditional example of overlapping where there exists one shared boundary by Tail and Tailless. Unlike (i), (ii) ensures that between two objects (Tail and Tailless) there are no gaps (not even a tiny one) because they have a common part: a boundary. While the bricks can be set apart from the pyramid without making any cut, Tail and Tailless are not separable unless we cut Cat. Thus, if two things are in ‘real’ contact (in contrast with a loose talk of contact) without fracturing the continuity of space, then overlapping seems to be the only way. However, as we have said, contact cannot be explained in terms of overlapping. So, strictly speaking contact never occurs and, if two things compose a further one through some spatial relation of their boundaries, it can only be by overlapping. Although the boundary between Tail and Tailless separates Cat into two parts, that boundary does not cut Cat's spatial continuity. However, there is a natural question to ask: which part is the genuine owner of that boundary? Tail or Tailless? Both? Or perhaps neither?

That question raises the Suárez-Peirce puzzle³⁵: A surface is divided into two halves, one of them has one colour, the other another colour. What is then the colour of the boundary-line that separates both halves? Peirce writes a version of this puzzle as follows:

³⁵ In his *Disputationes Metaphysicae*, Suarez posits the puzzle about a boundary separating two parts of an object as follows: “[I]n the continuous surface of a wall, one half is maximally white and the other half is maximally black, and those qualities each have their own indivisible boundaries [*termini*] by which they are contained and limited. It will then be necessary that, from that part in virtue of which they are contiguous, they each have their own boundaries inhering at the same time in the

A drop of ink has fallen upon the paper and I have walled it round. Now every point of the area within the walls is either black or white; and no point is both black and white. That is plain. The black is, however, all in one spot or blot; it is within bounds. There is a line of demarcation between the black and the white. Now I ask about the points of this line, are they black or white? Why one more than the other? Are they (*A*) both black and white or (*B*) neither black nor white? Why *A* more than *B*, or *B* more than *A*? (1933: §7)

This puzzle is basically about boundary-ownership, i.e., how to determine what owns a boundary that separates two things. This is what we called in the introduction the *belongingness puzzle*: Where does a boundary belong to? As we have said in Chapter Two, boundaries are ontological parasites –namely, they cannot exist unless something else exists. So, if a boundary exists, then it *must belong to something*. A boundary that separates a drop of black ink spread over a white paper should belong to somewhere. A similar example is the Equator: an equidistant boundary between the poles of the earth that divides it into two equal halves (i.e., the Northern and Southern Hemispheres). Like the paper, the surface of the earth is a continuous place divided into two parts by the Equator. There are no two boundaries in contact; just the equatorial line. Although we need to pass over the Equator when we move from one hemisphere to the other, we do not leave the earth’s surface because their hemispheres are continuous parts of it (the Equator line, as it were, is not a long and thin abyss between both hemispheres). Nonetheless, by walking along the Equatorial line (if it is possible), where are we really walking through? What does a boundary between two parts of an object belong to? We shall look at different possibilities.

What Does a Boundary Belong to?

Before addressing the *boundary belongingness*, we need to take the following metaphysical principles as true:

- (a) There are continuous regions of space occupied by physical objects.

same line connecting [*continuant*] the quantitative surface. [...] From this it further happens that in the same indivisible boundary of matter there would be, at the same, time two specific substantial forms with respect to something that is indivisible in extension” (1861: Disputation 40 Sect. V §58). The puzzle arises when there are two continuous parts of an object and each of them has its own boundary. If a boundary-line is a one-dimensional object that cannot be divided throughout its length into two lines, then how is it possible for two boundary-lines to be placed where only one line fits? This entails the oddity of two lines located where only one line can be located. So, maybe, it would be better to consider only one boundary between the two coloured halves of the surface. Nonetheless, we will have Pierce’s version of Suárez’s puzzle: “Suppose a surface to be part red and part blue; so, that every point on it is either red or blue, and, of course, no part can be both red and blue. What, then, is the colour of the boundary line between the red and the blue?” (1892: 545). Pierce’s answer is that from “the parts of the surface in the immediate neighbourhood of any ordinary point upon a curved boundary are half of them red and half blue, it follows that the boundary is half red and half blue” (1892: 545). However, this solution entails a similar problem regarding Suarez’s puzzle. No two boundary-lines can occupy a single one-dimensional place. A line is a one-dimensional boundary that can be divided into two equal segments: one blue and the other red. However, it is not possible for a boundary-line throughout its total length to be half blue and half red. If so, the line would not be a one-dimensional object, viz., the line is not a line, which is absurd. Maybe the line is both blue and red at the same time, but that entails something having two contradictory properties at once. Intuitively, this option does not seem more attractive than the others neither.

- (b) If a physical object has parts, each of them occupies a sub-region of the region occupied by it.
- (c) Boundaries separate the sub-regions that a region of space has.

Principles (a) and (b) claim that for a physical object O having its parts x and y , there is a region of space R occupied by O and two R 's sub-regions R_x and R_y exactly occupied by x and y respectively. Regarding (c), it entails that there exists a boundary β demarcating where x and y overlap that separates O_1 and O_2 . Given (a), β does not interrupt R 's continuity and, therefore, x and y are continuous parts O . By accepting (a)-(c) we thus have a complete picture: boundaries separate two objects that occupy two continuous regions of space that compose the larger region of space occupied by the sum of the two. The main question is about the belongingness of those boundaries. I will take Weber & Cotnoir's (2015) terminology of the possible views to answer it (the *classical*, *glutty*, *gappy*, and *coincidence* views) applied to the boundary that separates Tail and Tailless in Cat.³⁶

(i) *The Classical View*

The boundary must belong to either Tail or Tailless, but not both. A boundary belongs to an object x but not to y or x 's complement; more precisely, y does not have a boundary where x and y are connected insofar as y is externally bounded by x 's boundary. This is the standard topological distinction between 'closed' and 'open' objects, i.e., an object that contains a boundary among members of the set of parts it is composed of and an object that does not, respectively. A connected region of space is occupied by Cat where Tail and Tailless occupy a sub-region each and therefore both Tail and Tailless are two continuous parts of Cat (i.e., going from Tail to Tailless by passing through the boundary that separates them does not entail to leave the region of space occupied by Cat). As fig. 4.4 depicts, the boundary that separates Tail and Tailless only belongs to Tail, while Tailless is the Tail's complement being closed by Tail's boundary. This can be put as follows: Tail occupies a closed region of space that contains its boundary as a part of it, while Tailless occupies an open region of space where its boundary is completed by the boundary of the region of space occupied by Tail.



Fig. 3.4 Cat according to the *Classical View*

³⁶ These views are formulated first by Varzi (2015). They can also be found in Hudson (2005, 72-73).

This distinction stems from Bernard Bolzano's *Paradoxes of the Infinite* (1851).³⁷ From a topological account, some philosophers have adopted Bolzano's intuition of closed objects and open objects. For instance, Cartwright says: "[...] a region, spherical or otherwise, is said to be *open* just in case none of its boundary points is a member of it and *closed* just in case all of its boundary points are members of it" (1975: 154). Forrest also assumes a realism of regions as sets of points in a metric space where: "[...] the *boundary* of a set X may be explicated as the intersection of the closure of the complement of X. It then follows that the closure of a set is the union of the set and its boundary. [...] Closed sets are then just those which contain their boundaries and open sets just those which are disjoint from their boundaries" (1996: 40). In this case, the boundary of a physical object is simply understood as the set of boundary-points, i.e., the collection of points of the region of space occupied by that physical object which are in contact with the region's surroundings. So, while a closed object occupies a region of space whose set of points that compose it contains boundary-points, an open object occupies a region of space that does not. Hence, "[...] the only kind of material objects that would lack a boundary would be a material object with no boundary points at all (Hudson 2005: 69). Regarding this topological distinction, Casati and Varzi³⁸ also write:

When two entities are externally connected, they share a boundary; but this sharing is uneven. The boundary only belongs to one object, and bounds the other *from the outside*. (More precisely, the sharing may be even, in that each of two externally connected objects may include half of the common boundary. But no part of the boundary can be a boundary part of both objects: where the boundary belongs to one, the other is bound from the outside.) (1999: 86)

As we know, to say that a book and a table are in contact through their surfaces (or parts of them) is a loose way of talking about boundaries and contact. According to the *Classic View*, contact must be a topological relation of two objects where one of them has a boundary that encloses the openness of its complement. As Casati and Varzi comment: "[...] [M]aterial bodies such as tables or stones are naturally regarded as the owners of their boundaries (their surfaces). Thus, where the complement meets an object of this sort, *it* will be open. (The object, in turn, will be the closed complement of the complement)" (1999:

³⁷ Regarding the question 'Where does one body end and another begin?', Bolzano's answer is as follows: "I define the *limiting surface* of a body as the aggregate of all the *extreme* ether-atoms which still *belong to it*. [...] [M]any bodies are at certain places altogether devoid of limiting atoms; none of their atoms can be described as the *extreme* ones among those which still belong to it and would accompany it if it started to move. Whenever, in fact, we have two neighbouring bodies, and a place where one of them possesses an extreme atom ready to accompany it, the other of the two is for this very reason unable to possess an extreme atom" (1851: §66). Basically, Bolzano seems to suggest that when two bodies are in contact (i.e., when there is no other body between them), some atoms (specifically, what he calls 'limiting atoms' or those atoms in the extremity of an object) belong to only one of the two bodies while the other body does not possess any of those atoms. In other words, one of the bodies has a boundary among its parts while the other do not; contact then occurs when a body is closed and the other is open and externally bound by its neighbour's boundary.

³⁸ Varzi has fruitfully worked on the topological account of boundaries, see Varzi (1996, 1997) and Casati & Varzi (2000). See Adams (1986) for a topological analysis of surfaces as boundary of three-dimensional physical objects and so the space where they move. Finally, see Zimmerman (1996) for a historical approach to topology and the distinction between open and closed objects.

90).³⁹ Two objects are thus topologically connected⁴⁰ only if there is one object having a boundary and another object bounded by it. Cat is therefore separated into two continuous parts only if the boundary between Tail and Tailless belongs exclusively to one them.

(ii) *The Glutty View*

The boundary belongs to both Tail and Tailless. There is no distinction between closed objects and open objects. As Fig. 4.5 depicts, there is one shared boundary between them. Strictly speaking, the *Glutty* view is a case of overlapping between two objects through a common boundary.



Fig. 3.5 Cat according to the *Glutty View*

We can again look to Aristotle’s *Metaphysics* (1984a: V 1022a4-5) as a sort of *Glutty View* where the same boundary is both the first point from which an object can be found and the first point from which nothing of it can be found. This view seems to entail a paradox situation for a boundary that separates an isolated object from its spatial surroundings, viz., a boundary is a shared point where something is found and not found simultaneously. According to this view, if an object occupies the whole of a region of space and no parts of its surroundings (if it is isolated) are occupied by anything, then, on the *Glutty View*, the object’s boundary is both occupied and not occupied. Perhaps the *Classical View* looks more reasonable insofar as the object is a closed object while the parts of its surroundings are open.

Regarding a boundary that separates two parts of an object, the *Glutty View* entails overlapping as the fundamental mereological relation between two objects composing another object by sharing parts. Cartwright takes the contact between two objects is explained in terms of the overlapping of parts of their boundaries: “[a] body *x* touches body *y* when and only when at least one boundary point of the region occupied by *x* is also a boundary point of the region occupied by *y*” (1975: 154). Thus, two things are in contact only if there is some shared boundary-point between the region of physical space occupied by each of them. Heller seems to argue likewise when he says: “My living room and my dining room share a common wall. But this does not entail that there is a wall-shaped region of space occupied by both my living room

³⁹ Immaterial bodies such as holes might be considered as open entities or objects that lack of their boundaries. Like boundaries, holes seem to be entities which are located somewhere as dependent entities of their hosts. For example, the hole of a doughnut cannot exist unless the doughnut exists. The hole exists as the doughnut’s complement where it is externally bound by the boundaries at the doughnut’s centre. As Varzi says: “[H]oles are not the owners of their boundaries; these belong to the material bodies that host the holes. Thus, where the two meet, the complement (host) is closed and the entity (hole) open” (1997: 44).

⁴⁰ See Casati and Varzi (2000) for more details about topological connectedness.

and dining room. That region is occupied by the wall that is part of both rooms” (2008: 14). The wall is a boundary between the living room and the dining room and it is a common part between both rooms. Regarding the temporal boundary between a moving object that comes to rest, Aristotle wrote in his *Physics* that “the same thing can be at the same time at rest and in motion; for both the times have the same extremity, viz., the now” (1984b: V 3 234b4). According to this view, it can be said that between rest and motion there is a temporal boundary which is shared by both states: a common temporal boundary at the instant when an object ends moving and starts resting. One boundary (either spatial or temporal) can therefore be part of two objects or moments at the same time.

If the *Glutty View* is true, then someone is found in two places at the same time when we stand on a boundary (in the sense that we can be in both Europe and Britain). By walking along the Equator, we simultaneously walk on both earth’s hemispheres. And the same for Cat: petting the boundary between Tail and Tailless entails petting both Tail and Tailless at the same time.

(iii) *The Gappy View*

The boundary belongs to neither Tail nor Tailless. As 4.6 depicts, this entails that the boundary is a gap between both: an entity that is part of nothing. If we had to walk along the Equator, we would be neither in the southern hemisphere nor the northern hemisphere. In fact, we would be just in the Equator: somewhere between both hemispheres.



Fig. 4.6 Cat according to the *Glutty View*

We find this account in a Cartesian view about boundaries of material bodies (i.e., surfaces). According to it, places in space can be either internal or external: while an ‘internal place’ is where the matter that composes a body is found, an ‘external place’ is the boundary (or surface) immediately found in the surrounding of that body. By following Descartes’ explanations: “[S]urface’ here does not mean any part of the surrounding body but merely the boundary between the surrounding and the surrounded bodies. [...] Or rather what is meant is simply the common surface, which is not part of one body rather than the other but is always reckoned to be the same” (1985: 229). In his view, Descartes suggests that a boundary is part of neither objects nor objects’ surroundings. Boundaries and surfaces are then gaps between objects which remain unchanged despite the physical alterations of bodies.

Avrum Stroll (1979, 1988) attributes this *gappy* view to what he calls the *Leonardo Conception*. Leonardo da Vinci writes in his *Notebooks* that the boundary that separates the atmosphere from the water is an *interface* that lacks divisible bulk and, as he understands it, it is a sort of abstract object without taking physical space. Thus, according to the Leonardo Conception, a boundary that separates two different physical media (solid, gas, or liquid) is a non-physical object without taking part of either; so, if both media are really in contact, there cannot be some additional bulky object between them.⁴¹ Following da Vinci's view, unlike Tail and Tailless, the boundary between them is a gap without taking physical space. We can contend a similar thought about boundaries of temporal processes: "As the light comes on in a dark room, the room is apparently in some third state that is neither darkness nor nondarkness; and as I destroy a piece of paper it is apparently in a *limbo* between existence and nonexistence" (Hamblin 1969: 410).⁴² Hamblin describes the boundary between two events as a 'limbo', i.e., some kind of intermediate state between them. In the process of a dark room becoming an illuminated room, the boundary between both moments seems to be a temporal gap or a 'limbo' which is neither dark nor illuminated. If a temporal boundary is part of some event as a room being dark or a room being illuminated, it should be either at the end of the first, at the beginning of the second, or both at the same time. However, as a part of some event, that boundary should have some temporal duration. How long does that temporal boundary should last? Where does it belong to? The *Gappy View* says that the boundary has neither duration nor membership. Like boundaries in space which are extensionless, a boundary between temporal events is a gap in time without temporal extent. As Sorensen writes: "Consider 'present'. Since the present must contain neither parts of the past nor parts of the future, those who follow the path of precision should also conclude that the present is without duration. We are left to conclude that the present is a durationless boundary between the past and the future" (1986: 192). Boundaries take part of neither physical objects nor events since they are both extensionless and durationless entities; so, taking Casati and Varzi words, we may conclude that "[boundaries] have a peculiar relation to space: they are located in space, yet do not take up any space (just as temporal boundaries do not take any time)" (1999: 71).

(iv) *The Coincidence View*

There are two co-located boundaries between Tail and Tailless (one of each one). As Figure 4.7 represents, there is a part of Tail's boundary and a part of Tailless' boundary which spatially coincide at the same time; both boundaries occupy one single spot at once. That is, Tail and Tailless do not overlap, i.e., there is no one boundary shared by both, but one place in space shared by parts of their boundaries. Thus, for every two objects making contact, there are two different but coincident boundaries that separate both objects. All entities are closed; all of them have a closure as a boundary. Every material object and event have a boundary that demarcates its extension in space or its duration in time, respectively. By following this view, objects either in space or in time have a boundary as a matter of metaphysical necessity: something

⁴¹ For more details about the *Leonardo Conception* of boundaries see Chapter Two.

⁴² The emphasis is mine.

cannot exist in space or time unless it has a boundary (Smith: 1997). Although all entities are closed (i.e., they contain boundaries among their parts), the contact between two entities is still possible since their boundaries can spatially coincide.



Fig. 4.7 Cat according to the *Coincidence View*

This view is classically attributed to Franz Brentano. He claims that “the concept of a boundary and possibility of a coincidence of boundaries is essential to the concept of what a continuous is” (1988: 7-8). As we saw in detail in Chapter Two, the Brentano-Chisholm account is such that boundaries ontologically depend on objects of higher spatial dimensions, but they also are a *conditio sine qua non* for the spatial existence of the object they belong to. So, there is neither an isolated boundary nor a *continuum* without boundaries. This entails a rejection of Bolzano’s distinction between closed objects that contain their boundaries among their parts and open objects that do not (proposal that Brentano tagged as a ‘monstrous doctrine’ (1988, 146)). The idea that Tail and Tailless are in contact only if one of them gives up having a boundary looks arbitrary: Which one? Tail or Tailless? Brentano instead thinks of the possibility of coinciding boundaries that needs neither arbitrary decisions, nor spatial gaps, nor shared boundaries. 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” (1988: 41). Thus, Tail and Tailless are in contact when two different boundaries coincide in space. As 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. (1988: 11)

Strictly speaking, there are four coinciding points in the middle of a surface divided into four coloured quadrants: one of each colour. Think of a less complicated example as the boundary-point where two segments of a line—one red and another green—meet. In this case, Barry Smith explains 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*” (1988/89: 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.

The *Coincidence View* is closely related to the principle that everything that exists having spatial dimensions must have a boundary. This view says that when two objects are in contact, none of them lose their boundaries; so, if the region of space they occupy are continuous or topologically connected, there must be two coinciding boundaries. Inspired by Brentano's ideas, Chisholm has adopted the account of spatial coinciding boundaries in different writings (1983, 1989, 1993, 1996). 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" (1996: 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.

Chisholm has also treated with coinciding boundaries in time (1983, 1996, Chapter 10, 2008). In his paper 'Beginning and Endings' (2008), Chisholm takes Brentano's conception of boundaries of temporal processes. Regarding the *plerosis*⁴³ or orientation of boundaries, a boundary within a temporal *continuum* may have one direction as the starting point of an event or another direction ending point as the ending point of an event; or maybe a temporal boundary may have two orientations if it is an ending point and a starting point at the same time. This last case applies when a boundary is between two different events which are continuous in time. For instance, death. To die entails that someone is alive at some time and passes away at the following time. According to *Coincidence View*, there are two temporal boundaries at one instant or a single instant as a boundary having two opposite orientations within someone's life: one toward the event of being alive and other toward the event of being dead. This boundary therefore is that ending point when life ceases and that starting point when dead begins. Assuming Chisholm's explanation about something that begins to move after being in rest (2008), the moment when someone 'finishes being alive' and 'begins to be dead' is the same boundary but "twofold (*zweiteilig*) with respect to its plerosis" (2008: 115): the boundary is in half plerosis in being alive and in half plerosis in being dead. Thus, a temporal boundary separating two continuous events is two moments at a single time: the last moment of one event and the first moment of the other. As Chisholm writes about a puzzle raised by Suarez (1861: Disputation 50 Sect. II §10-16): 'If a thing ceases to be, then either there is a last moment of its existence or there is a first moment of its nonexistence, but there cannot be both. Which, then, is there?' Brentano is able to say that there is *both*

⁴³ See Chapter Two for a detailed explanation of the Brentanian concept of *plerosis* and the Brentano-Chisholm account on boundaries.

a last moment of existence and a first moment of nonexistence; they are one and the same” (2008, 120-121). Thus, two boundaries are able to share both the same location at once in space or the same moment in time. According to this view, Tail’s boundary and Tailless’ boundary then seems to violate Locke’s principle of only one thing at once.

Advantages of the *Coincidence View*

These three statements (i) the existence of boundaries, (ii), the possibility of contact, and (iii) the continuity of space, as we know, are not compatible at all unless it is determined the specific conditions of how contact between objects’ boundaries does not entail some discontinuity in space. However, to determine how boundaries make contact keeping the continuity of space involves the resignation to some ontological principles about boundaries.

First, the *Classical View* gives up the principle that every spatial object has a boundary. If two things are in real contact, then the regions of space occupied by them cannot be disconnected. So, for every two objects making contact, there is one closed object having a boundary all the way around, while there is another open object that does not and is externally bounded by the closed object. Second, the *Gappy View* must give up the principle (inspired by the Brentano-Chisholm account) that boundaries can only exist as constituents of spatial objects of higher dimensions. The *Gappy View* settles the spatial continuity of two objects in contact by taking boundaries as a sort of non-physical things that are parts of nothing. Since boundaries do not take any physical space (or time), they do not make space a discontinuous place when two objects in space are in contact. Third, the *Glutty View* must give up the principle that boundaries belong to an object exclusively. In this case, space is kept continuous by accepting that one boundary may belong to more than one spatial object; so, the contact between two objects occurs when they overlap through a shared boundary. Fourth, the *Coincidence View* must give up not a metaphysical principle about boundaries themselves, but the general principle that no two objects can occupy the same place at the same time. The continuity of space is settled by making sense of the idea that two boundaries can be spatially co-located. Since two boundaries are superimposed when two objects are in contact, there are no spatial gaps between those objects.

Which one of these principles is the most convenient (or ontologically least harmful) to abandon? The *Classical View* is an arbitrary option between one closed object that has a boundary among its constituents and another open object that does not. Is there however a clear criterion among two objects in contact to decide which one of them would have a boundary and which one would not? Maybe between Tail and Tailless is more less clear that Tailless deserves the boundary more than Tail insofar as Cat can exist without Tail; so, Tail should be considered as a complement of Tailless. But, if we shake our hands and our skins are in contact, how do we decide who is going to keep the boundary between our hands? Who is going to be the complement of the other? This seems to be an awkward question. As Casati and Varzi ask: “What

grounds are there to classify one object as closed and the other as open (in the relevant contact area)? More generally, what grounds are there to distinguish between closed and open entities in the first place?” (1999, 86). Weber and Cotnoir (2015) call the following principle the *Symmetry Principle*: if there is no difference between two objects, then there is no difference regarding their boundaries either. This principle allows that given two equal objects, their boundaries should be equal too. On the other hand, a space is topologically disconnected or discontinuous if there is an exhaustive division between two closed regions of space. To keep the space connected when two objects are in contact, the classical view allows one object to have its boundary while the other lacks one; but such as dissimilarity violates the principle of symmetry. To save the continuity of space, the *Classical View* draws upon to an arbitrary distinction in which there is no clear justification why an object keeps its boundary and other does not at the contact time. It may be a case of indeterminacy in which there is no need of that clear distinction, but we would need a clear reason why we should accept that sort of indeterminacy regarding boundary belongingness.

Although it might be unfair, the *Glutty View* can be considered arbitrary too. The border between Mexico and the United States is shared by *both* countries; hence, there is no arbitrariness: the border is *one* common boundary that belongs to both Mexico and the United States equally. However, what if we split or physically divide Mexico and the United States exactly through the border between them? Since both countries share *one* common boundary before the splitting process, one of them should maintain the border as part of itself after the separation while the other would become boundaryless. What country should however claim the right over the boundary? Mexico or the United States? This question begs an arbitrary answer again. Perhaps, while the cutting process between two objects is happening, the object that gives up the common boundary between them progressively acquires a new boundary. However, there is still some degree of arbitrariness in clearing up why one of the objects undergoes a topological transformation rather than the other.⁴⁴

The *Glutty View* gives up a relevant ontological feature of boundaries. The mutual ontological dependence between boundaries and physical objects is such that whereas a boundary exists only if the very spatial objects it belongs exists, an object exist in physical space only if it has a boundary. This ontological relation entails that a physical object depends on having *some* boundary but not a specific one, while a

⁴⁴ According to Casati and Varzi, in the gradual dissection of a solid sphere made of a compact and homogenous material, we have the following topological process: “[T]he cutting of an object is no bloodstained process –there is no question of which of the two severed halves keeps the boundary, leaving the other open and bleeding (as t were). Rather, topologically the explanation is simply that the outer surface of the sphere is progressively deformed until the sphere separates into two halves. To put it differently, the cutting does not ‘bring to light’ new surfaces that were trapped inside the sphere. Rather, the model is that of a splitting oil drop. The drop grows longer and, as it grows, the middle part shrinks and gets thinner and thinner. Eventually the right and left portions split, and we have two drops, *each with its own complete boundary*” (1999: 87). In this case, arbitrariness appears when two parts are in contact through a boundary that only belongs to one of them. However, arbitrariness is not found when an object is gradually dissected into two halves. In the precise time that the dissection starts, a topological change occurs where both parts begin to have their own boundaries until the dissection finishes. There cannot be an open object without being complemented by a closed object (in the relevant area of the contact) since there cannot be a spatial isolated object without having a boundary. However, if two halves of an object are in contact when one of them lacks a boundary, how does a second boundary pop up when both parts are dissected? In some way, the cutting does ‘bring to light’ a new boundary between both parts that it did not exist before the cutting. This is still a topological mystery that needs either to be revealed or to be explained why it is not a mystery at all.

boundary depends *exclusively* on the physical object it belongs to.⁴⁵ Following the *Glutty View* of contact, boundaries are shared entities by objects and, therefore, a boundary may not belong to an object exclusively. However, giving up this *exclusiveness* would contradict a fundamental ontological condition of a boundary: a boundary is destroyed when the very object it belongs is destroyed. This resignation to the exclusiveness comes from this ontological ambiguity in which a boundary may belong to more than one object simultaneously. This ambiguity becomes more problematic in the arbitrary process of cutting an object into two parts throughout a boundary: if a boundary does not belong to an object exclusively, then to attribute the boundary to only one part after the cut would be capricious.

The *Gappy View* is also problematic, even more than the other views. Since the *Gappy View* contends that the boundary between two objects (or parts of an object) belongs to neither, this view gives up the fundamental ontological nature of boundaries as dependent entities. If the existence of a boundary depends upon the existence of something else, then it cannot be the case that a boundary is the boundary of nothing. So, the boundary between two objects must depend at least on something different to itself. Moreover, Weber and Cotnoir (2015) find an inconsistency with the *Gappy View*. If the boundary between Tail and Tailless is part of neither, then that boundary is ‘something’ distinct between both Tail and Tailless. We then have three different and independent entities: Tail, Tailless, and the boundary between both (call it Limit). In that case, there should be a boundary separating Tail from Limit (the same between Tailless and Limit). However, that boundary between Tail and Limit is a new independent entity (called Limit₁); but, again, there should be a boundary between Tail and Limit₁ called Limit₂ and so on *ad infinitum*. Thus, between Tail and Tailless there would be infinite boundaries.

The *Coincidence View* has the advantage over the remainder views of avoiding both ontological problems and arbitrariness. Unlike the *Classical View*, the possibility of coincidence between the boundaries of two objects does not need to distinguish arbitrarily between open objects and closed objects. The *Coincidence View* only conceives closed spatial objects, i.e., objects having a location in space and containing a boundary among their components. From this ontological assumption, there is no need to give an answer to the odd question about boundary belongingness. Since each object has its own boundary, there are no worries about what object keeps the boundary and what object does not when they are in contact. The same kind of arbitrariness is found regarding the splitting process of an object into two parts throughout a boundary. The *Glutty View* has to deal with the question about what part will keep the boundary after the cutting process and what part will not, whereas the *Coincidence View* does need to take a decision about it. Given that the boundaries of two objects are in contact by occupying the same place at once, each object has its original boundary after the separation.

The *Coincidence View* deals better with the ontological nature of boundaries. The fundamental ontological condition of a boundary is such that its existence *rigidly* depends upon the existence of something

⁴⁵ See Chapter Two for more details about this claim.

else, whereas the existence of a physical object *generically* depends upon the existence of a boundary. Thus, the idea of either spatial objects having no boundaries or boundaries not belonging to a particular object is ontologically conflictive. The *Coincidence View* entails that every object is closed by its own and exclusive boundary. However, the *Glutty View* says that two continuous parts of an object are separated by *one* common boundary. By making a cut throughout the boundary, it must belong to some of the parts while the other part would remain boundaryless. The *Coincidence View* does not have to deal with this arbitrary and conflictive issue. When two objects are separated into two objects both objects keep their original boundaries after the splitting process because the boundaries just stop sharing a place simultaneously. Furthermore, unlike the *Gappy View*, the *Coincidence View* does not entail the problematic thesis of boundaries as gaps between objects and its regress *ad infinitum*: coincident boundaries entails that boundaries always belong to their object exclusively, so there is no need of infinite additional boundaries between an object and a boundary. Despite the advantages of the *Coincident View*, it must face another controversial issue (maybe more controversial than the other views): Is it metaphysically consistent the idea that two boundaries of material things can be located in one place at the same time? This question will be nonetheless addressed in the next chapter.

Final Remarks

Boundaries and contact are two concepts that suggest a natural relationship: material objects can make contact with each other and their boundaries are where contact specifically occurs. This chapter discussed two accounts of the contact between boundaries of material objects and their implications to the conception of what space is, *viz.*, *substantivalism* and *relationalism*. However, from quantum physics, saying that things make contact through their boundaries is a loose way of talking about mid-sized objects such as tables, chairs, snooker balls, or planets. In microphysical facts, things never touch one another because the particles that compose them repel each other due to their electromagnetic charge: objects can be very close to each other, but never in real or absolute contact.

On the other hand, the idea of contact not only is problematic according to physics but also according to a topological conception of space as a continuous or connected place where no gaps can be found. If boundaries are entities which could entail a discontinuity of some kind in space, then when two objects or parts of objects are in contact, the space they occupy is cut in discontinuous parts by gaps between them. If we do not want to rule out the existence of boundaries then we need to explain contact in which the continuity of space remains intact. We explained four different views that could settle the incompatibility between boundaries and a continuous space. Each of these views either gives up some relevant characteristics of boundaries or entails some arbitrariness. The *Coincident View* has fewer consequences in both aspects but entails the controversial claim that two physical objects could occupy the same place at once. Is this metaphysically more desirable than the existence of boundaries and the possibility of contact? This is an open question.

CHAPTER FOUR

Material Coincidence and Change Over Time

How do Boundaries Fit There?

Introduction

We left an open question in the previous chapter whether two boundaries can be co-located, i.e., whether it is possible for them to be in the same place at the same time. This chapter will address this topic: if two distinct physical objects can be exactly made of the same parts, then they would have the same boundary. However, if two objects are distinct, then they must differ in some properties (otherwise, how can we say that they are not identical?). Two co-located material objects occupy the same region of space by being made of the same matter at that time and, therefore, having the same physical properties (e.g., colours, textures, sounds) and causal powers (e.g., light reflection or corrosion) which, most of them, are shown by the same boundary or surface. Nonetheless, they must differ in other kinds of properties (we can say metaphysical properties) which are not physically perceptible. Traditional supporters of co-location argue that materially coinciding objects differ in their persistence conditions and modal properties. Although they can occupy the same space at once, they differ in both what changes they can survive and what worlds they exist.

Persistence plays a relevant role in how co-location is possible. On this respect, co-location has two solutions given by opposite philosophical theories of persistence: *endurantism* and *perdurantism*. The former contends that tables, chairs, or people as physical objects have *all* their parts at every time they exist, whereas the latter contends that those objects are four-dimensional entities made of temporal parts and so they never *wholly* exist at every time. These two views have different metaphysical implications for what is meant to be the boundaries of those objects conceived by what we call in Chapter One the *Ordinary Conception of the World*.

This chapter then has three sections. Section A explains the idea of co-location in terms of two spatially coinciding objects sharing the same boundary for a period of time. Section B addresses the discussion between *endurantism* and *perdurantism* and their solutions to co-location and how the picture of what boundaries are changes with both theories. Section C presents two arguments against *perdurantism* regarding problematic consequences about boundaries: four-dimensional objects would have their boundaries essentially and the resemblance between spatial and temporal boundaries.

A. Material Coincidence: Two Distinct Objects Having One Boundary

Co-location is basically the idea that two different material objects can share the same place at the same time. However, co-location seems to disturb a strongly embedded common-sense belief that, for instance, the place where the earth exactly is in space now cannot be occupied by something else. Compact and solid material objects cannot *pass through their boundaries*: co-location is strongly resisted in surfaces as the boundaries or the stopping place of material objects. Unless you are a bodiless object such as souls or ghosts, if you try to cross a wall by *passing through* it, you will probably hit your head against the wall. This painful (and embarrassing) situation happens when parts of your boundary and parts of the wall's boundary (i.e., parts of your skin and the wall's surface) meet or violently crush. As we saw in Chapter One, this is the feature of bodies that Locke called *impenetrability*: material objects fill space by excluding each other. Everyday boundaries make material objects impenetrable things; so, two of them in the same place at the same time looks as mere metaphysical tales. We can then put the idea of materially coinciding objects as it can be understood according to common-sense beliefs:

For an object x composed of the w s and an object y composed of the z s, x and y materially coincide –i.e., they occupy one region of space R at a time t – if and only if both the w s and the z s can be exactly found within R at t –i.e., both the w s and the z s share the same spatial boundary (R 's boundary) at t .

Common-sense rejects this kind of coincidence and that is why we do not normally try to pass through the surfaces of walls: the parts composing you and the parts composing the wall cannot be simultaneously located in the same place at once; and the boundaries of both you and the wall are the first stopping place. However, metaphysicians are not talking about material coincidence or co-location⁴⁶ in terms of the penetration of objects' boundaries. Spatial co-location –that one that attracts metaphysical interest– is not the common-sense belief explained above. What is philosophically relevant is that two numerically and qualitatively distinct object can be *composed of the same parts and have the same boundary (surface) at a given moment in time*.

Sharing Boundaries in Space

The co-location that interests metaphysicians is the following thesis: for two numerically distinct material objects x and y , it is possible for x and y to be made of the same physical stuff and have the same boundary and yet differ qualitatively. Co-location is thus based on two different statements: first, the same portion of matter can compose two different objects; second, two spatially coinciding objects can have different properties. This is the traditional case of the statue made of clay where both the statue and the piece of clay are made of the same physical stuff but differ in their modal and temporal properties. Spatial

⁴⁶ I will use now co-location and coincidence interchangeably.

colocation can be put in terms of whole-part relation: “two physical objects could be composed of exactly the same parts at some level of decomposition” (Merricks 2001: 38). That is, co-location arises at a fundamental level in which two distinct objects can be exactly made up of the same atoms. Even though a statue and the clay it is made of could differ in some non-fundamental parts such as heads, legs, or hands, there is a *bottom level* in which both objects have exactly the same atomic configuration (that’s precisely why the statue and the clay are said to be coinciding objects). We can say that while heads, legs, or hands are non-fundamental parts that can compose a statue of Achilles (and other man-shaped statues) made of clay, but the clay itself (and chunks of clays in general) has no parts such as heads, legs, or hands as Achilles has. So, although the statue of Achilles and the clay it is made of may differ in how we think of non-fundamental parts of statues and pieces of clay, Achilles and the clay both are exactly made of the *same* sub-atomic parts. Co-location therefore entails that the statue of Achilles and the clay it is made of are qualitatively distinct object located in the same place at once. That is, there is *one* region of space exactly filled by matter but two non-identical objects –Achilles and the piece of clay– occupying that region and, thereby, co-location occurs when “the whole of one object wholly occupies the place wholly and simultaneously occupied by the whole of another” (Burke 1994: 591). We can thus put co-location in the following way as regards metaphysical interest:

For every x, y , and ws , (i) the ws exactly fill a region of space R at some given time t (ii) each of the ws is a part of both x and y and, therefore, (iii) x and y share the same spatial boundaries (viz., R ’s boundary) at t , and (iv) x and y are qualitatively distinct objects.

Co-location can be then understood as two physical objects made of the *same* matter and having the *same* boundary (or surface) but differing in some non-physical properties. How can two different physical objects have the same boundary? In Chapter Two, we stated that the boundary of a physical object ontologically depends upon the very object it belongs to. However, if co-location is metaphysically possible and, therefore, two distinct physical objects can be composed of the same parts, then they also can have the same boundary. That is, the region of space where many objects compose O at some given time t is the same region of space of a different object O^* having the same parts of O and, thereby, β is a boundary for both O and O^* simultaneously. Thus, a boundary would not be exclusively the boundary of the very object it belongs to.

Following Olson’s words, “materially coinciding objects are made up entirely of exactly similar particles, related precisely the same way, in identical surroundings” (2001: 339). Objects’ surroundings are found in objects’ boundaries. As we said in Chapter Three, boundaries are characterized by being between things in different ways. The boundary of a physical object separates all the matter that composes that object from the spatial environment where that object is physically located. Although two duplicate objects might be composed of the same kind of matter (e.g., two white billiard balls), we cannot make the same description of their surfaces because they do not have the same spatial environment given the different physical location

of the objects they belong to. For two qualitatively distinct objects, the only way to have strictly the very same boundary (or for a boundary belongs to two different objects simultaneously) is to be both composed of the very same parts. So, co-location involves two material objects with identical spatial surroundings. For two coinciding spatially objects, both have only *one* boundary (or surface) that separates the very same parts they are composed of from the very same spatial environment.

Someone might object that to talk about boundaries of ordinary physical objects does not make sense. Matter composes things such as tables or trees, but there is nothing such as the boundaries of those things because surfaces are non-physical things without divisible bulk.⁴⁷ Instead of surfaces or let's say *everyday boundaries*, we can still put co-location but in terms of *spatial boundaries* or the boundaries of regions of space: two objects materially coincide if and only if there is boundary enclosing a particular region of space where both objects are exactly located. This can be put as follows:

(Principle of Co-location) Given a spatial boundary β , the zs , and two distinct objects x and y , β is the sum of points that encloses a spatial region where each of the zs is located at a given time t and each of the zs is a part of x and a part of y at t .

We can also say that there exists a spatial boundary where –within the region of space it encloses– each of the zs is located at a given time at which x and y are composed of the zs and yet they qualitatively differ. That is, a statue and a piece of clay both can be spatially sharing the boundaries of a determined region of space at the same time. However, how can two numerically distinct objects have the very same parts and boundary and yet to differ in properties?

Same Boundaries but Different Properties

Coincident objects have the same boundary (thereby, same parts) but different properties. We can think of the border of a country. A country and the territory where it exists are different things but having the same boundary. For instance, the United Kingdom's border and the boundary of the territory where the United Kingdom is emplaced are identical: both entities (let's say UK and Territory) having the same parts and surroundings. However, while UK is a place in the earth defined in virtue of the concept of nation and its social, cultural, and political rules, Territory is a simple piece of land as a natural feature of the earth's geography. Although UK and Territory have the same location given their spatial parts, they differ for instance in intentional and temporal properties: UK exists as a result of human conventions and decisions, but Territory does not; UK was founded at some time in human history, but Territory existed before UK. Therefore, UK and Territory have the same boundary given that they share all their spatial parts and surroundings but differ in some non-physical properties.

⁴⁷ This is, for instance, the *Leonardo Conception* of surfaces seen in Chapter Two.

Just like the borders of countries and their territories, the co-location puzzle is about material objects and their surfaces. Colocation occurs when material things as statues and lumps, following Wiggins' words, "have to *compete for room* in the world [...] and they must tend to *displace* one another" (1968: 94) because "there just is not enough room for them" (Heller 2008: 14). In his *Essay*, Locke contends that "we never finding, nor conceiving it possible, that two things of the same kind should exist in the same place at the same time" (2008: II, xxvii, §1). The world then has not enough room for two things of the same kind in one place at once. Wiggins (1968) takes Look's constraint that colocation is not possible for things of the *same kind*, but not for things of *different kinds*, i.e., things which satisfy different sortals.⁴⁸ What is it for objects to satisfy different sorts? Coinciding objects are made of the same matter and share some *perceptible properties* which are in principle discovered by simple observation at the time of coincidence (such as size, shape, colour, or weight), while they differ in some properties which are not clearly perceptible in that sense (Lowe 2002: Chap. IV). *Modal, temporal, and persistence* properties⁴⁹ are often taken to be the non-perceptible properties that make material objects to fall in different sorts. Bennett (2004) calls *non-sortalish properties* the perceptible properties, while *sortalish properties* the non-perceptible properties. These sortalish properties make it possible for two different objects to differ in properties without competing for the same room in the world: they can be made of the same physical stuff and share some perceptible properties and yet differ in their non-perceptible properties.

Burke (1992) calls the view above the 'standard account'. Philosophers who endorse it often reject the identity of two coinciding material objects by appealing to the *constitution relation* between them: when two objects coincide in physical space, there is one of them that *constitutes* the other. The constitution relation between two coinciding objects is *asymmetric* and *irreflexive*: they cannot constitute each other and none of them constitutes itself.⁵⁰ Given the different sortalish properties between two constitutionally related objects and the application of the Leibniz's Law (or LL) in which necessarily, for every x and every y , x and y are identical only if every property of x is also a property of y (and vice versa), *viz.*, $\Box \forall x \forall y [x=y \rightarrow \forall F (Fx \leftrightarrow Fy)]$, a statue and the lump that constitutes it are two spatially coinciding objects. As Olson (2001) mentions it, although constitutionalists do not often explain what a constitution relation is, they seem to agree what constitutes what in some cases: persons are constituted by bodies, statues are constituted by lumps, or cardigans are constituted by threads (and not *vice versa*). There are several puzzles about material objects such as the Ship of Theseus, Dion and Theon⁵¹ or Tibbles the Cat (the body-minus problem),

⁴⁸ Some philosophers believe that it is possible for two things of the same kind being temporally composed of the same matter. See, for instance, Simons (1985) and Shorter (1977).

⁴⁹ The *modal, temporal, and persistence* properties of a physical object O can be explained as follow: (i) O is such that it could have existed otherwise as it in fact does now (e.g., a table could have existed without being brown); O is such that it lasts some period of time (i.e., a table comes into existence at some time and goes out of existence at another); and O is such that it can survive changes throughout the time it lasts (e.g., a table can survive the loss of one of its legs).

⁵⁰ Those who endorse a constitution relation between coinciding objects are Wiggins (1967), Lowe (1983), Doepke (1997; 1986), and Thomasson (2007). Philosophers however disagree whether constitution entails identity, i.e., whether an object and another object constituted by it can be discernible (let's say whether a clay and the statue constituted by it are qualitatively distinguishable). For this discussion see, for instance, Noonan (1993), Johnston (1997), and Rudder (1997).

⁵¹ For an explanation of this puzzle and its possible solutions see Burke (1994).

Paradox of increase (the Debtor's Paradox),⁵² or the Statue and the Clay which all are instances of the problem of material constitution⁵³ (Rea 1995), i.e., the different ways that composite things and their parts can be materially related to each other. I will just focus on one of these puzzles to refer to the co-location problem: the statue and the clay.

David and Clay, but Just One Surface

Consider the following story. A shapeless piece of clay is on your table and someone challenges you to make a statue with it. Confident in your craft skills, you take the clay (call it Clay) at some given time t_1 to make with it some statue. Hours later, your artwork is finally done at time t_2 : a stunning human-shaped statue appears on your table (call it David). So, you have won the challenge. Several versions of this story have been used to support that two numerically and qualitatively distinct objects can be composed of the same parts (and so having the same boundary) at the same time. Basically, the argument is as follows:

- (i) Clay exists at t_1 and *can survive* being squashed until getting the David-shape at t_2 .
- (ii) David comes into existence at t_2 but, unlike Clay, *cannot survive* being squashed.
- (iii) Given (i) and (ii), Clay and David are not identical despite being made of the same stuff at t_2 .
- (iv) Hence, Clay and David are two materially coinciding objects at t_2 .

This argument follows the *co-location principle*, i.e., there exists a spatial boundary enclosing a region of space where two qualitatively distinct things are located (sharing all their parts) at a given time. As we will see later, some philosopher explains co-location in terms of constitution: if Clay and David are wholly located in the same region of space at t_2 , then Clay constitutes David at t_2 and both share the same parts and boundaries. As Hawley explains it: "Constitution theorists are endurance theorists who believe that there can be more than one object exactly occupying a spatial region at a certain moment, that *there can be objects that have the same boundaries at the same time and yet are distinct*" (2001: 146). Clay and David differ in temporality, modality, and persistent conditions. First, David's career starts at t_2 and finishes when it loses its human shape, but Clay exists at both t_1 and t_2 and still can exist after David loses its human shape. Second, Clay could survive being shaped into any other non-David form, but David could not. Third, Clay can survive any change of shape at any time, but David cannot.⁵⁴ Even though Clay and David may differ in their sortalish properties, they are made of the *same* material and have the *same* boundary (and surroundings) at least during t_2 .

⁵² For an explanation of this paradox and its possible solutions see Olson (2008).

⁵³ For an explanation of each of these puzzles and a general treatment of the problem of material constitution see Wasserman (2017).

⁵⁴ This argument is based on some kind of essentialism: while Clay is not essentially a statue, David is essentially a statue. If Clay and David do not fall essentially under the same sortal (to be essentially some F), then they cannot be identical; therefore, Clay and David are distinct spatially coinciding objects. This argument is defended by Rudder (1997).

Everyday boundaries (surfaces) play a relevant role in the metaphysical consideration of spatially coincident objects. Coinciding objects have the same *basic physical profile* (Levey 1997): they have the same particles, electric charge, mass, shape, colours, perceptual features, and take up the same amount of space, and so on. Physical profiles, in that sense, can be mostly determined by the boundaries of material objects. As Doepke puts it:

Why, just because *a* and *b* are in the same place (at time *t*), should they *also* be of the same weight, smell, and taste? Let us take note of the following facts: the place, shape and (spatial) size of an object are *determined by the places of its outermost parts*; the weight of an object is a function of the weights of its parts; its taste is determined by how certain of its parts affect our gustatory senses; the colour and smell of an object are determined by the qualities and interrelations of certain of its outermost parts. (1997: 15)⁵⁵

Following this passage, many of the (non-sortalish) physical features that we attribute to coinciding objects are determined by the collection of the shared outermost parts that make up the objects' surfaces. Let's see some examples. First, material objects have properties according to colours, textures, flavours, and sounds they may produce and most of them can be perceived from their surfaces.⁵⁶ Given that Clay and David both have the same boundary, they have the *same* physical features which can be perceived from any surface through our senses. Second, the size and spatial extension of material objects can be related to objects' boundaries: size is measured by measuring the boundaries that a physical object has along the three spatial dimensions; likewise, the spatial extension of an object reaches a boundary as the stopping place all the way around of the portion of space occupied by that object. Given that Clay and David both have the same boundary, they have the same size and extension in physical space. Third, shapes –the external form, contours, or outline of an object– are given by object's boundaries. We identify the shape of ordinary material objects by following the form of their surfaces. Since Clay and David both have the same surface, they have the same shape. In this case, changes in shapes of boundaries determine how Clay and Statue can differ in persistence condition. The change in shape of Clay by operating with our hands on its surface does not destroy Clay itself; by contrast, David can be destroyed by squeezing David's surface until David's shape is gone. Therefore, there are non-sortalish features occurring in the boundary shared by two spatially coinciding objects, but also changes of shape –observed in objects' boundaries– can determine those objects to fall in different sorts.

Although materially coinciding objects having same parts and boundaries looks quite strange for common-sense beliefs, it is quite reasonable for some metaphysicians. However, some philosophers (e.g., Olson 2001; Burke 1992) reject it because they consider too mysterious how two objects having the *same parts and the same boundary* can yet differ in some properties. The dispute is not resolved yet, but other

⁵⁵ The emphasis is mine.

⁵⁶ See Chapter Two for more details about this topic.

philosophers have adopted a sophisticated solution to co-location that avoids the problems involved in objects sharing same parts and same boundaries: material objects, besides having spatial parts, they also have temporal parts.

B. Boundaries in Time: The Problem of Persistence

As we saw above, differences in persistence conditions are often evoked to explain how two materially coinciding objects are qualitatively distinct. Persistence necessarily entails commitments to both *time* and *identity*: what is meant for a very same object to last from one moment to another despite having different properties at each moment. Hirsh (1982) explains persistence as the qualitative makeup and spatial location that a material object undergoes over an extended period and how those alterations occur *continuously* (i.e., in small degrees). Despite locational, qualitative, or compositional changes, you, I, and the objects around can persist in space and time continuously. The world would be too chaotic to live otherwise. However, the steadiness of the continuous changes over time undergone by material objects seems to conflict with some metaphysical concerns. One concern is what Lewis called the problem of *temporary intrinsic properties*: “Persisting things change their intrinsic properties. For instance shape: when I sit, I have a bent shape; when I stand, I have a straightened shape. Both shapes are temporary intrinsic properties; I have them only some of the time. How is such change possible?” (1986: 203-204).⁵⁷ Lewis distinguishes between *intrinsic* and *extrinsic* properties: while for the former things have them *in virtue of the way they themselves are*, for the latter things have them *in virtue of their relations or lack of relations* to other things (Lewis 1986, 61). The problem of change is basically how a unique object can instantiate two intrinsic properties (i.e., properties possessed in virtue of the way the object itself is and not in relation to other things) which are incompatible.

The puzzle of change is such that a material object exhibits spatiotemporal and qualitative continuity across time, but some of its properties can be in flagrant conflict with each other. Although a material object can exist in several places at different times and have different properties at each of those times (and even some of them contradictory to each other), it is the very same object that can remain in physical existence without being destroyed or having gaps (i.e., without going out of existence for a while and coming into existence later again) despite all its possible spatiotemporal modifications and qualitative alterations. Following the way Hinchliff (2006) explains how a candle can be straight at some moment and bent at another, the problem of temporary intrinsic properties can be put in four main claims: (i) the candle persists through the change; (ii) shapes are properties, not relations; (iii) the candle itself has shapes; (iv) shapes are incompatible. The first claim can be taken as a common-sense fact and sets the problem to solve. The second claim assumes that properties are one-placed, while relations are many-placed. Properties such as being straight and being bent are directly possessed by the candle requiring nothing more than the candle itself to be instantiated. Relations such as being taller than... or being brighter than... are not properties possessed

⁵⁷ For a similar formulation of this problem see Lewis (2006).

by the candle itself, but relations that require something else to be instantiated. The third claim follows from the second claim: the candle *itself* has different shapes. The fourth claim states the problem of change across time and the inconsistency of accepting those claims: “There can be two candles with incompatible shapes; but if the straight candle persists, it is then the bent candle. So there is only one candle with incompatible shapes, which is impossible” (Hinchliff 2006: 287). Change across time is then problematic since it seems to violate Leibniz’s law: if a candle is straight at some time and the alleged candle is bent at another time, then they cannot be the *same* candle since they differ in their intrinsic properties. The solution to this problem is therefore to explain how an object can have incompatible properties at different times: “the demand for an account of where to locate the obvious sensitivity to time that is manifested in these sorts of property attributions” (Koslicki 2008: 188).

Two Different Solutions: *Endurantism* and *Perdurantism*

Two standard solutions have been given for the problem of change over time: *endurantism* and *perdurantism*. Both have, to take Koslicki’s word, a different ‘sensitivity’ to time: while *endurantism* conceives time as a *relation* to be found between physical objects and their properties, *perdurantism* conceives time as an extra *dimension* where physical objects are spread out. This distinction has a contradictory implication. According to *endurantism*, a physical object is a three-dimensional entity that persists by being ‘wholly’ present at different times. According to *perdurantism*, a physical object is a four-dimensional entity that persists by having a succession of different temporal parts. What does all this mean?

Let’s start with *endurantism*. Philosophers often explain this solution to the problem of change over time saying that everyday objects have only the three spatial dimensions (length, width, and depth) and they *wholly* exist at different times. Peter Simons, for instance: “at any time at which it exists, a continuant is wholly present (1987: 175); David Wiggins says that three-dimensional continuants “are conceptualized in our experience as occupying space but not time, and as *persisting whole through time*” (1980, 25); Katherine Hawley says that for *endurantists* “objects seem to ‘move’ through time in their entirety” (2001: 10); E. J. Lowe characterizes *endurantism* as the view in which “an object persist through time in virtue of being wholly present at every time at which it exists” (2002: 49); and finally David Lewis, who endorses *perdurantism*, states that something endures if and only if “it persists by being wholly present at more than one time” (1986: 202). Thus, *endurantism* seems to defend a common-sense metaphysics: objects persist *through* time by having all their parts at every time and properties are therefore instantiated by the whole of those objects at those times.

Endurantism then sorts out the problem of temporary intrinsic properties by adopting the intuitive idea that a candle can be straight at t_1 and the same candle be bent at t_2 . Thus, three-dimensional objects can instantiate incompatible intrinsic properties insofar as those properties are time-indexed. That is, *endurantism* adopts a temporally relativized property instantiation that allows three-dimensional objects to

persist through either qualitative or compositional changes by being wholly present at some given time and wholly present at another. Given that property attribution is relativized to time, endurantism can avoid the inconsistency of incompatible properties. The endurantist proposal of change over time is thus a relational solution. The candle not only has the properties of either being straight or being bent, but it possesses them *in relation* to different times: having a property is having it at some time. Properties such as being straight or being bent are temporal instantiations insofar as their bearers have them at some time; properties are therefore *related* to times in virtue of something *being-straight-in* relation to t_1 and *being-bent-in* relation to t_2 .⁵⁸

Following perdurantism, physical objects wholly exist at different times includes all the parts they are composed of and boundaries (surfaces) where most of the properties to determine their *physical profiles*. Whenever an object exhibits some of its time-indexed properties on its surface (e.g., shapes, colours, or textures) it does on the *entirety* of its surface. Although it is true that when we see or touch an object's surface we can only see or touch a part of the surface and not its entirety, we can be at least sure that the object's surface is entirely present at the time that we see and touch a part of it. If the existence of a surface *rigidly* depends upon the physical object it belongs to, then *wherever* and *whenever* the object wholly exists, *that* surface will wholly exist too. Thus, it seems to be trivially true to say that 'when I see the brown and oblong surface of my dinner table what I see at that time is the *whole* table having a brown and oblong'. However, perdurantist theorists argue that we do not see the whole table and its surface, but only a *temporal part* of it.

The perdurantist solution to the problem of change defends the idea that physical objects are four-dimensional entities having spatial parts as well as temporal parts. Objects do not persist *through* time by being wholly present at every moment of its existence as endurantists argue. Perdurantists instead contend that physical objects are *spread out* in time in a similar way as a road can be spread out in space: "Perdurance corresponds to the way a road persists through space; part of it is here and part of it there, and no part is wholly present at two different places" (Lewis 1986: 202) On this account, ordinary material objects persist by having an extra temporal dimension in addition to the three spatial dimensions that we often think of them. As Hawley says: "Objects occupy temporal intervals in much the same way as they occupy spatial regions: they have different spatial parts in different parts of the spatial region they occupy, and they have different temporal parts in different parts of the temporal interval they occupy" (2001: 10). Since a perduring object is temporally extended, the whole of it is the sum of each of temporal parts or temporal slices that successively make the object's career. On this view, physical objects are four-dimensional mereological sums and, as perdurantist theorists often accept, four-dimensionalism is committed to unrestricted composition (or universalism) in which composition always occurs whenever a plurality of objects exists.

⁵⁸ A perdurantist may also focus not that the candle both has and does not have a property like being-straight-in relation to t_1 and *being-non-straight-(or bent)-in* relation to t_2 , but in the *temporal way* that the candle has its properties. That is, if the properties that the candle has are time-indexed, then the candle persists by having all its parts and instantiating *being-straight in a t_1 way* and having all its parts and instantiating *being-bent in a t_2 way*. This view is called *adverialism* and is endorsed by Lowe (1987), Johnston (2006), Haslanger (1989).

Thus, for every two (or more) objects occupying each one a spatiotemporal region x and y , there exists an object occupying a spatiotemporal region that fuses x and y .

The perdurantist endorsement of unrestricted composition is mainly motivated by the problem of vagueness of temporal boundaries. If we think of events or processes having as their boundaries beginning and endings, then there are some cases in which it can be indeterminate either when an event begins or when an event ends. For instance, the geological periods of the earth take long periods of time such that their beginnings and endings cannot be determined with precision in time. A similar example is the controversial boundary to determine the precise moment at which human life begins. If physical objects are four-dimensional entities, then temporal boundaries can be applied to them in a similar way as they apply to geological eras. In that case, the beginning of an object as the Pyramid of Giza (call it Pyramid) can be as vague as the beginning of human life or the end of the glacial period. Given that Pyramid is a four-dimensional object, there are so many coinciding Pyramid's temporal parts that slightly differ one another that seems to be arbitrary to just consider one of them rather than others as Pyramid's ending point. Any sharp boundary would be a matter of human considerations rather than a boundary of Pyramid itself. This example, with more or less clarity, can be applied to every physical object. So, it would be up to us when something starts and when something ends. However, this power would be quite doubtful or at least very mysterious. In that case, some perdurantism theorists prefer the endorsement of unrestricted composition. Otherwise, we need to find some boundary to argue that composition occurs not *always*, but *sometimes*.⁵⁹ However, such a boundary can have borderline cases and, thereby, vagueness would part of the world again. The idea of the world itself as a vague place is resisted by many philosophers, though.⁶⁰ In order to avoid this metaphysical vagueness, perdurantists would accept no restriction in composition, i.e., any collection of objects—wherever they are—has a sum, so there might be an object composed of two spatiotemporal scattered objects as the Pyramid of Giza on the day that Egypt was declared independent from the British Empire and your nose just now.

Perdurantism presents itself as atemporal property attribution. Lewis contends that the problem of endurantism is that being straight or being bent are not genuine intrinsic properties instantiated by objects but rather relations to times. The perdurance strategy therefore is to deny time indexed properties in favour of properties instantiated by temporal parts of four-dimensional objects. As Lewis says: “We endure; we are made up of temporal parts, and our temporary intrinsics are properties of these parts, wherein they differ one from another” (1986: 204). According to perdurantism, being straight and being bent are not incompatible properties of a candle since it is not the candle itself that is entirely straight at some time and entirely bent at another. Rather, there is a ‘straight’ candle and a ‘bent’ candle which are both temporal parts the Candle; so, “on this view, change over time is the possession of different properties by different temporal

⁵⁹ See Chapter Five for more details about different composition thesis and their relations to the concept of boundary.

⁶⁰ See Chapter Five for more details about the four-dimensional argument in favour of vagueness and see Chapter Six for more details about what ontological vagueness is and how the idea of *bona fide* vague boundaries can be metaphysically possible.

parts of an object” (Hawley 2001: 12). In this case, whenever an ordinary material object *O* exhibits on its surface some property (e.g., shapes or colours), it does just on the surface of an object that is a temporal part of *O*. The boundaries of physical objects around us now are not entirely there insofar as those objects are just one of the many temporal parts of four-dimensional entities. So, when I see the brown and oblong surface of my dinner table, I do not see the surface in its entirety, but only a temporal part of it. The entire surface can be traced in a four-dimensional world in that region of spacetime filled by each of the temporal parts that composes the table it belongs to. We therefore never see boundaries wholly present in the world, but just temporal parts of those boundaries that belongs to perduring objects in a three-dimensional world.⁶¹

A Perdurantist Solution to the Coinciding Problem

One of the reasons often given by perdurantists to accept four-dimensionalism is that the metaphysics of temporal parts offers an elegant and unified theory to resolve the puzzles of material coincidence (Heller 2008; Sider 2001, 2008)⁶² On this respect, I will explain first how boundaries enter into the discussion between endurantism and perdurantism and then their solutions to the case of Clay and David. For the former, Heller’s way to describe both endurantism and perdurantism is quite helpful:

[An enduring object] has boundaries along only three-dimensions. The whole object is that hunk of matter that entirely fills up those boundaries. The whole object, therefore, exists at noon and still exists at one. A four-dimensional object, on the other hand, has boundaries along an additional dimension. The whole object must fill up all its boundaries and, therefore, does not exist at a single moment. (2008: 5)

Endurantism contends that ordinary physical objects fill up three-dimensional regions of space at different times. To have a boundary along three spatial dimensions entails for a physical object to have a surface. Physical objects fill up regions of space having three spatial dimensions (length, height, depth) whose boundaries are two-dimensional entities (surfaces). Two-dimensional objects fill up regions of space having only length and height whose boundaries are one-dimensional entities (lines). One-dimensional objects fill up regions of space having just length whose boundaries are zero-dimensional entities (points).

⁶¹ However, according to the *stage theory*, a perdurantist account of change, it is not the case that when you see a physical object you only see a temporal part of it. A stage consists of the existence of an object at some given instant or moment in time. A four-dimensional object therefore is a sum of stages rather than temporal slices or temporal parts. To talk about the very same candle that survives different changes throughout its existence entails that to talk about a candle -the whole of it- being straight right now and the same candle -the whole of it- being bent at some other instant. The candle is, for instance, a four-dimensional entity that occupies a region of spacetime composed of its different stages. Thus, by seeing the candle having a straight shape at one time and having a bent shape at another time, what we see are temporal stages of it, i.e., it is the candle itself being straight at one instant and being bent at the other instant. The candle therefore exists for a very short (or, so to speak, instantaneous) period of time, and the sum of all instants or stages that bear an identity relation to the candle make of it an object having different properties at those different stages. So, according to this view, when we see the surface of a physical object we really see the entire surface of *that* object and not just a temporal part of it, but just for a short moment in time. The complete temporal career of the surface can be traced through the sum of stages of the table it belongs to. I will not go further in the stage theory but for more details see Hawley (2001).

⁶² For a critical view about four-dimensionalist solutions to the problem of material coincidence see Moyer (2009) and McGrath (2007).

So, boundaries always have a lower spatial dimensionality than the objects they belong to. What about four-dimensional objects? If such kind objects exist and have a boundary, then they should have a three-dimensional boundary. If zero-dimensional entities (points) are boundaries of one-dimensional entities (lines), one-dimensional entities boundaries of two-dimensional entities (surfaces), and two-dimensional entities are boundaries of three-dimensional entities (bodies), then, following this relation between boundaries and objects of higher dimensionality, three-dimensional entities should be the boundaries of four-dimensional entities (perduring objects). If (i) time is an additional dimension for bodies (i.e., physical objects do not only have boundaries along the three traditional dimensions of space but also along an *extra* temporal dimension) and (ii) objects that fill spacetime regions cannot exist without having a boundary (just like the spatial existence of three-dimensional objects *generically* depends upon the existence of boundaries), then for any four-dimensional entity, there must be some three-dimensional entity to be its boundary. This entails that bulky objects should be the boundaries of four-dimensional objects.

This is a quite odd picture or at least difficult to imagine. Just as a physical three-dimensional object has a boundary that cannot be divided into three-dimensional parts (since surfaces only have boundaries along length and height), a four-dimensional object should have a boundary that cannot be divided into four-dimensional parts. Put it differently, if boundaries always have a lower dimensionality than the objects they belong to, then the boundaries of four-dimensional objects cannot be four-dimensional entities, but bodies that can be divided into three-dimensional parts. That is, perduring objects consists of the temporal parts they are composed of but also of three-dimensional boundaries. We can understand this as an analogy with events or processes by saying that the beginning and the end of a perduring object are both *durationless three-dimensional entities*, i.e., bulky objects which do not take any time at all. So, the beginning and the end Pyramid should be both pyramids (of only three dimensions) without having a temporal duration. On the other hand, we can say that Pyramid is a perduring object having a boundary such that it encloses the portion of four-dimensional spacetime that the Pyramid occupies. However, we have again the odd picture in which just as the boundaries of a three-dimensional object are the collection of those *simple parts* in contact with the object's surroundings,⁶³ the boundary of a four-dimensional object should be the collection of *durationless three-dimensional parts* in contact with the object's spacetime surroundings. Perhaps these views can be right according to a theory of what boundaries are and the kind of ontological dependence that boundaries and objects have, but it still seems to be a very mysterious way to understand what ordinary physical objects and their boundaries are.

Maybe a possible answer by perdurantists is that they do not add a *fourth* dimension for physical objects, but rather these objects have three dimensions in space *plus* a temporal dimension. Time is not strictly speaking the fourth dimension 'coming after' the three dimensions of space, but a dimension utterly different from the spatial dimensions. However, the analogy of space and time is a key point to support the four-dimensionalist thesis: material objects are extended in time in the same way as they are extended in

⁶³ For more details about this definition of the boundaries of physical objects see section A of Chapter Two.

space. Should this analogy be taken literally or just a metaphorical way of arguing? How serious is the *space/time* analogy for four-dimensionalist? As we will see further on, even though we take the *space/time* analogy as a serious business to be endorsed, it could not rule out problems with the *spatial boundaries/temporal boundaries* analogy. But, before this, let's see first how four-dimensionalism sorts out the problem of coincidence between Clay and David.

An endurantist solution to co-location may take the *material constitution* answer: Clay and David are constitutionally related: David is *constituted* by Clay. Clay constitutes David insofar as Clay is a determined quantity of masses of matter that makes up David. Material constitution is understood as both *irreflexive* and *asymmetric* nothing can constitute itself, and while Clay constitutes David, David does not constitute Clay. Material coincidence then occurs when one object constitutes another object and *constitution is not identity*⁶⁴, i.e., when the *constituting object* and the *constituted object* differ in some qualitative aspects but coincide in others. Clay and David have the same parts (they are composed of the same atoms) insofar as David is constituted by Clay: the atoms that compose the matter of what Clay is made are also the atoms that compose David. Clay and David have the same parts at the same time and sharing all those physical properties that supervene on the atomic configuration shared by them. Given that endurantism adopts a temporally relativized property instantiation, both Clay and David wholly exist sharing all their parts at every time they are constitutionally related and, therefore, the properties instantiated by Clay at different times are also the properties of David: if Clay itself has a red surface at t_1 , then David itself has a red surface at t_1 ; if Clay itself has a rough surface at t_2 , then David itself has a rough-surface-at- t_2 . So, according to the endurantist point of view, the coincidence between Clay and David occurs when they simultaneously share a boundary of a three-dimensional region of space where –within of it– the same configuration of matter instantiates different time-indexed properties borne by both Clay and David which are constitutionally related and constitution does not entail identity.

If Clay and David are two coinciding objects, they cannot be identical: there must be some aspects in which both differ at the time of coincidence. One aspect in which Clay and David differ is in their persistence conditions: while Clay might *endure* a change of shape, David would be destroyed. Given that Clay and David are composed of the same matter, both can be then found share the same spatial boundary of a given three-dimensional region of space. However, given that Clay and David do not share the same persistence conditions (i.e., one endures changes that the other does not), each one is said to satisfy different sorts. Although Clay and David share the same parts, the same boundaries, and instantiated the same physical properties at the same times, they are not the same kind of being. Therefore, following the endurantist view, the same boundary (a surface) can belong to two different objects wholly present at the same time. Thus, coincidence occurs when one object is constituted by another object, but their constitution relation does not make them identical insofar as they differ in some metaphysical properties such that one can survive some changes across time that the other does not.

⁶⁴ See Johnston (1997) and Baker (1997) for those ones who support the thesis that constitution is not identity.

The perdurantist solution to the problem of co-location seems to be more efficient than the endurantist one. As we know, endurantism may adopt a constitutionalist answer, but how two material objects *sharing all its parts* at a given time can yet differ in properties? How can the same atomic configuration instantiate different (even contradictory) properties borne by two non-identical objects? This kind of questions often seems to lack convincing explanations. Nonetheless, perdurantism adopts a metaphysics that avoids that sort of question: Clay and David are *spacetime worms sharing temporal parts*. According to this answer, both Clay and David are four-dimensional objects filling up regions of spacetime: in addition to the conventional spatial dimensions, they are also stretched out in time. Both Clay and David are perduring object, i.e., aggregates of temporal parts. Following this picture, Clay and David are not identical since the former has a longer temporal career than the latter. Some temporal parts of David overlap with some temporal parts of Clay for a while: early temporal parts of Clay are not temporal parts of David; some middle temporal parts are shared by both Clay and David; later temporal parts of Clay are not temporal parts of David (period at which David's temporal career has already ceased). As Sider explains: "Whenever distinct material objects coincide, they are never at that time wholly present, but rather overlap in a shared temporal slice or segment. Coincident objects are therefore no more mysterious or objectionable than overlapping roads" (2001, 152). Clay and David coincidence is just a partial overlap of temporal parts "and partial overlap is metaphysically innocent (who would raise question about roads partially overlapping?)" (McGrath 2007: 164).

Clay and David are therefore *four-dimensional worms* which coincide when some of their parts are shared in a region of spacetime. They do not wholly exist at different times and their properties are not temporally indexed; they rather exist *partially* at every time and each of their temporal parts can instantiate different properties. The coincidence of Clay and David thus occurs at the period of overlapping of their temporal parts and, therefore, each property instantiated by those shared temporal slices correspond to or describe both Clay and David. If a temporal part instantiates the property of 'having a red surface' and that temporal part is shared by both Clay and David, then both Clay and David have a red surface at the time of coincidence. According to a perdurantist view on collocation, "objects are distinct, though they share all their present microphysical parts, because they differ in their temporal parts, in the past and, perhaps, in the future" (Hawley 2001: 151). Clay and David both share *all* their physical parts at the time of coincidence and, therefore, they instantiate the same physical or non-sortalish properties at that time, but they share only *some* temporal parts and so differ in their non-physical or sortalish properties as their persistence conditions. Put it differently, as three-dimensional objects, Clay and David share all their spatial parts and boundaries at the time of coincidence; as four-dimensional objects, they share some temporal parts and differ in their temporal boundaries insofar as Clay is longer spread out in time than David.

Mark Heller (2008) has an even more radical four-dimensional view on co-location. According to his metaphysics of temporal parts, the genuine ontological items of the world are *four-dimensional hunks of*

matter; these are the filler of regions of spacetime whose existence does not depend upon any human preferences, decisions, or beliefs but only upon how the world is itself. On this respect, Clay, David, and any other ordinary physical object are *conventional* entities. That is, linguistic attributions and human preferences create these objects having their essential properties and persistence conditions which make them fall in different conventionally agreed sortals. As Heller spells it out:

To say that an object is conventional is not to say that [...] we have certain conventions that lead us to act as if there is an object that has those persistence conditions and essential properties. More accurately it is our conventions together with our beliefs about the structure of the world lead us to act as if there is such an object. (2008, 39)

Clay and David are conventional objects and their identity conditions depend on human decisions: when their existing either starts or ends up is a matter of vagueness. There are no sharp boundaries there, but just conventional ones. Conventional objects therefore have vague boundaries, i.e., boundaries that depend on the contingency of human decisions. Thus, vagueness does not belong to the world itself, but rather to the boundaries drawn by human beings to represent everyday objects having such and such identity conditions.⁶⁵ On the other hand, as Heller contends: “If there are any nonconventional objects, then they must not be vague objects. They must have precise boundaries along all dimensions, including the temporal dimension. Moreover, these boundaries must not be in function of our special interests or arbitrary choices” (1990, 51). According to Heller, the only objects whose having precise boundaries are four-dimensional hunks of matter. As Heller himself acknowledges: “It is crucial for my overall project that the objects of my ontology have precise boundaries; for any of the objects in my proposed ontology there is a unique and determinate region that that object exactly fills” (2008, 10). Temporal boundaries of four-dimensional objects filling determined regions of spacetime are not given by the vagueness of conventionality; rather, they have precise temporal boundaries (or identity conditions) since boundaries are essential to them. Essential boundaries can however lead four-dimensionalism to serious philosophical problems.

C. Two Problems with Perdurantism

Four-dimensionalism can be seen as a ‘radical’ solution to the problem of material co-location and temporal persistence (Olson 2002).⁶⁶ In fact, it challenges the common-sense view of how ordinary material objects are related with space and time. Some philosophers have raised critics to the metaphysics of temporal parts. For instance, McGrath points out that four-dimensionalism overpopulates the world since “within the temporal boundaries of any ordinary object there reside countless objects” (2007: 171). Given that the fundamental objects accepted by four-dimensionalism are temporal parts and every single change in

⁶⁵ The problem of vague boundaries and the distinction between mind-dependent and mind-independent boundaries is addressed in detail in Chapter Six.

⁶⁶ As he does with four-dimensionalism, Olson (2002) likewise labels both relative identity and eliminativism (nihilism) as radical solutions to the problem of coincidence.

properties is instantiated by different temporal parts, then the world is crowded of many temporal slices everywhere rather than single objects having all their parts at every time they exist. That's why Thomason (2006) characterizes four-dimensionalism as a 'crazy metaphysic' in which just by having on our hands an ordinary material object, many objects (temporal parts) are constantly coming into existence *ex nihilo* at different times.⁶⁷ However, I will not focus on this objection, but on two problems for perdurantism regarding boundaries.

(i) Essential Boundaries

Let's go on with Heller's account about four-dimensionalism. According to him, objects have *spatial*, *temporal*, and *modal* boundaries: where they are located, the times at which they exist, and the worlds at which they exist. To talk about 'modal boundaries' is not as clear as to talk about boundaries in space and time. However, I take 'modal boundaries' as metaphor to mean that an object can be spread out across possible worlds as much as they can be in space or time. It refers to whether an object has some of their properties essentially, i.e., whether it has them at every world it exists: "Asking about a thing's modal boundary is really just to ask about its essential properties. This is analogous to the fact that asking about a thing's temporal boundaries is, in effect, to ask about its persistence conditions" (2008: 72). Objects can have imprecise or vague boundaries regarding their either spatial or temporal features. A table's spatial boundary can be vague if we look its surface from a microphysical point of view: there might be some particles which are definitely part of the surface's table, but it is a matter of vagueness whether other particles are part of it. Likewise, a table clearly goes out of existence at the time when all its parts are destroyed, but it might be a matter of vagueness whether a table goes out of existence when it losses just some of its parts. To ask questions about spatial and temporal boundaries of objects entails to ask about their modal boundaries too: Does an object have the spatial location, parts, or properties that it has at every world the object might exist? What is the essential molecular configuration that a table must have to temporally persist? What are the required essential properties that allow a table to exist in all possible worlds? In case of spatial, temporal, and modal boundaries of ordinary material objects such as pieces of clays or statues, everything seems to be a matter of vagueness due to the imprecision of those boundaries.

Four-dimensional hunks of matter, following Heller's view, are not ordinary objects having imprecise boundaries. Those objects exactly fill determined regions of spacetime whose boundaries are essential to them. Conventional objects do have conventional boundaries. Our decisions and preferences can design in different ways not only the spatial and temporal boundaries of ordinary objects (i.e., their persistence conditions and material configuration our conventions), but also can determine their modal boundaries or what properties are meant to be essential to them and what are not. If there are any material object which is a genuine ontological item of the world, then its spatial, temporal, and modal boundaries

⁶⁷ For a reply to Thomason's attack to temporal parts see Sider (2001: 216-218) and Heller (2008: 16-19).

should not depend upon any kind of conventionality. According to Heller's proposal, four-dimensional hunks of matter are the only objects that fulfill such requirements:

The temporal boundaries of *four*-dimensional hunks are not selected by us. [...] A given four-dimensional object goes out of existence at the time that it does because the object's boundaries are its defining characteristics. [...] It is because of the nature of a four-dimensional object that it has just those spatiotemporal boundaries and no others. A four-dimensional hunk that is now one cubic meter, could not have now been any other size. Any hunk of a different size at this time would have had different spatiotemporal boundaries, and, hence, would have been a different hunk. Therefore, a four-dimensional hunk of matter, by its very nature, has its spatiotemporal boundaries essentially. (2008: 53)

Four-dimensional hunks of matter are not conventional objects because they have precise and essential spatiotemporal boundaries which do not depend on the vagueness of our linguistic agreements or cognition. The spatiotemporal location of four-dimensional objects is ontologically given by the sharpness of the boundaries of the region of spacetime that those objects fill up. Given that four-dimensional objects have their spatiotemporal boundaries essentially, there are no possible worlds where they could have existed in a different way as they actually do. Heller's version of four-dimensionalism therefore maintains that the atemporal conception of parthood is held by necessity. If a temporal part is part of a spacetime worm, it is essentially part of it. The world (beyond conventionality) consists of a huge number of hunks of matter filling up sharply bounded regions of spacetime having their spatiotemporal boundaries essentially.⁶⁸ This essentialist account about boundaries of four-dimensional objects is close to the following Sider's definition of temporal part:

x is an *instantaneous temporal part* of *y* at instant $t =_{df}$ (1) *x* exists at, but only at, *t*; (2) *x* is part of *y* at *t*; and (3) *x* overlaps at *t* everything that is part of *y* at *t*. (2001: 59)

Sider's definition captures the idea that a temporal part of a four-dimensional object exists only at the precise instant at which it is part of that four-dimensional object and overlap any other part that the object has at *that* instant. There is however a modal difference between Heller's account of essential boundaries and Sider's definition of temporal parts. This can be formulated as a *de dicto* modal claim: *necessarily*, every four-dimensional object has a temporal part at every instant at which it exists. On the other hand, Heller's essentialist view on boundaries of spatiotemporal objects demands a *de re* modality of temporal parts: every four-dimensional hunk of matter *necessarily* has the temporal parts it has at every instant at which it exists. Heller's modal essentialism is a response to van Inwagen's attack to perdurantism who basically contends

⁶⁸ Michel Jubien (1993) also believes that the fundamental objects are four-dimensional worms which have their temporal boundaries essentially, but, unlike Heller, Jubien conceives their spatial boundaries accidentally: "The thought that a thing's *spatial* boundaries might have been different was in essence the product of an everyday intuition that we have chosen not to abandon. [...] Now, in contrast, we have chosen to regard a thing's *temporal* boundaries as essential" (33).

that the metaphysics of temporal parts entails *modally inductile* objects. Van Inwagen presents the argument as follows:

If there are objects of the sort the [worm-theorist] calls temporal parts, then their temporal extents must belong to their essence. [...] If [the worm theory] is correct, then Descartes is composed of temporal parts, and all temporal parts are modally inductile. But Descartes himself is one of his temporal parts -the largest one, the sum of all of them. But then Descartes is himself modally inductile. which means he could not have had a temporal part extent greater than fifty-four years. But this is obviously false, and [the worm theory] is therefore wrong. (2001: 119)

The problem of modal inductility is that it seems to imply a *four-dimensional mereological essentialism*, viz., temporal worms have the temporal parts it is composed of essentially. Temporal parts exist at a time and only at *that* time. Four-dimensional objects have their temporal boundaries essentially: a temporal part of a four-dimensional object could not have existed at a different time from it actually exists. Descartes is a four-dimensional object, i.e., Descartes is never wholly present at a given time since it is an aggregate of temporal parts. Following van Inwagen's argument, Descartes is composed of temporal parts whose boundaries are held essentially, so the temporal part in which Descartes wrote the *Discourse of Method* could have not been otherwise as it in fact was. The temporal part Descartes-writing-Discourse-of-Method is therefore modally inductile. The sum of the modally inductile temporal parts of Descartes could not have been temporally longer or shorter than it actually is. If Descartes is identical to the sum of its temporal parts, then Descartes *essentially* lived fifty-four years having all the properties he had. Hence, Descartes has its temporal boundaries essentially: its temporal career could not have been otherwise. However, this is false: Descartes could have lived longer or shorter; even more, Descartes could have existed without the temporal part that instantiates the property 'being a philosopher'. As van Inwagen claims: "If there are philosophers who think that temporal parts have their temporal extensions and their careers essentially, I can't see how what they believe could be true" (2001: 133). To say that everything happens essentially seems to be an absurd consequence of perdurantism.⁶⁹

This leads us to another problem with four-dimensionalism. Unlike a constitutionalist answer to the coincidence puzzle taken by endurantists, perdurantism is not committed to the idea that Clay and David are objects sharing all their parts. The problem with constitutionalism is that it is not clear at all how two objects physically identical at some time can yet differ qualitatively at that time. Four-dimensionalism is not supposed to deal with that problem because Clay and David do not coincide, it is just that *some* of their temporal parts overlap. However, four-dimensionalism must still deal with a similar problem if we think of two perduring objects that share all their spatiotemporal parts. That is, imagine that God creates *ex nihilo* the

⁶⁹ See Sider (2001: 218-224) and Hawley (2001: 191-194) for more details about four-dimensionalist responses to van Inwagen's objection of modal inductility.

statue of the David made of clay and he annihilates it at some later time: David and Clay both come into existence and go out of existence exactly at the same time. In this case, according to four-dimensionalism, David and Clay would be two coinciding spatiotemporal worms sharing not only *some* of their temporal parts but *all* of them: David and Clay would have the same temporal career. They would fill the same region of spacetime and, therefore, share the same spatiotemporal boundaries. The problem now that puzzles four-dimensionalism theorists is like what puzzles constitutionalism. Despite David and Clay are made of the same configuration of spatiotemporal parts, they yet differ in their modal properties and persistence conditions. Is not this a similar objection that endurance theorists who adopt constitutionalism are accused of? It looks inconsistent to say that Clay and David are identical (given that they share all their spatiotemporal parts) if the former could survive squashing but the latter could not. This what Olson (2007: 111) calls the *problem of modal incompatibility*.

As we know, Heller takes a radical solution in which four-dimensional objects are such that they have their temporal, spatial, and modal boundaries essentially. That is, if David and Clay share the same boundaries and they have it essentially, then, necessarily, they share exactly the same persistence conditions, same location in spacetime, and they also share the same worlds in which they exist. Thus, the problem of modal incompatibility is resolved by assuring that two alleged coinciding spatiotemporal objects share a boundary that is essential to them and, therefore, no modal differences can be seen. Hence, if David and Clay have the same boundary essentially, then David and Clay are essentially identical: they have neither physical differences nor metaphysical differences. So, while van Inwagen argues that perdurantism entails *modally inductile* objects, i.e., objects which cannot be otherwise, taking Heller's view, objects cannot be otherwise since they have their boundaries essentially; and so, if two four-dimensional objects share the same boundary, then they cannot be *modally incompatible* objects; they would instead hold an identity relation.

However, the option that settles the problem of modal incompatibility by accepting things having essential boundaries seems to pay a high metaphysical cost. It does not look metaphysically preferable to settle the problem of modal incompatibility by endorsing, as it were, an ontology in which the world consists of spatiotemporally 'frozen' hunks of matter. A perdurance theorist might rather answer to the inductility objection by adopting a counterpart-theoretic account of modality. A modal counterpart can be understood as follows:

A modal counterpart x of an object y at a world w is an object that resemblances y at w in so many relevant aspects such that x should be considered as a genuine version of y itself at w .

In the case of Descartes, there are two counterpart relations: one is a *person* counterpart relation and other a *temporal-part* counterpart relation in which Descartes himself is a temporal part but the largest one that fuses every proper temporal part of Descartes. This entails, as Olson (2007: 111) explains, that there are no unqualified modal properties but only qualified or kind-relative modal properties. This is traditionally put

in the following terms: given that Descartes is both a person and a temporal part, Descartes, *qua* temporal-part, could not have had either greater or lesser temporal extent, whereas Descartes, *qua* person, could have a different temporal extent. So, on the one hand, x is a modal counterpart of Descartes *qua* temporal-part at a world w only if x resembles Descartes at w in the relevant aspect of having exactly the same temporal extension of Descartes. On the other hand, x is a modal counterpart of Descartes *qua* person at a world w only if x resembles Descartes at w in the relevant aspects that define what is for something to be a person (whatsoever they are); x could therefore have a longer or shorter life than Descartes (or even have a different biography), but to the extent that x meets the relevant aspects that define what is for something to be a person, x can be treated as a modal counterpart of Descartes but only Descartes *qua* person.

Thus, a four-dimensional object O , *qua* temporal-part, has its *spatiotemporal boundaries* essentially since O 's modal counterparts cannot differ with O 's temporal extent. However, O , *qua* some kind K (that is not a temporal-part), does not have its spatiotemporal boundaries essentially, but, so to speak, essentially, O has the boundary that determines what falls under K and what does not. If a metaphysics of temporal parts is a radical and strongly counterintuitive theory to be accepted, to add a modal counterpart-theoretic account makes everything even harder to swallow. So, if four-dimensionalism entails either considering the idea of essential modal boundaries or accepting a metaphysics of modal counterparts, then, for some philosopher (e.g., van Inwagen 2001), it is a good and sufficient reason to deny perdurantism.

(ii) Do Temporal Boundaries Resemble Spatial Boundaries?

One of the main reasons often invoked by perdurantists to underpin the four-dimensionalist thesis is the *analogy argument*: to be spread out in time is as much as to be spread out in space. For instance, Heller contends that “insofar as time is just one more dimension, roughly alike in kind to the three spatial dimensions, we should expect that our claims about an object’s spatial characteristics have analogues with respect to its temporal characteristics” (2008: 5). On the other hand, Sider acknowledges that “the heart of four-dimensionalism is the claim that the part-whole relation behaves with respect to time analogously to how it behaves with respect to space” (2006: 59). The analogy argument seems to be a fundamental piece in the perdurance device to explain temporal persistence: if it is not the case that time is a dimension where objects are physically extended similar in many aspects to space, then the four-dimensional account of temporal persistence fails. Richard Taylor (2006) defends the analogy argument from a collection of claims that emphasize different dissimilarities between space and time. For example: an object cannot be in two places at once, but it can occupy two or more times at only one place; things can change their spatial positions, but not their temporal ones; time is something moving or flowing, but space is unchanging; or a thing can move either backward or forward in space, but it cannot do so in time. Although Taylor gives an answer to all those objections and others, I would like to focus on another sort of dissimilarity between space and time not considered by Taylor. According to Heller, the analogy argument “allows us to understand the

notion temporal boundaries as analogous to that of spatial boundaries” (2008: 6). However, I will offer some arguments to show that spatial boundaries and temporal boundaries do not resemble so easily.

Spatial boundaries and temporal boundaries are both ontologically dependent entities (they do not exist unless something else exists). However, they do not share that characteristic due to the resemblance between space and time, but because every boundary (not only temporal or spatial ones) exists in that way. Dissimilarities between spatial and temporal boundaries are fundamentally given by dissimilarities between the objects they ontologically depend on. Perdurantism theorists would say that both spatial and temporal boundaries belong to the same kind of things: four-dimensional objects. If ordinary material objects such as tables, chairs, planets, animals, or people are spread out over time as well as they are in space, then the boundaries of such kind of things should not make a distinction between spatial and temporal boundaries. Nonetheless, I will give some ideas to reject this four-dimensionalist view on boundaries:

- (a) *A fundamental difference between spatial and temporal boundaries is given by the kind of object they belong to.* Spatial boundaries are found where some object occupies a place in space. Ordinary material objects such as trees, billiard balls, tables are found in physical space, so they have ordinary boundaries which are found where those objects are found in physical space. We attribute many physical features (e.g., colours or textures) and physical phenomena (e.g., light reflection or physical damages) which often occur on the boundaries or surfaces of those objects. On the other hand, temporal boundaries seem to belong to different sort of things which are not concrete at all. We may talk about temporal boundaries by referring to *events* of different sorts such as processes, procedures, biographies, stages, periods, ages, epochs, and so on. Unlike physical objects which can have different *locations* in space, events *happen* or *occur* in time and only at some given time. A table can be located in different places at different times, but the WW2 happened once from 1939 to 1945 and only during that particular period of time. Whereas spatial boundaries demarcate *where* the spatial extent of physical objects ends, temporal boundaries demarcate *when* the temporal extent of events either starts or finishes: nothing of an event occurs before its starting point and after its finishing point. However, temporal boundaries of events do not have the physical features and cannot undergo the physical phenomena that can be attributed to boundaries of physical objects (i.e., surfaces). It seems nonsense to say that the WW2 has a red boundary in a similar way as a table might have a red surface. Thus, spatial and temporal boundaries are found in several objects: objects having location and objects having duration; that is, objects which are *placed somewhere* in space and objects which *occur sometime* in time. Although ordinary material objects have temporal duration (they exist for a while) and can be part of events (e.g., a rifle used during the WW2), they have some features held by their ordinary spatial boundaries (or surfaces) which cannot be held by the temporal boundaries of events in which they can be part.

- (b) *Unless they are points, spatial boundaries can be divided into parts; temporal boundaries cannot.* Since points are zero-dimensional boundaries, they cannot be divided into further parts. Unlike points, while lines can be divided into segments along their one-dimensionality, surfaces can be divided into parts along with their two-dimensionality. On the other hand, temporal boundaries seem to be durationless.⁷⁰ Events have some duration; they last for a while. Events can be divided into temporal parts: During WW2 from May 10th to June 22nd of 1940, the ‘Lighting War’ occurs when Germany took control of most of Western Europe. The ‘Lighting War’ is a part of WW2 that happened during some particular period of time and can be studied in its different moments. However, boundaries of events –beginnings and endings– do not have temporal parts because they do not last: they are temporally indivisible instants. Someone might however object that either beginnings or endings of events can be long processes. For instance, German’s invasion of Poland is often pointed out as the beginning of WW2. The invasion was not an instant, but an internal event (the starting event) of WW2 which happened during 1939. Therefore, temporal boundaries of events can last for a while and have internal moments. Nonetheless, if a temporal boundary had duration, then it must have boundaries; if these boundaries had duration, then they must have boundaries; if these boundaries had boundaries, they must have boundaries too; and so, *ad infinitum*. Hence, temporal boundaries of events cannot have temporal parts in the same way that spatial boundaries as surfaces and lines do have spatial parts.
- (c) *Spatial boundaries may have different dimensionality, but temporal boundaries do not.* As we have already said, spatial boundaries can have two, one, or zero dimension. Each of these boundaries ontologically depends on higher dimensional objects: two-dimensional boundaries are surfaces that exist as boundaries of three-dimensional (or bulky) objects; one-dimensional boundaries are lines that exist as boundaries of two-dimensional objects (surfaces); zero-dimensional boundaries are points that exist as boundaries of one-dimensional objects (lines). Thus, ordinary material objects have surfaces as boundaries separating them from their spatial surroundings; and both one-dimensional and zero-dimensional boundaries such as edges and joints can be found in the discontinuities of their surfaces. On the other hand, temporal boundaries do not have different dimensionality in time as spatial boundaries in space do; there are no boundaries having different ‘temporal dimensions’ as boundaries having different spatial dimensions. Unlike objects located in physical space which can have spatial boundaries of different dimensionality, events that happen in time do not have boundaries of different temporal dimensionality. Across time, there seem to be only boundaries that indicate when an event either starts or finishes. Unlike the relationship between ordinary physical objects and their boundaries, events are not ‘objects’ having a higher dimensionality than the boundaries they have. Temporal boundaries are durationless entities in the extremities of events and they do not differ in ‘temporal dimensionality’.

⁷⁰ See the *Gappy View* in Chapter Three for more details about the idea of temporal boundaries as durationless entities.

(d) *Physical objects have one boundary (their surfaces), but events always have two boundaries (beginnings and endings).* As we said above, events can start and finish at some given times. Unless an event had infinite duration (i.e., it has neither beginning nor ending) or it begins at some time but never ends, most of the events have two temporal boundaries which indicate *how long they last*. Put it differently, nothing of an event happens *before* its temporal beginning and nothing of that event happens *after* its temporal ending. By contrast, objects do not have two boundaries or surfaces (or, at least, they do not have two boundaries as events have them). If a physical object is a matter-filler of regions of space, then its spatial boundary is the set of boundary-points in contact with the object's surroundings of unoccupied space.⁷¹ Unlike events which have two temporal extremities, physical objects have one extremity which is the collection of its boundary-points. Talking about boundaries of ordinary material objects (surfaces), material objects have a surface which is the boundary that indicates *where* an object's physical extension terminates; *where*, beyond that boundary, nothing of what composes that object can be found. Thus, while two temporal boundaries are required for an explanation about how events have temporal extent, only one spatial boundary can be required for an explanation about how material objects have physical extent.

These arguments may not be sufficient to reject the fundamental four-dimensionalist space/time analogy, but can give us a leading thought: by taking the space/time analogy literally, if spatial boundaries and temporal boundaries are not alike, then four-dimensionalism has fewer chances to succeed. My view is that they are not; otherwise, the categorical distinction between 'object' and 'event' would be missing. Four-dimensionalism advocates' pretension is a sort of metaphysics in which material objects can in many aspects be treated as events or process. Quine likely has the most radical view on this point: "physical objects, conceived thus four-dimensionally in space-time, are not to be distinguished from events or, in the concrete sense of the term, processes" (1960, 156). According to this view, ordinary objects such as trees, chairs, and people are not three-dimensional physical objects existing at different times that can participate in several events; rather, those objects are *literally* events which are materially spread out in time having temporal parts. There is no therefore an ontological distinction between objects and events. Ordinary objects do not persist by being wholly present in space at every time; rather, they persist (or perdure) by having different temporal parts for every qualitative change. Four-dimensional objects are, therefore, like sums of temporal slices composing temporal processes. When you see a tree and the matter that composes it now you do not see the tree itself and its matter, you just see a temporal part of the tree or a singular stage or instant of the tree's temporal career. We do not thus perceive physical objects at all, but events or processes.

The four-dimensionalist answer thus is to adopt time as a further dimension in addition to the spatial dimensions usually held by physical objects. Nonetheless, dimensionality seems to be a relevant factor to regard objects and events as different sort of ontological categories: "objects are not 'cross sections' of events, and events are not kinds of objects. [...] For events do not occupy space as objects do, hence are

⁷¹ See Chapter Two for more details about this idea and what surfaces are supposed to be.

neither two-, nor three-dimensional. While many events need space to take place, they do not themselves have any spatial *dimensions*” (Hacker 1982: 7). Following (a)-(d), boundaries along spatial dimensions behave, in fact, in a different way from boundaries in time. This divergence regarding boundaries can thus be decisive to become suspicious about a four-dimensionalist metaphysics and its elegant solutions to the problem of co-location and other philosophical puzzles alike.

Final Remarks

We have seen how two boundaries can be spatially co-located for a while insofar as they belong to two distinct objects having the same atomic configuration at the same time but differing in some metaphysical properties. Differences in persistence conditions and modal properties are invoked to support the possibility of co-location. That is, although two objects have the same parts and the same boundary (or, we can say, there is one boundary in space that encloses a matter-filled region occupied by two non-identical objects), they differ in both how long they last and what world can exist. Endurantism and perdurantism offer opposite theories about how things persist which entail different views of their boundaries in terms of space, time, and modality. However, perdurantism, in particular, has two undesirable consequences regarding boundaries: one is that objects have their boundaries essentially; the other is that spatial and temporal boundaries would not be ontologically distinguishable at all. The following last two chapters move towards the role that boundaries can play in composition and the problems of vagueness that arise from it.

CHAPTER FIVE

What Boundaries are the Denizens of the World?

Vagueness, Composition, and Simplicity

Introduction

This chapter inquires about what boundaries are the genuine denizens of the world, i.e., *what* is the kind of boundary that exists and *how* it does (what is related with the kind of objects it belongs to). It mainly focuses on the two extreme answers to the *Special Composition Question* that asks under what conditions some objects compose some further objects (van Inwagen, 1990): *nihilism* and *universalism*. This question entails to ask for a boundary to separate *when* composition occurs and *when* it does not. This a compositional boundary. Despite they are opposite answers, nihilism and universalism agree that there cannot be a vague compositional boundary: it can happen *never* or *always* but no *sometimes*. Universalism has no boundary at all to indicate when composition occurs since it *always* occurs. Nihilism, on the other hand, contends that composition has a very restrictive boundary that indicates that composition *never* occurs. This entails that ordinary physical objects such as tables, balls, pyramids, and any kind of composite objects do not exist and, therefore, the boundaries (surfaces) of such objects neither. The only material beings are simples, i.e., objects without proper parts. If simples have no borderline parts since they do not have parts at all, then they are said to be objects having sharp and precise boundaries. So, the restrictive compositional boundary of nihilism leads to a world consisting of only simples having sharp and precise boundaries. However, even in such world of precise boundaries, there is still room for vagueness in terms of modality and location. The chapter thus has two sections A and B. The first one addresses the Special Composition Question and how Universalism and Nihilism deal with boundaries and vagueness. The second one addresses what is a simple and how they can have vague boundaries in terms of modality.

A. The Special Composition Question: An Eliminativist Approach to Boundaries

In his book *Material Beings* (1990), Peter van Inwagen has raised a question which has been much discussed in contemporary metaphysics: Under what circumstances does composition take place? Or, let's take the plural quantification used by van Inwagen: When is it true that $\exists y$ and the x s compose y ? This question is labelled as *The Special Composition Question* (SCQ) which can be also put in mereological terms: Under what circumstances is a thing a (proper) part of something else? Van Inwagen defines composition in the following terms:

The x s compose y =_{df} each of the x s is a part of y , no two of the x s share a part, and every part of y shares a part with at least one of the x s.

An object x , we can say, is (a proper) part of something else when x is a portion of it and not vice versa. Some basic definitions and axioms of parthood are as follow:⁷²

x overlaps y =_{df} x and y have some common part; or given x , y , and z , x overlaps y if and only if z is a part of both x and y .

x is a sum (or fusion) of the y s =_{df} x has all of the y s as parts and has no part that does not overlap each of the y s.

Transitivity: If x is part of some part of y , then x is part of y ; or given x , y , and z , if x is part of z and z part of y , then x is part of y .

From an intuitive approach, boundaries seem to be relevant to answer SQC: two things compose a further one when their boundaries are touching each other. Many bricks may compose a wall when they are bunched one over the other and parts of their surfaces are in contact. Van Inwagen actually suggests that *contact* is a representative answer to SCQ: “To get the x s to compose something, one need only brings them into contact; if the x s are in contact, they compose something; and if they are not in contact they do not compose anything” (1990, 33). As we saw in Chapter Three, x and y are in *direct* contact if no empty space can be found between (parts of) x ’s boundary and (parts of) y ’s boundary. On the other hand, given x , y , and z , x and y are in *indirect* contact if no part of x ’s boundary touches any part of y ’s boundary but x and y are both in direct contact with z . Hence, although the brick’s surface on the bottom of a wall is not in direct contact with the brick’s surface on the top of the wall, both are in indirect contact in virtue of the contact of the bricks’ surfaces between them. Nevertheless, contact is not enough to answer SCQ. Take this principle:

$\exists y$ the x s compose y if and only if $\exists y$ and the x s relate one another by being in (either direct or indirect) contact.

As we saw in Chapter Three, according to common-sense, contact occurs only if two objects have a non-overlapping relationship where no empty space is found between their boundaries (where contact happens). Nevertheless, this can lead us to puzzling situations if the existence of boundaries entails some kind of interruption in the region of space composed of two continuous sub-regions occupied by two objects in contact. From a topological point of view, the regions of space occupied by x and y cannot be continuous unless one of them does not contain a boundary among its components (topological openness) and it is closed by the other’s boundary, but which one? There is maybe only one boundary between them, but which one

⁷² These definitions and axioms are mostly taken from Lewis (1991), Simons (1987), and Varzi (2016).

does own it? We could also maintain that there is one boundary between x and y which does not belong to either. Or even it is arguable that the boundaries of x and y do not overlap, but occupy the same region of space at the time of contact. Each of these views has its drawbacks and risks.⁷³

We nevertheless seem to accept many cases where objects not in contact compose something such as constellations or archipelagos. Furthermore, much of what composes ordinary physical objects such as tables, planets, and people is a vastly empty space where numerous scattered particles coexist. But, even if we accept the thesis of contact, it does not give an appropriate answer to SQC. As van Inwagen writes in the case of handshaking: “Despite our being in contact, therefore, nothing is such that you and I compose it. Or, at least, if you and I compose something, this is not *in virtue of* our being in contact” (1990: 35). Contact not only does not explain composition; by accepting it as *the* answer to SQC, it can make us clash our heads against boundary puzzles unnecessarily.

There are three other spontaneous answers to SCQ which van Inwagen (1990: 56-60) calls the *Simple Bounding* answers: *fastening*, *cohesion*, and *fusion*. On the one hand, we might say that two or more objects compose something every time they are fastened to one another. Unlike contact, fastening entails some sort of bonding relation between objects’ boundaries. Contact, van Inwagen says, is a highly unstable relation. To separate two objects which hold a contact relation just entails putting their boundaries away until leaving some empty space between them. Fastening is a much stronger physical relation that might ensure that two fastened things do in fact compose something. Two objects are fastened to one another if there is, for instance, a physical force that is applied on their boundaries that makes them inseparable. Think about the magnetic fastening between two pieces of metal: given the magnetic force between their surfaces, even though they could be not in ‘real’ contact, they are joined in such a strong way due to the magnetic force that together compose something else. Another example can be the fastening between a bolt and a nut screwed onto it: although there are no magnetic forces between them, the sort of physical features and precise shapes of their surfaces where fastening occurs cause a strong adherence between the bolt and the nut. Nevertheless, much like contact, fastening does not seem to be a complete and sufficient answer to SCQ. Van Inwagen takes shaking hands as an example again; but, in this case, our fingers have become entwined due to a paralysis, so our hands are not only in contact: they are fastened. However, this situation does not entail that you and I compose a further object: “our paralysis has not added to the furniture of earth; it has merely diminished its capacity to be rearranged” (van Inwagen 1990: 58).

Similar objections can be raised about cohesion and fusion. If I know the needed mechanism to disassemble the sort of fastening held by two objects, then fastening could be not strong enough to bring into existence composite objects. As a desperate move, in order to make things to compose a further thing, we need only cause them to cohere by gluing (parts of) their surfaces. However, as van Inwagen points out:

⁷³ For more details about these possible answers of contact See Chapter Three and for more discussion about co-location see Chapter Four.

Between objects that have been caused merely to cohere, there is a *discernible boundary*: a welding seam, say, or a layer of dried glue. It is possible to cause objects to be joined more intimately than this, so that they melt into each other in a way that leaves no *discoverable boundary*. (1990: 59)⁷⁴

It seems that to make things to compose one thing we just need to find out the way to make the boundary between them the least discernible possible. Fusion can be a better answer to SQC insofar as it entails boundaries to merge in a way such that it becomes indeterminate where an object begins and the other ends. Composition therefore occurs every time that the object's boundaries become together until fusing and disappearing. Van Inwagen's example is the case of artificial Siamese twins Alice and Beatrice. Through an exhaustive surgery, it might be theoretically possible to join one part of Alice's skin with one part of Beatrice's skin. Given the precise match and the healing of both, there is no discoverable boundary to be distinguished between them. However, fusion does not properly answer SQC either. According to his view, if Alice exactly just fits into a region of space R_1 and Beatrice exactly just fits into a region of space R_2 , there is no one object that exactly just fits the fusion of R_1 and R_2 . Or, at least, if there really exists such object, it is not in virtue of the fusion of Beatrice and Alice. If Alice and Beatrice compose an object at every time they exist, then they do compose the very same object; but, if Alice and Beatrice compose the same object necessarily, then their fusion is an insufficient explanation of how composition occurs.

Boundaries therefore are relevant things when we think of composition. We can see that all *Bounding Answers* can be thought in terms of the physical interaction or spatial relations between objects' boundaries. Composition may thus occur when: boundaries are in *contact* and no empty space is left between them; boundaries have physical features or there are physical forces happening on them which make objects to *fasten*; boundaries are so strongly attached (or glued) to one another that they are caused to *cohere*; or boundaries must be completely merged in order to make things to *fuse*. However, most of these answers found in common-sense wisdom are not satisfactory to answer SQC. Maybe, SQC can only be settled if we consider extreme answers in which composition occurs either *always* in all possible circumstances or *never* regardless of the circumstances. However, if we take the latter option, the boundaries of ordinary material objects would not exist at all.

Three Answers to Composition: *Always, Never and Sometimes*

SQC can basically have three different answers: *always, never* or *sometimes*. Compared to *always* and *never*, *sometimes* can be considered as a moderate answer. The 'sometimes' answer entails that composition is *restricted* to only particular conditions; that's why this view can be labelled *Compositional or Mereological Restrictivism* (restrictivism, for short). To say that composition happens sometimes begs

⁷⁴ The italics are mine.

for an explanation to clarify both *when* composition occurs and *when* it does not. Common-sense is a pre-theoretic sort of restrictivism. As we said, there are some cases when composition clearly occurs, others when clearly does not and also when it is not clear at whether it occurs or not. However, the reasons why this happens can be pretty vague in many cases when they depend on arbitrary preferences or spatial intuitions regarding, for instance, how close or far things need to be to compose something.

Peter van Inwagen prefers a philosophically sophisticated restrictivism. His answer to SCQ is that two (or more) objects compose a further object if and only if what they compose involves life activity; or more precisely: the *x*s compose *y* if and only if *y* is an organism and the activity of the *x*s constitutes the life of *y* (1990: 91). Basically, van Inwagen's ontological list only includes simples and organisms.⁷⁵ The remaining things that commonsense is normally used to include as physical objects do not exist; so that the *when* of composition is given by the *when* of life. Nonetheless, criteria to define when something happens and when it does not might entail vagueness. For instance, Rea (1998) suggests that organisms are composite objects insofar as they can show some sort of *functionality*, i.e., their parts serve to a collective function that organizes them in virtue of a unified whole. If functionality works as a compositional principle, then a natural answer arises: "Are there some objects that together exhibit enough functional organization to count as parts of a whole but are not parts of a living organism" (Rea 1998: 354). Rea thinks of 'objects arranged computer-wise' which are not living things but they would satisfy the functionality criterion of composition. Can there be more functionally composite objects? Maybe some watch's parts are functionally organized in such a complex way that together compose a watch. Or maybe what is alive and what is not can be vague if we take the earth itself as a living thing insofar as it shows a functional organization in terms of its continuous geological formations, the natural cycles of its waters, or the different periods of glaciation and deglaciation. Restrictivism therefore is not an extreme answer to SQC, but any criterion to explain the 'when' of composition can be vague if we start finding many borderline cases of *when* some things compose another thing.⁷⁶ If there are too many borderline cases for our criterion of composition, then there are good reasons to think of it as arbitrary. However, this problem can be avoided if we take some radical position.

The 'never' and 'always' are extreme and opposite answers to SQC.⁷⁷ While the former is endorsed by *Compositional or Mereological Nihilism* (nihilism, for short), the latter is endorsed by *Compositional or Mereological Universalism* (universalism, for short). Nihilism is the thesis that for any *x*s, it is never the case that there exists a further object composed of the *x*s. Universalism, on the other hand, is the thesis that for any *x*s, where the *x*s are material objects, it is always the case that there exists a further object composed of the *x*s. Although nihilism and universalism have different ontological commitments to composition, both

⁷⁵ This view is also supported by Merricks (2001) but for different reasons which will be explained later. See also Koslicki (2008: 168-188) for another restrictivist theory of composition based on Aristotelian mereology where composition occurs when some objects compose a single object of a given *kind* under certain formal components associated with objects of that kind.

⁷⁶ It is not a goal of this chapter to criticize restricted composition, but only to explain it to show the contrast with compositional nihilism.

⁷⁷ The labelling of universalism and nihilism as 'extreme' answers to SQC is due to van Inwagen (1990, 72).

have a common advantage over restrictivism. If composition occurs either never or always, then there is no room for vagueness and arbitrariness. Vagueness in composition is related to the idea of a metaphysical boundary that separates when composition occurs and when it does not (call it a *compositional boundary*). If a compositional boundary entails borderline cases where it is indeterminate whether some objects compose other objects, then the attempt to set any sharp boundary to restrict composition in some way or another can entail different degrees of arbitrariness. However, if composition occurs either ‘never’ or ‘always’, then there is neither vagueness nor arbitrariness. Let’s first take universalism.

Universalism looks too strange to be accepted by common-sense. According to it, there exists an object composed of your left thumb and the Obelisk in Buenos Aires and an object composed of that mug in your kitchen and the sun (literally!). As Koons & Pickavance write: “These are entities that neither science nor common sense have ever found need to postulate: Universalism seems to inflate our ontological inventory of the world needlessly” (2015: 127). If someone is willing to accept such a ‘needless inflation of the world’, it must be because of good philosophical reasons. The most widespread one is to prevent the world from being a *vague* place. As we know, common-sense restrictivism is a pretty vague compositional principle. On the other hand, we have also seen that restrictivism in which composition only occurs when some life activity is involved is vague if some non-living things can show a similar functionality than living things. So, if our compositional principle is not necessarily true, then vagueness seems to be foreseeable and “once we admit that this isn’t the distinction that separates the sheep from goats, it is hard to see why any other should” (Rea 1998: 354). David Lewis has a well-known passage about it:

The trouble with restricted composition is as follows. It is a vague matter whether a given class satisfies our intuitive *desiderata* for composition. [...] But if composition obeys a vague restriction, then it must sometimes be a vague matter whether composition takes place or not. And that is impossible. The only intelligible account of vagueness locates it in our thought and language. The reason it’s vague where the outbreak begins is not that there’s this thing, the outbreak, with imprecise borders; rather there are many things, with different borders, and nobody has been fool enough to try to enforce a choice of one of them as the official referent of the word ‘outbreak’. Vagueness is semantic indecision. (1986: 212)

According to Lewis, the source of vagueness can be either language or thoughts, but not the world itself. If it is vague whether the *xs* compose some further object is not due to the indeterminacy of a compositional boundary, but rather to either the imprecise boundaries of our concepts or the limitation of our thoughts of how the world really is. Once we are convinced of the implausibility of vague compositional boundaries, the option for universalism seems to be inexorable. Universalists thus seem to agree with the following argument:

- i. If composition is ruled by some restriction, then there might be vague compositional boundaries (borderline cases) where it is indeterminate whether composition occurs.
- ii. There cannot be vague compositional boundaries. Otherwise, the world itself would be vague.
- iii. Hence, if the world cannot be vague, composition must occur always.

Although universalism has important drawbacks to be aware,⁷⁸ this research does not intend to spell out its advantages and disadvantages. The main target is to highlight the role that boundaries can play in its ontological commitments. On this respect, we have seen that main motivation to support the ‘always’ of composition is in fact a problem about boundaries. Universalism is grounded on the conviction that there cannot be ‘cut-offs’ in composition since it brings vagueness to the world. To lay down any cut-off in composition (i.e., a compositional boundary that separates when composition occurs from when it does not) involves setting a boundary that accepts some cases rather than others. However, to the extent that some borderline cases arise for that boundary, we may have justified reasons to slightly move it either closer or farther, so we would change the boundary that we first set. We may then find out now more justified reasons to slightly move this new boundary again, and the same story can be said about any boundary or ‘cut-off’ in composition. If every compositional boundary brings with it the existence of borderline cases, then to restrict composition entails the existence of ontologically vague boundaries. There are so many possible philosophically well-justified boundaries that to pick up one rather than others could be an arbitrary choice. Universalism rejects the existence of vague boundaries of composition and the arbitrariness it entails, but its solution is radical: there are no boundaries to set when things can compose a further thing because composition is unrestricted –it *always* occurs.

Vagueness appears every time we think of boundaries. Once we have eliminated boundaries, vagueness is not a problem to be concerned anymore. If there are no limits when composition occurs, then there cannot be cases of vagueness in our justifications of why composition occurs in *this* case rather than *that* case. Think about sorites paradoxes. A heap of sand can survive the loss of some of its grains if the detached portion is small enough; the same heap cannot survive the loss of some of its grains if the detached portion is big enough. However, when do ‘small enough’ and ‘big enough’ set a clear boundary to determine whether the heap has survived or not the loss of some of its grains? Or how many of the atoms that compose a table are needed to guarantee the existence of the table? There are too many possible boundaries to set there that any of them seems to be an arbitrary decision. According to this view, any boundary that intends to restrict either *when* things compose one thing or *when* something can survive mereological changes can entail different degrees of vagueness. However, if the world itself, as universalism contends, cannot be a

⁷⁸ Some of them are as follow. The first is related to this last commitment to four-dimensionalism. Universalism itself is an ontology which is resisted by both commonsense and science, but to add the view in which ordinary objects are in fact temporal parts seems to be a metaphysical candy too big to swallow. Second, van Inwagen (1990) argues that universalism would be similar to a Set theory: for any collection of objects, there is a set that always has those objects as its members. Universalism would therefore have mereological essentialist consequences. Finally, universalism is a highly counter-intuitive account: it promotes the existence of too extravagant objects. This is what Markosian calls the ‘fatal objection’: “Universalism entails that there are far more composite objects than common sense intuitions can allow” (1998: 228). We could have very good philosophical reasons to accept universalism, but its ontological promiscuity goes even beyond common-sense.

vague place, it is preferable an ontology that gets rid of any boundary that separates cases where composition succeeds from cases where it does not. There are no metaphysical boundaries that restrict composition. If any boundary is meant to set that restriction, its source can only be either our language or our thoughts.

Nevertheless, the ‘always’ of the unrestricted composition is controversial because it does not tolerate only atoms composing tables or planets, but also an object composed of your dinner table and Saturn. Maybe, a better but equally radical answer can be the ‘never’ of nihilism, but it would entail that there is no room in the world for tables or planets and their boundaries.

Nihilism: The *Problem of (Many) Boundaries*

In Chapter One we saw three answers to the question ‘How many things are there in the world?’: *many*, *one*, or *none*. We already know that, according to common-sense, the world consists of *many* composite objects but *when* composition occurs can be vague in many cases. By adopting monism, the world is drastically reduced to only *one* substance having no parts. On the other hand, to say that there is *nothing* is meaningless unless we specify what kind of objects are said to be none. Nihilism is the position that there is nothing such as your house, the bed where you sleep, the shoes you wear, and any everyday physical object including yourself. How can we however make sense of such radical ontological claim? The strategy looks paradoxical: in order to reject the existence of the countless number of things that common-sense usually accepts, a nihilist claims that there only exists a sort of things which are countless too. Nihilists do not believe that there is nothing at all. They instead believe that there is nothing composed of other things ever. The world thus consists of a huge number of mereological atoms (objects without proper parts) and no two or more of them can compose something ever –regardless if they are either far away, close, very close, or even when their boundaries are side by side (in contact).

What does it motivate nihilists to dismiss common-sense beliefs about what kind of objects exist? As I see it, one motivation follows what Peter Unger (1980) called the *problem of many* which basically stems from the vagueness found in boundaries of everyday physical things. Unger first presented it in two different works in terms of ‘sorites of decomposition’: ‘I Do Not Exist’ (1997) and ‘There Are No Ordinary Things’ (1979). The argument is as follows:

- i. There is at least one stone.
- ii. For anything there may be, if it is a stone, then it consists of many atoms but a finite number.
- iii. For anything there may be, if it is a stone (which consists of many atoms but a finite number), then the net removal of one atom, or only a few, in a way which is most innocuous and favorable, will not mean the difference as to whether there is a stone in the situation.

These three premises are jointly inconsistent. If there is a stone, it must be composed of a large number of atoms. That is, there are many but finite atoms –let’s say a billion– within a region of space *R* occupied by the stone. The net removal of one atom from *R* leaves a billion minus one atoms within *R* and there is still a stone occupying *R*. We can remove two atoms away from *R* and there is still a stone occupying *R* and so on until removing a billion of atoms from *R*. The absurdity is that there cannot be a stone consisting of no atoms at all. There cannot be a stone occupying *R* where no atoms can be found within *R*. According to Unger, the alleged existence of the stone in premise (i) has driven us to an absurdity in which we have a stone made of no atoms. If this argument applies for stones and every composite object of everyday life, then it is better to eliminate them from our list of *what there is*.

Unger’s *problem of many* is also based on sorites of composition but from a different approach. The problem is mainly focused on vagueness boundaries of ordinary objects. The strategy is to think of the vagueness that sorites concepts such as ‘tall’ or ‘bald’ entail regarding where a boundary must be drawn. Being tall or being short as well as being bald or being non-bald are features of people. What is however the exact height to determine when someone is definitely tall rather than short or the exact amount of hair to determine when someone is definitely bald? Are there sharp boundaries? Apparently, there are none but only vague or fuzzy ones. Unger takes boundaries of ordinary physical objects as instances of vagueness: “the leading idea is to focus on physical, spatial situations where no natural boundaries, no natural stopping places, are to be encountered” (1980: 413). Taking the Unger’s example of a cloud, the *problem of many* is as follows:

Any ordinary physical object seems to be a bounded entity, i.e., the matter that composes it reaches a boundary and, beyond it, nothing of the object can be found. A cloud is an instance of physical objects. A cloud must have a boundary or, as Unger calls it, a *stopping place* where “once one is beyond such a stopping place, or group of stopping places, or, as I shall most often say, such a boundary, one is outside the cloud, that is, at a place where the cloud is not” (Unger 1980: 419). A cloud has a boundary as the ‘stopping place’ of the extension of the physical space filled by the cloud. By seeing a single perfectly white cloud in a beautiful blue sky, our naked eye seems to see a sharp boundary which clearly distinguishes where the cloud stops and the sky begins. If we could however see it closer, we would realize that the fluffy and homogeneous stuff that compose the cloud becomes a collection of swarms of water droplets separated by either larger or smaller portions of empty space. At the boundary or *stopping place* of the cloud, the swarms of droplets and the surrounding sky gradually melt down: there is a progressive transition from more density to less density. As Unger says: “there is no place at all where suddenly, or dramatically, the “denseness” falls off and the “sparseness” first begins. [...] In this reality, which in all relevant regards is the actual reality, [...] there is no natural break, or boundary, or stopping place, for any would-be cloud to have” (1980: 415). The alleged single cloud has been so far considered as the only object having its boundary. Nevertheless, the *problem of many* begins with the vagueness involved in considering ordinary physical objects as single entities having *one* boundary.

If we carry on with our closer inspection of the cloud, some droplets are *certainly* parts of it (they are scattered either inside of the portion of space enclosed by the cloud's boundary or along the boundary itself), whereas many other droplets are scattered in the cloud's surroundings near but it is indeterminate whether they are part of the cloud's boundary. By taking some of them, the boundary of the cloud would be one, while by taking others, the boundary would be other. Given that there are so many borderline droplets for the cloud, there are also many possible boundaries for the cloud which slightly differ each other. Therefore, the alleged cloud's boundary becomes now a very vague stopping place. Unger's argument (1980: 10-12) can simply be paraphrased like this:

- i. If something is a (typical) cloud, then there is something that limits or bounds the cloud, i.e., something that is the boundary of the cloud.
- ii. In the vague *stopping place* of one cloud there exist millions of others candidates to be the cloud's boundary which slightly differ in the droplets they bound.
- iii. If there are millions of candidates of boundaries to be the cloud's boundary, then there are millions of clouds where only one cloud is supposed to be.

What is the boundary of the cloud? What is the 'genuine' cloud? Given the overpopulation of boundaries, any cloud to be said the 'genuine' cloud is an arbitrary answer. Thus, if every boundary counts as a possible boundary of a cloud, then there are many aggregates of droplets which count as a typical cloud. As Unger writes:

We need only realize that "between" the two boundaries considered there are an infinite number of others. [...] Each one, so to say, makes a slightly greater bulge than the one before it, the maximum being the bulge of the secondary boundary. So we have an infinite number of very similar boundaries there. Each bounds an entity different from that bounded by every other; indeed, they all differ, though very slightly, in mass, in volume, and even in shape. We have here an infinite number of bounded concrete entities. (1980: 435)

In this paradoxical situation, Unger offers a disjunctivist solution: either there is a typical cloud which entails millions of other genuine bounded clouds or there is no cloud at all. Since the former leads to absurdity, the latter seems to be the most preferable. If the existence of boundaries of everyday objects leads us to overpopulate the world unnecessarily with millions and millions of objects, then it is better to get rid of them. Although nihilism and universalism are opposite philosophical theories, both agree with something: composition should not have boundaries (it can happen either *never* or *always* respectively) because, otherwise, the world would be vague.

The *problem of many* is exclusively a problem of (many) boundaries. Commonsense ontology consists of many composite objects having each one a boundary or surface. However, to include such boundaries in an ontology of material beings introduces a vagueness in the world such that boundaries as well as the objects they belong to suddenly begins popping up indiscriminately. This unnecessary increase of things encourages a nihilist to adopt the radical ontology in which composition *never* happens. If there are neither many atoms going together to compose droplets of water nor many droplets of water going together to compose clouds, then there is no such thing as a cloud and its boundary, the *stopping place* where

all problems begin. The same can be thus said about more compact and dense ordinary physical objects having a sharper boundary than a cloud:

In actual typical situations with stones and tables, in contrast to the case with clouds, we find a more problematic part of the object's presumed boundary—the part “adjacent to” (part of the boundary of) some other “solid object.” Now, even if there were no problem with the more exposed parts of a stone's boundary or surface, these problematic parts would generate the problem of the many quite well enough. For in these areas, at least, there is no natural break of any sort; there is no natural limiting place for an object, where it leaves off and where another object, which it is touching, first begins. (Unger 1980: 443)

From a microscopic inspection, the surface of a table also has blurred *stopping place* where some atoms are definitely part of it while others may be and may not be. By taking some of them we have one surface, while by taking others we have a different surface. Since there are many atoms in the border of a table, we have many candidates to be *the* surface and, therefore, many candidates to be *the* table. In this uncertain situation, it would be better to think that there is nothing there to be a table and, therefore, nothing like its surface either. The only things that exist are simples (many of them) which, under no circumstances, can compose something else. These many simples are ontologically harmless insofar as they do not multiply *what there is* unnecessarily. Actually, this is the argument for nihilism that Sider calls ‘Ideological Parsimony’ which posits an epistemic principle: “ideologically simpler theories are more likely to be true” (2013: 239). Unlike universalism, nihilism is an example of parsimony: simples are the only existing material things. Insofar as this is true, “nihilism allows us to eliminate ‘part’ from the ideology of our *fundamental* theories” (Sider 2013: 240). This reduction of the constituents of the world allows to show that puzzles as the ‘Statue and the Lump’ or the ‘Ship of Theseus’ are not really problems since there are no things such as statues, lumps, and ships (van Inwagen 1990: Ch. 13). This ontological parsimony of nihilism is also encouraged by Merricks (2001) and his arguments of *overdetermination*. This argument rests on the following argument:

- i. An ordinary material object *O* (if there is any) is causally irrelevant to whether the *x*s (those simples that *O* is composed of), acting in concert, cause a physical event *E*.
- ii. *E* is caused by the *x*s.
- iii. *E* is not causally overdetermined.
- iv. Therefore, if *O* exists, it does not cause *E*.
- v. Therefore, if *O* exists, it is causally inert; it has no causal powers.

For a physical event, to be overdetermined entails the existence of causes which are not really needed to explain how such event occurs. If an object is not needed in the causal explanation of any event, then that object is causally inert and, therefore, it does not exist. For instance, in the event of a baseball

shattering a window, the baseball would not be needed to explain the window's shattering since such event is already explained by some atoms arranged baseball-wise shattering the window. The baseball (and any macrophysical object) would be a mere epiphenomenon but nothing physically relevant. If the baseball has no causal powers and makes no relevant contribution to explain the alleged event, then we should not accept its existence unless we were willing to accept that the window's shattering is causally overdetermined. Since no events are overdetermined, then the baseball does not exist. According to this view, our ontology must keep the principle of parsimony in order to avoid the excess and redundancy of causal explanations of physical events. A nihilist option is therefore to eliminate ordinary objects as aggregate of parts and just accept simples, as Merricks says, *acting in concert* (whatever it means) are by themselves enough to explain physical events.

In everyday objects, as we have seen, many of the physical phenomena occur on their boundaries or surfaces. The shattering of a window caused by a baseball occurs when their boundaries make contact. Actually, the event is not caused by all the parts that compose both the baseball and window, but only those exposed parts or surfaces. However, by following Merricks' argument, physical events are not caused by composite things having boundaries, but only by atoms arranged baseball-wise or window-wise. If we insist that physical phenomena mostly occur on the surfaces of composite things, then the physical world would be overpopulated by entities causally unnecessary. By following Unger's *problem of many*, the acceptance of the existence of one boundary commits us to accept the existence of billions of boundaries and therefore billions of objects. Thus, the shattering of the windows would be caused by billions of baseballs. The event would be 'over-overdetermined' by millions of bounded entities. Parsimony and causal determination have been violated: there are too many objects causing a single event. It is therefore needed to eliminate boundaries in order to avoid those disastrous ontological consequences. The scattering of the window is already explained by atoms arranged baseball-wise. The explanation of the contact between the surfaces of both the window and the baseball is not needed to explain the event itself. Surfaces are, we might say, causally inert; hence, their existence is not needed at all.

We have seen that both universalism and nihilism do not accept any vagueness in composition. Vagueness is fundamentally a lack of clarity of why a boundary is found 'here' instead of 'there': there are *borderline* cases where it is bluntly indeterminate whether something is definitely 'inside' or definitely 'outside' of what a given boundary separates. Both universalism and nihilism do not accept that the world itself is a vague place. Any sort of vagueness must be sourced in either language or knowledge: vague boundaries can only be the result of either semantic indecision or ignorance. Since a boundary can entail different degrees of vagueness, both universalism and nihilism rule out any sort of boundary to set when composition occurs and when it does not.

On the one hand, universalism is committed to the idea that *there is no boundary* of composition. The world has no boundaries to restrict when two or more objects go together to compose a further one:

composition *always* occurs. Universalism is not affected by vagueness of composition since there are no boundaries where ontic vagueness can emerge. Common-sense agrees that ordinary objects such as tables, books, and stars exist and they have boundaries that we normally refer to them as ‘surfaces’. However, common-sense restrict other sorts of objects that a universalist accepts without remorse such as the object compose of your table and the sun. Universalism accepts the existence of a table and its ordinary boundary or surface, but it may be also committed to boundaries of scattered region of space occupied by the table and the sun. That is, there is spatial boundary enclosing a region of space occupied by an object composed of your table and the sun. Put it differently, the disavowal of boundaries in composition leads to a proliferation of boundaries of regions of space occupied by composite objects that only universalists can accept.

On the other hand, nihilism is committed to the idea that *there is a boundary* of composition. However, it is a sharp and well-defined one that restricts composition in the world: composition *never* occurs. Both universalism and nihilism are not affected by ontological vagueness in composition, but they differ in the strategy regarding how to draw a boundary of when things compose other things: while universalism contends that there is no boundary at all (any composite object is allowed), nihilism contends that there exists a sharp and restrictive boundary (no composite object is allowed). Since the vagueness of boundaries of everyday physical objects radically increases the number of bounded entities and the causal explanations of physical events, the level of vagueness in the world becomes higher and higher. In order to avoid this undesirable situation, nihilism allows a strict ontological boundary in composition. Because of this sharp boundary, ordinary physical objects and their ordinary boundaries are not considered genuine denizens of reality.

Nevertheless, following nihilism, we could argue that there must exist a sort of boundary which is indestructible, *viz.*, the boundaries of simples. Whatever simples can be, necessarily, they are partless objects. If simples cannot be divided into parts, then it can be argued simples must have sharp and precise boundaries where no vague stopping place is possible. Under this circumstances, simples should be metaphysical objects having sharp and indestructible boundaries and any other sort of boundary would be excluded from the ontology room. However, by adopting simples and the kind of boundaries that they would have, does nihilism get rid of the vagueness that boundaries bring into the world after all? This is the topic of Section B.

B. *The Boundaries of Simples*

The Simple Question

Simples are relevant elements in the discussion about composition. If nihilism is the right answer to SQC, simples are the fundamental pieces that the world is made of (which could only compose something,

as van Inwagen's answer to SQC, if and only if life events are involved). In mereological terms, we can define a simple as follows:

x is a (proper) part of y =_{df} x is a part of y and y is distinct from x .

x is a simple =_{df} x is an object that lacks proper parts.⁷⁹

By definition, simples have no parts (taking as a trivial truth that everything composes itself since everything is a part of itself). They can be part of a whole, but nothing can be a proper part of them.⁸⁰ However, if that object exists, what is it? What sort of thing is a simple? Markosian (1998) raises what he calls the *Simple Question*: What are the necessary and jointly sufficient conditions for an object's being a simple? I will briefly mention two main approaches to this question: an *indivisibility account* and a *spatial account* of simplicity.⁸¹ I will start with the first one. Simplicity is a case of *indivisibility* (this naturally comes from the Greek word 'atom' which means *indivisible thing*). A simple is an extended material object which cannot have physical parts, i.e., it is physically indivisible.

(PI) *The Physical Indivisibility View of Simples*: Necessarily, x is a simple if and only if it is impossible to *physically divide* x into parts.

According to PI, simples are material extended objects, i.e., physically bounded entities spread out in three spatial dimensions. They are the fundamental building blocks of the world: where the division of reality stops and matter cannot be cut off into smaller pieces. A vase (and any ordinary physical object) is destroyed when it is broken into so many pieces that no vase is said to be there. Those pieces can also be broken into further smaller parts and those further parts broken into further smaller parts and so on. This chain of division cannot be *ad infinitum* if simples exist since they cannot be broken into further smaller parts. Simples are in fact the smallest possible physical objects that could be identified with fundamental particles in physics (e.g., quarks, electrons, or bosons). If simples are physically extended in space, then we can conceive them as objects having some sort of indestructible boundaries (whatever that might mean for fundamental particles). To divide an object entails making a cut to separate it into parts. Nevertheless, there are no possible cuts to make on simples insofar as –by definition– they are partless objects. Simples would have a sort of physically impenetrable boundaries which allow them to be indivisible objects.

However, PI does not necessarily entail for something to be a simple. As it is proposed by Markosian (1998a), we can imagine a chain made of some unknown material which is physically impossible to divide

⁷⁹ Hudson for instance defines a simple as follows: "An object's *proper parts* are those of its parts numerically distinct from it. A *simple* is an object with no parts" (2007: 292).

⁸⁰ This is an opposite view to what David Lewis (1991: 20) has called 'atomless gunk'. There are no simples in a gunky world since, necessarily, everything has proper parts. See Sider (1993) for a more detailed discussion about this topic.

⁸¹ This distinction is taken from McDaniel (2007) who also includes the *Fundamentality Account* that is divided into *The instance of a Fundamental Property View of Simples* and *The Independence View of Simples*. However, I overlook them now.

or break into pieces. According to PI, this object is a simple. Although the chain is unbreakable, it is clear that a chain is made of parts; hence, it is not a simple. We can therefore imagine material objects having parts even though their surfaces are physically impenetrable boundaries. We can turn the argument by saying that simplicity is not a matter of physical indivisibility but *metaphysical indivisibility*:

(MI) The Metaphysical Indivisibility View of Simples: Necessarily, x is a simple if and only if x cannot be *metaphysically* divided or decomposed into further parts.

This definition is obscured if there is no clarity of what is meant by *metaphysical division*. We can take some passages from Wittgenstein's Tractatus (2001) to attempt one possible explanation:

- 2.02 Objects are simple.
- 2.021 Objects make up the substance of the world. That is why they cannot be composite.
- 2.024 Substance is what subsists independently of what is the case.

Simples are not taken to be objects incapable of being physically divided, but some kind of metaphysical basic elements which are the *bedrock* of the world. Simples are the result of the *logical analysis* of the world and language. There is a top-down logical structure from *complexity* to *simplicity* shared by language and the world in virtue of a common logical form: while the world consists of states of affairs which are broken down into simples (objects), language is articulated through propositions which can be logically reduced to its most basic semantic elements (names). This is the traditional procedure of *logical atomism*. Instead of physical indivisible objects, simples are metaphysical atoms which are an *a priori* postulate of logical analysis of language. MI is given by logical necessity: simples are metaphysically indestructible insofar as they are the basis of the world where logical analysis reaches its limit. PI can be rewritten as follows:

(MI) The Metaphysical Indivisibility View of Simples: Necessarily, x is a simple if and only if x is an analytically *indivisible* (or logically unanalyzable) component of the world.

Since there is no further logical analysis to do once simples have been postulated, they must be ontologically independent objects: their existence only depends on themselves insofar as they are the ultimate and unchangeable components of the world. As Russell writes: "The justification of logical atomism, of the view that you can get down in theory, if not in practice, to ultimate simples, out of which the world is built, and that those simples have a kind of reality not belonging to anything else" (1985: 142). Simples are not *partless* objects in *physical space*, but *unanalyzable* objects in *logical space*. *Simplicity* is

therefore given by *logical indestructibility* (indivisibility). Unlike PI, according to MI, simples do not have *physically impenetrable boundaries*, but *logical limits*.⁸²

On the other hand, the *Spatial Account* of simplicity suggests that being a simple entails some spatial feature. For instance, one option is to believe that simples cannot be extended in space: they fail to have any spatial dimensionality (simples are zero-dimensional objects). This is called the *Pointy View of Simples*:

(PV) *The Pointy View of Simples*: x is a simple if and only if x is a pointy object.

Simples are point-like particles as an idealization or abstraction of the fundamental particles studied in physics. Points do not take up space in any of its possible dimensions (they have neither width, height, nor length). Having some spatial dimension entails a parthood structure. Every spatially extended object can be divided into parts of its same spatial dimension while having a boundary of fewer dimensionality: cubes can be divided into three-dimensional parts having a surface as a boundary; planes can be divided into two-dimensional parts having lines as boundaries; and lines can be divided into one-dimensional parts or segments having points as boundaries. To be an extended object entails being a bounded entity spread out through some spatial dimension. Points are not bounded entities insofar as boundaries of fewer dimensionality than points do not exist. If points have no boundaries, then they are non-extended objects which cannot be divided into further spatial zero-dimensional parts. Euclidean geometry is therefore built on these primitive objects which cannot be defined in terms of other objects or boundary possession. If PV is correct, simples do not have spatial dimensionality.

The main objection to PV raised by Markosian is that, if PV were true, then it is not possible a world in which only one physical object exists. Imagine that there exists a perfectly an isolated solid object O surrounded by empty space. In this possible world, O is a *spatially continuous object*⁸³ made of some homogeneous material substance that fills a region of space continuously without leaving empty sub-regions of space. In this case, in the region of space filled by O exists infinite objects: either some parts of O can be composed of simples or at least some part of O is composed of atomless gunk (i.e., every part of that part has a proper part). Following PV, if O exists, the region of space that fills must contain an infinite number

⁸² MI is also explained in relation to the intrinsic properties of an object: necessarily, S is a simple if and only if S cannot be metaphysically divided without first changing the intrinsic properties of S (e.g., size and shape). See McDaniel (2007) for some criticism about the Indivisibility account in general and the idea of intrinsic properties in the metaphysical view in particular.

⁸³ Markosian defines a *spatially continuous object* as an object that occupies a *continuous region of space*. He understands the concept of a 'continuous' space from what Cartwright calls a 'connected' space. According to the set of Cartwright's definitions: R is *continuous* means R is not discontinuous; R is *discontinuous* means that R is the union of two non-null separated regions; R and R' are *separated* means that the intersection of R and R' with the closer of the other is null; and the *closure* of R means the union of R with the set of all its boundary points. The remaining definition of boundary takes the classical topological distinction between open and closed objects. A *boundary point* is a member of the set of points of a region of space R where there is intersection between R and R' 's complement. A region of space R is closed if and only if R 's boundary points are members of R , whereas R is open if and only if R is closed by the set of boundary points which are members of R 's complement. On this respect, a spatially continuous object O is an object that occupies a connected region of space R where no separated sub-regions of R exist. Thus, O saturates R where all the space within R 's boundary is connected (or continuous).

of points. In both cases, either O composed of points or O composed of at least a gunky part, the number of objects in the world is infinite. This entails that PI is inconsistent with a possible world where only one spatially extended object exists. That world would in fact be highly populated by the alleged isolated object and the infinite parts it is composed of. However, as Markosian says, “it seems to me that the expression ‘a world containing just one physical object, which happens to be spatially extended’ is also a perfectly good, and literal, description of a possible world” (1998b: 219). This conclusion leads Markosian to endorse a different answer to the *Simple Question*:

(MaxCon) The Maximally Continuous View of Simples: necessarily, x is a simple if and only if x is a maximally continuous object.

A mereological simple is a maximally continuous object which “occupies the largest matter-filled regions of space” (Markosian 1998: 222). That is, x is said to be a maximally continuous object occupying a matter-filled region of space R when (i) R is not proper sub-set of some larger matter-filled region, and (ii) R is entirely filled by the matter that composes x (i.e., R has no empty sub-region where the matter that composes x cannot be found). According to MaxCon, a mereological simple is an extended physical object that fills with matter everywhere the region of space it occupies.

MaxCon is not an intuitive answer to the Simple Question. Unlike PV in which simples are point-like particles without any spatial dimensionality, a MaxCon simple is not defined in terms of size (or shape), but in terms of whether an object *maximally* occupies a matter-filled region of space. Simples can be perfectly physical objects filling three-dimensional matter-filled region of space. If the main requirement for something to be a simple is to fill with matter a region of space continuously without being part of some larger region of space, then simples can be any size or shape. MaxCon allows that a mereological simple could be bigger than sub-atomic objects, or even as big as the universe thought by Parmenides as a giant simple. On the other hand, the invisibility account (either PI or MI) can raise an objection to MaxCon: if an object is spatially extended, then it has two halves; if an object is divided into two (or more) parts, then that object is not simple. MaxCon rejects the first premise since it rejects what van Inwagen (2001) calls the *Doctrine of Arbitrary Undetached Parts* (DAUP). Roughly speaking, DAUP says that a material object has proper parts which correspond to every sub-region of the region it fills at some given time. If there are good reasons to reject DAUP, then there can be extended simples (without proper parts) regardless the shape or size the region of space it occupies could have.

I have briefly spelled out different answers to the Simple Question.⁸⁴ Although they disagree the right answer to simplicity, they seem to agree that simplicity is about boundaries. First, PI and MI both define simplicity in terms of invisibility: something is *physically* indivisible if it has an impenetrable physical

⁸⁴ There is another not considered answer to the Simple Question but as important as the views examined here. It contends that simplicity is brute. This is the *Brutal View* defended by McDaniel: “There is no correct, finitely stable, or non-circular criterion for being a simple. There is no non-mereological criterion for being a simple” (2007: 233).

boundary that makes impossible to break it into parts, whereas something is *metaphysically* indivisible if it has a logical limit of further analytical decomposition. Second, PV simples must be non-extended objects. An object is extended insofar as it has a boundary of lower spatial dimensionality, and it can be divided into parts of its same spatial dimensionality. Since points do not have boundaries along any spatial dimensionality (and so they cannot be divided into parts), they are simples. Thus, simplicity needs to get rid of boundaries. Finally, MaxCon accepts extended simples, i.e., entities having a boundary along some spatial dimension. A Material object of any size and shape can therefore be a simple if and only if it is a maximally continuous object. That is, to find a material simple implies to find a sharp boundary of a continuous three-dimensional region of space that contains and compresses all the matter that composes that simple without leaving empty space. However, despite either their indestructibility, sharpness, or indivisibility, simples are objects that can have vague boundaries.

Quantum Physics and the Likelihood of Location

Nihilism can be thought as a consequence of the problem of vagueness that composition brings into the world. Following the *problem of many*, vagueness arises from *composition* and *location*. First, there are so many borderline atoms spread out in a table's surroundings that it is indeterminate whether some of them are part of the table's surface. If we take some of them we have one surface, while by taking others we have another surface. Which surface is the genuine boundary of the table? We can choose either only one (which looks arbitrary) or millions of them (which overpopulates the world with tables unnecessarily). Second, if an object is located at some given time where their parts are found, then it would be indeterminate where an object having many borderline parts can be found at that time. If a table has now millions of borderline atoms along its surface at a given time, then it is indeterminate where it can be exactly located at that time. If vagueness cannot be ontological (as nihilists believe), it is preferable to eliminate composite objects and their boundaries. Once composition has been completely dismissed, simples remain as the only material beings.

If simples are partless objects, there cannot be borderline parts in their outskirts; so, there is no vagueness in both composition and location. If a simple x is just trivially composed of itself, then (i) there are no other simples slightly different to x which would emerge from x 's outskirts and (ii) x 's location can be exactly found in space insofar as x has no borderline parts. Simples seem to have completely sharp boundaries having no vague *stopping place* (or any spatial boundary as pointy objects). Simples cannot have internal boundaries either. As MaxCon suggests, simples can be any size and shape, but given the denial of DAUP, internal boundaries dividing a simple are just arbitrary lines. If vagueness then comes from parthood, simples cannot be vague since they lack that kind of structure. Simples wholly exist in one place at an instant and we do exactly know where that place is. Does nihilism however avoid any sort of vagueness in the world? Can simplicity still be vague despite it lacks parthood? In my view, the removal of composition does not free the world from its problems about vague boundaries.

Someone can argue that a nihilist does not accept vagueness of composition but she could accept vagueness in the location of a simple as a case of ontological vagueness. In fact, the idea that a simple is vaguely located does not contradict the thesis that simples are the only existing material beings. However, to deny ontological vagueness in some case (when composition occurs) and to accept ontological vagueness in other cases (where a simple is located) can entail a vague boundary again that separates when the world is vague and when it is not. If we take seriously the thesis that the world itself cannot be a vague place, then there cannot be some vague boundaries and some sharp boundaries because the boundary between both can always have borderline cases. If ontological vagueness is not possible, then it is not possible in any case.

Philosophers often think of simples as objects to be defined by science rather than philosophy. For instance, van Inwagen (1990) believes that there is no need for a philosophical definition of simplicity. Instead of some ontological purpose, the usage of the term ‘simple’ is merely in virtue of an economic view of the world in which its basic components can be defined by science.⁸⁵ Thus, I take simples, if they existed, as extended objects defined in terms of fundamental particles posited by physicists. What can it be learnt from physics about the ultimate constituents of the world?

What quantum physics theorists have discovered about fundamental particles challenges the classical Newtonian framework in which objects are located somewhere at once and moving from place to place in either straight or curved lines. According to contemporary physics, particles have a dual behavior as both particles and waves that shows us that we cannot know with precision whether particles are *here* rather than *there*. The wave-particle duality has been empirically confirmed by the *double-slit experiment* carried out by Clinton Davisson and Lester Germer in 1927. Basically, it consists of a ‘particle gun’ sending an electron beam toward a plaque with two small slits. On the other side of the plaque, there is a screen that indicates the position where every electron hits. A pattern is drawn on the screen following the slits where electrons go through. If electrons behave as balls traveling in a straight line over the surface of a snooker table, the pattern should then follow the pattern of the slits: two well-defined places where electrons hit the screen. Nature however says something different. The pattern found in the screen shows that the electrons hit the screen in more than two patterns. How can this be possible? The only explanation is that electrons do not travel as objects normally do, but as waves spread out in space (like waves through the surface of a pond) which overlap with each other forming an interference pattern on the screen. As Cox and Forshaw write in their book *The Quantum Universe*: “This therefore is the challenge: build a theory of point-like particles such that those same particles are also spread out. This is not impossible as it sounds: we can do it if we let any single particle be *in many places at once*” (2011: 28). If particles are literally waves, then they do not

⁸⁵ Van Inwagen says: “I do not know much about simples. The notion of a simple is a functional, not a structural or ontological notion. The term ‘simple’ was introduced into our discourse as a name that play a certain role in the economy of the physical universe. If there are things that play this role, it is by no means evident what their nature might be. If current physics is right, then it seems fairly clear that the category ‘simple’ comprises quarks and leptons and gauge bosons” (1990, 158).

move by occupying different continuous points of space at different times, but by being spread out as in *all of them at once*.

Physicists call the ‘wave function’ to the mathematical measurement of the probability of where particles can be spatially found. Unlike particle objects which are placed somewhere at an instant, waves are spread out in space having different simultaneous disturbances. The wave function does not tell us the exact place where electrons can be found at some given time, but their *likelihood* of location: the probability of finding an electron is higher where the wave is larger, whereas it is lower where the wave is smaller. Electrons can be thus located *somewhere* throughout waves and not just in one spot at once; and “when we said that the electron is ‘somewhere within the wave’ we really meant to say that it is simultaneously everywhere in the wave!” (Cox & Forshaw 2011: 31-32). The travel of electrons does not follow straight movements from one place to another, but it rather sweeps through all possible paths simultaneously.

A consequence of this wave-particle duality is the *Heisenberg Uncertainty Principle*. This principle states that it is impossible to know simultaneously the position and momentum of a particle: the more is the knowledge of the possibilities of locating a particle somewhere at some initial time, the less is the knowledge to measure and predict how fast it moves. The best what physicists can do is predict the likelihood of a quantum particle of being here rather than there; but, whereas probabilities of location are limited, some information about velocity is inevitably missing (and *vice versa*). This uncertainty is due to neither knowledge nor imprecision of mathematical language, but nature itself does not work accurately. As Cox & Forshaw states:

It is not the case that we can only predict the probability of a particle being in one place or another because we are ignorant. We can’t, *even in principle*, predict, with what the position of a particle will be. What we can predict, with absolute precision, is the probability that a particle will be found in a particular place if we look for it. [...] Theoretical and experimental progress indicate that Nature really does use random numbers, and the loss of certainty in predicting the positions of particles is an intrinsic property of the physical world. (2011: 45)

Boundaries and the Modal Vagueness of Simplicity

What are the consequences of quantum particles for any account of simplicity? First, the idea of simples as bounded objects existing in one place at some instant is challenged by the wave-particle duality. Insofar as we think of simples as objects, then it is more less natural to conceive them as having a boundary at every time they exist. Nonetheless, waves are different kind of material beings where the idea of boundary becomes a fuzzy issue. As a wave, an electron is spread out in space without being located just in one place at once. We could say that the boundaries of a wave-particle are given by both the *maximum amplitude* (reached in the wave’s crest) and the *wavelength* (distance between the wave’s peaks). In this case, there

would not be vagueness to the extent that we can make precise mathematics for the values of both ‘boundaries’. However, even though it may work this representation of what boundaries of a particle could be, it is still quite different from our natural notion of boundaries of three-dimensional extended objects.

Given that simples are partless objects having sharp boundaries (or points lacking boundaries of any spatial dimension), we have said that they cannot have instances of vagueness in both composition and location. However, this picture of simplicity is diluted to the extent that quantum particles can play some relevant role to define simplicity. I take from Heller (2008: 72) that physical objects have spatial, temporal, and modal boundaries: we can know the *place* where it exists, the *times* at which it exists, and the *worlds* where it exists.⁸⁶ According to quantum physics, there is neither an exact place *where* a particle is located nor a precise time *when* to find it and so the best we can do is predict likelihoods. This sort of vagueness of simplicity does not arise from parthood, but it does from an indeterminacy of its *modal boundaries*. For a modal boundary is meant that boundary drawn to determine the actual world among many other possible worlds. Since a quantum particle has similar likelihood of being found *here* or *there* throughout the wave (i.e., it moves through all *possible* paths simultaneously), we can think of the likelihoods in terms of the possible worlds where a particle can be located at once. However, how can we draw a precise (modal) boundary to determine what world should be the *actual* world where a particle is *now* located? If nature itself is not precise about where a simple can be found at an instant and it only gives us probabilities of location, then there is no precise modal boundary to determine whether *this* world or *that* world instantiates its actual location.

Imagine a little rubber-ball (called Rub) bouncing and moving so fast inside of a room that you cannot know its actual location. To make it easier, put Rub inside of a box. Rub is a simple according to quantum theorists. Following the *Heisenberg Uncertainty Principle*, if we collect more information of Rub’s velocity, we have less information of its actual location; if we instead collect more information of the point where Rub is located at an instant, we have less information of how fast it moves from that point to another. Since Rub behaves as a wave, it is not merely located at one point at once, but spread out *everywhere* in the box. We thus have a range of probabilities of all *possible* paths of Rub. In modal terms, there are many possible worlds (with similar likelihood) where Rub is inside the box at a given time. Rub’s location therefore is indeterminate insofar as nature does not give us exact information to decide which one of those worlds is the actual world. We cannot pick up only one world since Rub is spread out along *all* of them. What we certainly know is that Rub’s travel cannot be measured by taking all points that Rub occupies at different times. Rub’s travel is therefore the sum of the worlds where Rub has more probabilities to be found. We cannot indicate a single and precise spot of Rub’s location inside the box because Rub is literally *everywhere*. This is however pretty vague. If your keys are lost inside your house and you ask ‘Has anyone seen my keys?’ and someone says ‘Yes, I’ve seen them. They are everywhere in the house’, then you would be right to feel upset.

⁸⁶ See Chapter Four for more details about Heller’s idea of ‘modal boundaries’.

Vagueness of simplicity cannot be given by composition because simples are just trivially composed of themselves in every possible world where they are found. Simplicity does not allow vagueness of both spatial boundaries and temporal boundaries: at different times, simples should exactly occupy a region of space having no borderline parts in their spatial surroundings. An extended simple is therefore presented as a whole at every time in the region of space it occupies. However, a simple can be vague due to the diversity of the possible matter-filled regions it might occupy: the likelihood for a simple to occupy *this* matter-filled region and *that* matter-filled region are similar. Vagueness therefore arises, taking Heller's expression, from the *modal boundaries* of simples. If we think of simples as those fundamental particles in physics, then we can think of a simple as an object *modally spread out in different possible world* where it is located. If it is indeterminate whether a region of space is occupied by matter, then we cannot draw a modal non-arbitrary boundary to clearly set the world in which a determined matter-filled region is actually occupied by a simple.

This sort of vagueness of simplicity can be also taken from Peter Simons who defines an extended simple as "an entity without proper parts (so a simple) whose locus *does* have proper parts" (2014: 63). This view of simplicity is based on rejecting what Simons (2004) calls the *Geometric Correspondence Principle* (GCP) in which any extended object has parts corresponding to the parts of the region it occupies. There is a perfect geometrical match between the mereological structure of space and the mereological structure of bodies: the parts composing a whole exactly correspond to the sub-regions of the largest region of space that the whole occupies. Simples would make GCP easy to follow: since an extended simple is a partless object, the region of space it occupies has no sub-regions. It is not that easy though. According to Simons, the *locus* is the region of space that an extended object occupies. Simples are extended simples without proper parts corresponding to sub-regions of its *locus*. For a quantum particle, the probabilities to find its possible *locus* are distributed in every sub-region of the space where it moves. Thus, an extended simple –let's say a quantum particle *P*– has no physical parts which correspond to parts of the region *R* it occupies; *P* is a mereological simple that occupies a modally complex region *R*. However, *P* does not occupy sub-regions of *R* at different times; rather, it exists spread out along every part of *R* without becoming itself a composite object. As Simon writes: "P has *ex hypothesis* no parts (itself excepted of course) so *a fortiori* it has no parts corresponding to R. We have to think of P's occupation of R as a holistic fact: all of P occupies all of R, and that's all there is to it" (2004: 377). Put it differently, a simple is a partless object modally spread out in the different sub-parts of the region of space it largely occupies. This violation of GCP triggers a source for modal vagueness insofar as there is no sharp boundary to take one possible world as the actual position of a simple to be chosen over other worlds.

The modal vagueness of simplicity is also inspired by Katherine Hawley (2004). From quantum theory, she assumes that if it is sometimes indeterminate whether a given point is matter-occupied, then simplicity could admit modal vagueness. In case of the *Pointy View* of simplicity, points are the only candidate of simplicity. Nonetheless, vagueness arises for each matter-filled point insofar as it is

indeterminate whether a point-sized object exactly occupies it. If we take the *Indivisibility View*, then modal vagueness could arise “whether a given possible object is the actual object, or from vagueness as to whether the relevant possible object is divided” (Hawley 2004: 399). If it is indeterminate whether or not a given point is matter-occupied, then it would be vague whether or not an object is divided.⁸⁷ If other worlds do not make sure whether the actual object is divisible, then there would be borderline instances for the indivisibility answer to simplicity. Something similar can be said about MaxCon. A MaxCon simple does not have vague spatial boundaries insofar as the region of space it occupies has a determinate and homogenous distribution of matter without gaps or unoccupied sub-regions of space: a maximally continuous object exactly occupies a matter-filled region that is not part of any larger region of space. Hawley argues that if x is the largest region that *determinately* contains matter of an object O and y the largest region that *indeterminately* contains matter of O , then identity vagueness could arise. It is determinate that an object fills x with the matter, but indeterminate whether an object fills y . If so, it is also indeterminate both whether O is identical with x (i.e., a simple that occupies a maximal continuous region) or whether O is identical with the sum of x and y (i.e., a composite object). Thus, if we take the uncertainty of location as a feature of wave-particle duality in quantum theory, then answers to the Simple Question may still have vague components.

Although nihilist theorists seem to avoid compositional vagueness, they cannot take vagueness of simplicity away from the world. This vagueness comes from neither spatial boundaries nor temporal boundaries, but from the vague modal boundary of whether *this* world or *another* world actualizes the precise location of a simple. If each world has a similar likelihood, then any selection would be arbitrary. As Hawley says, “answers to the Simple Question are supposed to be metaphysically necessary truths, true in far-fetched worlds as well as what we take to be the actual world” (2004: 402). Nevertheless, the universe itself is a vague place where the best we can do is predict the possible worlds where simples can be probably found. Following nihilism, if there is any boundary in the world, it is the boundary of a simple which can be spatially sharp and precise, but modally vague and indeterminate.

Final Remarks

We wondered about what boundaries can be considered genuine denizens of reality. If we take nihilism as the right ontology, then there is no such kind of things as the boundaries of ordinary material objects since there are in fact no material objects at all. Nihilism and universalism are both extreme answers to the Special Composition Question: while the former says that composition *never* occurs, the latter says that it *always* occurs. Despite their opposite views, nihilism and universalism both agree that the world cannot be a vague place. That is, there cannot exist a vague boundary in which it is indeterminate when

⁸⁷ Hawley gives the following as an example: “Imagine a cheese-sandwich-shaped object, in which the slices of bread correspond to regions determinately filled with matter, and the cheese corresponds to a region indeterminately filled with matter. The sandwich-shape region is continuous, but the bread-shape region is discontinuous. Now, imagine an object which exactly occupies the sandwich-shape region if that region is matter-filled, and exactly occupies the discontinuous sum of the two bread-slice-shaped regions otherwise. If it is vague whether the cheese-shaped region contains matter, then it is vague whether the object in question is divided” (2004: 399).

composition occurs and when it does not (it does occur either never or always but no sometimes). Following nihilism, the world just consists of nothing else than simples which, given their lack of parthood, can be seen as objects having sharp and precise boundaries. Nihilism then would avoid ontologically vague boundaries by restricting composition in all circumstances and by accepting simples and their sharp spatial boundaries as the only existing objects. However, nihilism does not free the world from vague boundaries at all insofar as simples have modally vague boundaries of location in terms that there is no sharp boundary to draw to determine what world actualizes the location of a simple and what world does not. Next final chapter will address in more details the distinction between natural and artificial boundaries.

CHAPTER SIX

Sharpening the Boundaries of Things

Fiatness and Fideness

Introduction

This last chapter addresses, in my view, one of the most interesting topics to discuss about boundaries: the distinction between natural and artificial boundaries. Are there boundaries in the world which only depend on how the world itself is regardless our thoughts? If there are, what and how are they? Are artificial boundaries mere arbitrary lines or they can be based on some real features of the world? Is the boundary that separates natural boundaries from artificial boundaries clear at all? Are the boundaries of everyday physical objects genuine denizens of reality? Each of these questions will be raised throughout the chapter. The main thesis is that we draw *fiat* or artificial boundaries over objects having *bona fide* or natural vague boundaries. In particular, boundaries of composite physical objects (i.e., objects having parts) can be blurry zones that we tend to make as sharp as possible by drawing our own boundaries. However, in what sense a boundary can be ontologically vague, i.e., vague for itself and not because of our own imprecisions?

In this chapter, it is thus explained first the distinction between *fiat* boundaries and *bona fide* boundaries. Second, following the discussion in Chapter Five, it is addressed nihilism as the thesis in which boundaries of ordinary physical objects (and any other composite object) are *fiat* constructions but nothing existing in reality itself; the only *bona fide* boundaries (if there is any) would be the sharp boundaries of simples. Third, it is discussed the role that boundaries can play when objects can compose other objects. In particular, if there are good reasons to posit the existence of a *bona fide* boundary in the contrast between a collection of objects and the spatial environment, then there might also be good reasons to posit the existence of a composite object. Finally, if there are *bona fide* boundaries of composite objects, then, in a modal context, they can be ontologically vague things that we try to precise them as much as we can.

***Fiat* Boundaries and *Bona fide* Boundaries**

Much of what human beings do is related to drawing boundaries of different sorts. For instance, one thing that we do very well is to build walls: from the ancient walls built by the Roman Empire to the several walls in the modern world because of wars and migration. States and Nations stablish sovereignty by drawing borders that demarcate the territory where they have jurisdictional and military control. Boundaries also have taxonomical usages to classify species, races, social classes, mental diseases, genders, and so on. Moral norms are created by societies, so to speak, to set limits of what is permitted to do and what is not in

accordance with social contracts. Boundaries are thus used for several and different purposes: they are drawn every time we separate or distinguish things.

Boundaries can be the result of social, political or scientific agreements, arbitrary decisions, or violent impositions. They are *artificial* boundaries which depend on human commitments in opposition to *natural* boundaries which can be found in the world without human design. This distinction has been largely used in geography regarding *frontiers*. For instance, Thomas Holdich, a British geographer, says: “Frontiers, and the boundaries which define the frontiers, may be classed under two heads –natural and artificial” (1916: 147). Natural boundaries are formed by different types of geographical breaks or interruptions which are detectable divisions in the earth’s landscapes (e.g., mountains, rivers, lakes, seas, or deserts). On the other hand, as Lord Curzon writes in his book *Frontiers*, artificial frontiers are “those boundary lines which, not being dependent upon natural features of the earth’s surface for their selection, have been artificially or arbitrarily created by man” (1908: 23). Natural frontiers have been often used for setting artificial frontiers in accordance to human interests: they “figure largely in the political geography of the globe as indications of lines of partition between nations or communities” (Holdich 1916: 147). For instance, while the Andes is a large mountain range that separates Chile and Argentina, the German-Swiss border naturally follows the course of the High Rhine. However, natural frontiers and artificial frontiers do not always coincide and not frequently artificial frontiers have been drawn by agreements and conventions in human history. Military invasions and modern colonialism are examples of arbitrary imposition of artificial boundaries over the original cultural borders designed by local communities. The long history of humanity shows that every line in the map has been the result of political, cultural, and social negotiation, but also the source of injustices, wars, and massacres. Many people seem to be equally willing to either give their own lives or take someone’s life for a boundary.

The natural/artificial distinction of frontiers corresponds to what Barry Smith (1995, 2001) calls *bona fide* boundaries and *fiat* boundaries. The former are boundaries whose existence does not depend upon any sort of human activity. This is what Frege suggests about the Equatorial Line: “One often calls the equator an imagined line; but it would be false to call it an imaginary line; it does not originate through thought, the result of a mental process, but rather it is only recognized, apprehended, by thought” (1884: 40). On the other hand, *fiat* boundaries are human demarcations coming from cognition, language, political decisions, or simple perception. In short, *fiat* boundaries are mind-dependent; *bona fide* boundaries are mind-independent.

If the *fiat/bona fide* distinction is applied to boundaries, then we can think of the objects those boundaries belong to with the same categories. *Bona fide* entities can be you, myself, tables, chairs, books, and most of the physical objects that common-sense believes to be mind-independent things. *Fiat* entities can be states, constellations, brain divisions, football pitches and all those objects which seem to come into existence by drawing some imaginary line. However, there might be *bona fide* entities “whose boundaries

involve a mixture of *bona fide* and *fiat* elements” (Smith and Varzi 2000: 403). For instance, a table can be thought as is a mind-independent object but its surface has some components which may depend on our perception (e.g., colors, textures, and shapes). It also happens that the boundaries of *fiat* objects are not merely the result of *fiat* processes but also there are some underlying *bona fide* elements. Great Britain, for instance, is a *fiat* object whose artificial border coincides with the natural shore of an island. Many countries have actually set their borders from the natural discontinuities on the earth’s surface. We can therefore set arbitrary boundaries everywhere by just drawing random lines, but sometimes there are some natural joints in the material world underlying our drawing of artificial boundaries that makes the *fiat/bona fide* distinction vague.

Heller’s example of Manhattan (2008) can be taken to show this distinction between *bona fide* entities and *fiat* objects in terms of boundary coincidence. Manhattan is an island at the southern end of New York State. It is historically created by the declaration of some legislative body and rules which explicitly sets the boundaries of the alleged created entity. Such boundaries lay down both the stopping place where Manhattan spatially finishes and the responsibilities and privileges of the people leaving in it. However, Manhattan is also an island (call it Island), i.e., a land mass surrounded by water along its boundary where Indians communities used to leave before Manhattan became the most populated borough of New York City. Since Island and Manhattan differ in their persistence conditions (the island existed before Manhattan), then they are spatially coincidence objects: “the land mass and the borough now have the same spatial boundaries” (2008: 33).

A first approach to dissolve coincident boundaries is to say that Island is a *bona fide* object and so its boundaries too, while Manhattan is a *fiat* object and so its boundaries do not take physical space. This view would not contradict commonsense at all. Heller’s view however is more disturbing for our everyday beliefs of *what there is*. He argues that both Island and Manhattan do not exist; there are neither Island’s boundaries nor Manhattan’s boundaries. Both are of the *fiat* sort which only depends on human conventions: “It is our conventions together with our belief that there is a certain land mass in a certain location that lead us to act as if there is such a thing as Manhattan” (2008: 39). Much like the case of the statue and the lump, Heller argues that Manhattan and Island both are the result of human decisions and preferences whose boundaries correspond to the vagueness of our conventions and “what is characteristic of conventionality is arbitrariness” (2008, 43). By contrast, according to Heller’s metaphysics of temporal parts, *four-dimensional hunks of matter* are the only *bona fide* entities whose boundaries do not depend on conventionality but only on how the world is in itself: “these boundaries must not be a function of our special interests or our arbitrary choices” (2008, 51).⁸⁸ Ordinary objects and their ordinary boundaries are the consequence of *fiat* processes, regardless those objects and boundaries can be considered as natural formations in the geography of the earth’s surface.

⁸⁸ For more details about spatially coincident boundaries and Heller’s account of four-dimensionalism see Chapter Four.

Fiatness and Fideness in Nihilism

As we saw in Chapter Five, nihilism is the thesis that there are no composite objects, only simples. Those objects accepted by common-sense ontology can be therefore taken as *fiat* objects, while simples as the only *bona fide* objects. That is, ordinary objects and any sort of composite things depend on conventions, beliefs, or linguistics constructions; by contrast, only simples are the genuine chunks of reality. On this respect, sentences such as

- i. The table has a soft surface.
- ii. The tomato has a shiny red skin.
- iii. The trunk has a rough bark.

cannot be true propositions because there are neither tables, tomatoes, nor trunks and, therefore, their surfaces either –where properties as softness, redness, and roughness are perceived. Put it differently, there exist no boundaries to enclose matter-filled regions occupied by composite objects such as tables, tomatoes, and trees. Such boundaries would only be *fiat* boundaries that belong to *fiat* objects. As van Inwagen puts it: “Our conceptual activity may involve a lot of boundary drawing, but drawing a boundary around a filled region of space does not make it the case that there is some one thing that exactly fills that region” (1990: 139). Simples and their boundaries are the only *bona fide* objects.⁸⁹ Unlike simples, composite objects bring indeterminacy into the world through the vagueness of their spatial boundaries. So, vague boundaries can only be the result of the *fiatness* of composition, whereas sharp boundaries a consequence of the *fideness* of simplicity.

Are we entirely wrong with our everyday beliefs of material objects having boundaries where most of their physical properties are perceived? Nihilists have argued that the apparent contradiction with common-sense beliefs is superficial (or, at least, it can be mitigated). We might claim that although propositions (i)-(iii) do not have truth-makers in the material world, they do not express beliefs which are *plainly* false. But what could ‘plainly’ really mean here? One option is to claim that sentences such as (i)-(iii) are useful *fictions*. Rosen and Dorr have adopted this view: “It is possible to regard the idea of composition as a fiction to live by. We speak as if composite things were ubiquitous. But we need not, in so speaking, take on a commitment to this hypothesis. We may take a light-hearted stance toward our discourse about composition”(2002: 171). Our talk about composite objects –they say– is like our talk about films. Suppose that someone asks you what happens in *The Exorcist* and you say ‘There is a girl who is possessed by a daemon’. Most people would not believe that what you say, taken *literally*, expresses a truth, but a belief which is true according to some fictional facts of the movie. Likewise, (i)-(iii) do not express any *literal* truth about the world, but just true beliefs in the ‘fiction’ of everyday life. When we talk about composite objects we are just using language in a *loose and fictional* sense which should not be taken as a *strict and*

⁸⁹ See section B of Chapter Five.

literal ontological truth. Merricks has a lightly similar view on (i)-(iii) which are “justified, in various ways for various people, in virtue of being *nearly as good as true*” (2001: 173) So, for example, unlike unjustified beliefs as ‘Unicorns exist’ or ‘Dragons fly in the skies’ which are *plainly* false, (i) expresses a *reasonable* belief to the extent that (i) is as false as ‘Unicorns exist’ (since unicorns and composite objects do not exist), but it is true that there are some *things arranged tablewise*. On this respect, (i)-(iii) are false but ‘close’ to being true, while propositions where unicorns and dragons are involved are merely false since nothing is arranged unicornwise or dragonwise.

This sort of paraphrasing of ordinary beliefs is the strategy adopted by van Inwagen (1990) who contends that: “[...] tables and other inanimate objects is simply that there *are* none. Tables are not defective objects or second-class citizens of the world; they are just not there at all” (1990: 99-100). However, he also states that “when people say things in the ordinary business of life by uttering sentences that start ‘There are chairs...’ or ‘There are stars...’, they very often say things that are literally true” (1990: 102). Although both claims seem to be contradictory, van Inwagen proposes that (i)-(iii) can be paraphrased as follows:

- iv. There are *xs* that are arranged *tablewise* having a soft surface
- v. There are *xs* that are arranged *tomatowase* having shiny red surface
- vi. There are *xs* that are arranged *trunkwase* having a rough bark.

To say that (i)-(iii) are literally true just entails something similar to our ordinary uses of claims as ‘The sun moved behinds the elms’ (van Inwagen 1990: 101-102). Such sentence expresses a belief about how two objects are spatially related to each other that everyone, in everyday contexts, can reasonably accept as true. Although that belief gives a misleading information that contradicts astronomical facts, it *does* report that it has occurred an alteration in the spatial relation between the sun and the elms. Likewise, (i)-(iii) can be literally true insofar as they *do* really report (iv)-(vi). Thus, the sentence ‘The table has a soft surface’ describe a fact in a loose or even wrong way, but it at least tells us that some particles are arranged in some way causing a physical phenomenon that activates in our brains the perceptual experience of softness. If the alleged table and its surface really existed, then, as Merricks argues, such physical event would be causally overdetermined.⁹⁰

According to eliminativist ontologies, ordinary objects and their ordinary boundaries (i.e., surfaces) are not genuine denizens of reality. Objects such as tables, chairs, planets and their surfaces where most of the everyday physical action seem to occur depend on our loose way of talking or, let’s say, linguistic *fatness*: conceptual fictions and grammatical constructions conventionally agreed. We express beliefs about the physical *appearance* of ordinary material things according to what we perceive from their boundaries or surfaces. However, according to nihilism, simples are the genuine *bona fide* beings whose existence depends on nothing else but how the world is in itself. A group of simples can go together somewhere but it never

⁹⁰ For more details about Merricks’ overdetermination theory see section A in Chapter Five.

occurs that something else comes into existence due to such spatial gathering. Our cognition, perception, and language are sources of *fiat* boundaries which shape those things believed to populate the everyday world. Although *fiat* boundaries are ontologically unimportant for a description of *what there is*, they are helpful inventions (and non-entirely arbitrary ones) for the practical uses that the everyday world demands from us.

Boundaries, Environments, and Composition

The easiest way to answer what sort of thing is a boundary is to bring up what sort of thing a boundary *does*. To *separate* things is the manifest action that boundaries do at any context regardless how they can be represented. *Bona fide* boundaries and *fiat* boundaries are both thresholds which separate places and things of any kind: if a boundary indicates where something stops, then it must also indicate where something else begins. For instance, borders separate countries from other countries; shores separate lakes, rivers and seas from lands; the ancient Roman Limes used to separate the Roman territory from the barbarians; the atmosphere separates the earth from the outer space. As we saw in the introduction, boundaries are defined by Euclid as the extremities of anything, but to be in the extremity entails that a boundary, according to Aristotle's definition, indicates both the point where everything of a thing can be found and where, beyond it, nothing of it can be found. We cannot therefore conceive a boundary without thinking of it as something to be found in the extremity of anything and separating an object from what surrounds it, so "the concept of a boundary arises as soon as we think of an object demarcated from its environment" (Casati & Varzi 1990: 70) or just Varzi elsewhere:

Boundaries play a central role at *any* level of representation or organization of the world, and so does the relevant artificial/natural distinction. We think of a boundary *every* time we think of an object as of something separated from or distinct within its surroundings. (2011: 131)

Environments play an important role in our understanding of boundaries. Boundaries can pop out from the contrast between of an object and its environment. An object can be found in space insofar as a boundary is spatially distinguishable between the space occupied by the object in contrast with the environment where it is located. As Sorensen suggests: "The role of boundaries is too central to be ignored. Boundaries confer integrity by distinguishing the object from its environment, neighbors, and its own various stages" (1998: 282). As we saw in Chapter Two, boundaries are relevant things to determine objects' location: whenever an object can be found in space(time), a boundary will be found with it.⁹¹ On this respect, for an object *O* to be in space entails *O* having a boundary that makes the contrast between *O* and the spatial environment of *O*'s location.

⁹¹ For more details about this point see section B of Chapter One.

Environments and boundaries have been largely studied by different disciplines. For instance, the *Gestalt* theory of perceptual psychology consists of an interpretation of perception as a holistic phenomenon in which our brain articulates sensory information as organized wholes. Our brain has an active performance in completing perceptual information interpreted as missing parts of reality. Our perceptual system tends to interpret intersecting objects as continuous objects. This phenomenon occurs when our brain draw ‘missing’ boundaries to fill gaps found in reality making up the contours of objects that *ought* to be present. Figure 6.1 shows a classic example of Gestalt psychology:



Figure 6.1

Our visual perception is an object-oriented system that identifies figures through the completion of boundaries in contrast to their backgrounds or environments. According to Köhler (1947), our visual system spontaneously tends to interpret a broken-down reality in terms of *articulated* unitary objects standing out from its surroundings. Boundaries take many things which are ramblingly disposed in space to become well-defined objects composed of parts and distinguishable from their environments where they are spatially located. In a higher level of complexity, the completion of boundaries is also taken to occur in our articulated perception of ordinary objects having surfaces in contrast with their environments:

Along the boundary between a natural object and its environment some discontinuity will generally prevail. This discontinuity separates the environment from the interior of the object by a closed outline. [...] The things around us are either made by man, or they are products of nature. Objects of the first class are fabricated for our practical purposes. Naturally, we give them forms and surfaces which make them likely to be seen and recognized as units. (Köhler 1947: 158-159)⁹²

With regard to boundaries of ordinary physical objects (or surfaces), they follow the contour or outline that gives the shape of such objects. If we want to describe the shape of an object, we have to look at its boundary that demarcates the object’s contour in contrast to its surroundings. For example, a snooker ball is made of a compact and homogenous material that, we can say, continuously fills every point of the region of space it occupies. A soft and perfectly black surface follows the round shape of the ball that separates it from its spatial environment. If we put the ball on a black background, we could not see it since

⁹² See Koffka (1935, Chapt. III-VII) for more details about this topic.

the ball's surface will be camouflaged with the ball's environment. Nonetheless, the ball is perfectly visible on the snooker table since the black surface of the ball makes contrast with the green surface of the table. In the case of scattered objects as a bird flock (call it Flock) in fig. 6.2, it is spatially articulated as a unified entity having all its parts and occupying some specific place in space at different times insofar as a boundary pops up between the sum of their parts in contact with Flock's spatial environment.



Figure 6.2 A Bird Flock.

Unlike the snooker ball, Flock does not fill the space continuously: some matter-filled points are occupied while others not. The spatial scattering of the parts that compose flock makes easier to note the vagueness of Flock's boundary: it can be indeterminate whether some birds are definitely part of Flock's boundary or definitely part of Flock's surroundings. By taking some birds we can have one boundary and by taking other birds have another boundary.⁹³ However, vagueness of boundaries does not imply vagueness of existence. Although we have no certainty of what Flock's genuine boundary is, we do have certainty that there is something composed of many birds flying together in the sky following precise and harmonious movements. The vagueness of Flock's boundary does not make vague the contrast between Flock and the unoccupied spatial environment in the Flock's surroundings, it rather makes vague the precise place where Flock's boundary should be drawn. A boundary—either sharp as the snooker ball's surface or vague as Flock's borderline—stresses a contrast between an object and its spatial environment. It can be more in some cases or less clear in others, but every time that many things can be spatially related with each other in such a way that they seem to compose some further steady and well-articulated object, there is a discernible boundary (more or less vague) that emerges between the object and the object's environment. As Hirsh writes:

A leading articulation-making factor is *boundary contrast*. A portion of matter seems to impress itself upon us as unit insofar as it is segregated, bound off, from its surrounding. This segregation is accomplished primarily by the fact that there is a qualitative contrast between points on the object's surface and points in the surrounding medium. (1982: 107)

⁹³ For more details about boundaries and the Problem of Many see section A of Chapter Five.

Articulation-making is one of the causes that we intuitively think about how some things show a relation and distribution in space such that they together compose an object of some kind. *Boundary contrast* then is a leading-articulation factor insofar as the contrast that a boundary draws in space –between many things having a particular spatial distribution and their spatial surroundings– makes to pop out a *more or less* identifiable material being of some *sort*. Material beings such as snooker balls or bird flocks which occupy delimited regions of space at different times having their particular physical features, persistent conditions and modal properties. A boundary therefore seems to be a relevant factor for an object to be a well-articulated spatially distinguishable being. The following principle and boundary definition can thus be stated:

(BSP) Boundary Spatial Principle: For every x that is an object spread out in space, x has a boundary (either sharp or vague) that *separates* every part of x from x 's spatial environment. Otherwise, x would pervade the whole space instead of only some part of it.

β is a boundary of x =_{df} β is the sum of points within the region of space occupied by x which are in contact with x 's geometric spatial environment.

BSP is based on the intuitive idea that if an object did not have a boundary, then it could not be said where the object's spatial occupation ends. If an object had no spatial end of any kind, then it could be spread out in the whole space or perhaps the object's boundary would wholly overlap with the boundaries of the space itself (if it had one). However, both a world of ordinary material objects and a world of only simples do not have among their components that kind of boundaryless objects. So, if the space that physical objects occupy is finite, then a boundary must indicate where the object's spatial occupation ends and where the object's spatial environment begins. An apple has a surface or external boundary where beyond of it nothing of the apple can be found in space. Otherwise, if the matter that compose an apple did not have some stopping place in space, then the apple would permeate the world everywhere.

Since material beings leave big portions of unoccupied space, there must be boundaries separating those objects from their spatial surroundings. These boundaries, following BSP, are the collection of points (or boundary-points) located at the 'edge' of the matter-filled region occupied by some physical object. Material objects are composed of parts spread out in three spatial dimensions having a two-dimensional boundary. Thus, following the idea of *boundary contrast*, if many physical objects can show some articulation in their spatial distribution such that a boundary becomes a spatially discernible entity enclosing a region of space they collectively occupy, then a composite object can be said to be spatially found in virtue of the contrast between the collection of their parts and its spatial environment. According to this intuitive idea, the following principle of composition can be stated:

The x s compose y only if (i) y exists, (ii) the x s have some particular spatial distribution such that they collectively show a spatial contrast, and (iii) y has a discernible boundary that emerges from such spatial contrast.

If the x s compose y , the spatial distribution of the x s collectively brings into existence a boundary that becomes the boundary of y as a whole having the x s as its parts in contrast to y 's spatial environment where none of the x s is found. If wholes were grounded in the existence of their parts,⁹⁴ then a boundary would emerge from that grounding relation that separates all the parts composing a whole from the whole's spatial environment or geometric complement. Put it in the other way around, if a boundary is said to come out when a group of things are spatially gathered, then a whole grounded in those things should be the bearer of that emergent boundary. Following BSP, if boundary-contrast occurs somewhere in space, it can be enough for an object O to be composed of other things if O has a boundary that more or less separates O from O 's spatial environment. That is, there is a set of boundary-points that makes distinguishable a matter-filled region occupied by some objects showing a particular spatial distribution. These objects collectively compose O as a well-articulated object in space insofar as they bring into existence a boundary in the contrast between O and the unoccupied space in the O 's surroundings. Such boundary restricts O 's spatial extension; otherwise, O would be spread out in the whole space. Thus, if for something to exist somewhere in space entails the possession of a boundary, then boundary-contrast can be an important factor for composition. So, by following the above principle, composition can be then defined in this way:

The x s compose y =_{df} there exists y and the x s together articulate a discernible boundary to be possessed by y .

To set a sufficient and necessary definition of composition is utterly beyond the scopes of this research about boundaries. It just intends to emphasize the role that boundaries could play in explaining when some objects compose a further object. If having a physical existence entails the possession of a spatial boundary of some kind (in the same way that you could not exist without having a skin along every part of your body), then boundary-possession can be necessary to answer the *Special Composition Question* (SQC)⁹⁵, but not sufficient: for many things, the existence of a boundary that collectively separates them from unoccupied regions of space is a necessary condition to compose a further thing that exists in space having *that* boundary, but having a boundary is not sufficient for itself to answer SQC since other elements can be needed. In fact, a boundary can be said to exist and yet composition may not occur; but, necessarily, whenever composition occurs, a boundary exists. For instance, if we accept van Inwagen's restrictivism, then there might be a boundary when simples are arranged *tablewise* but not a table. However, necessarily,

⁹⁴ This thesis is endorsed by Cameron (2014). He argues that we should reject the claim that composition is identity. The connection between a whole and its parts is not explained by an identity relation. Instead, it should be taken to be a *superinternal relation* in which parts are not identical with their wholes, but they ground them. That is, if there exists a superinternal relation held by parts and a whole, then the relation is obtained insofar as the latter exists only in virtue of the existence of the former.

⁹⁵ For more details about SQC see section A of Chapter Five.

whenever simples compose an organism x , a boundary is possessed by x that more or less indicates what objects compose x and what objects do not.⁹⁶ So, if there exists a boundary to be possessed by some alleged composite object, then we could have good reasons to endorse the existence of such object, but not good for themselves.

Our talk about inanimate objects and artefacts is a loose way –*as good as true*– of referring to things having some particular arrangement without composing anything at all where “for the x s to be arranged chairwise is as much a matter of their contrast with their surroundings as it is of their distribution in space” (van Inwagen 1990: 109). Put it differently, the term ‘chair’ refers to some objects arranged in some particular shape whose spatial distribution makes them distinguishable from its spatial background. Nevertheless, there are no sufficient ontological reasons to consider the existence of some material composite being having a boundary or surface. Following figure 5.3, although two alleged objects seem to pop up from the contrast between the spatial distribution of their parts and their surroundings, this contrast does not bring into existence composite objects having boundaries.

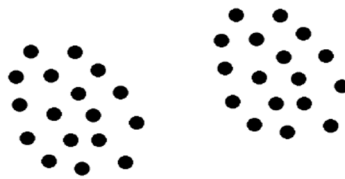


Figure 6.3

Any boundary in 6.3 would be the result of *fiat* processes rather than *bona fide* events in the world. Maybe a psychological tendency, according to Gestalt theories of perception, to articulate objects in the world by drawing imaginary boundaries to fill gaps in reality. Our mind tends to impose boundaries in the world and this psychological habit brings into existence well-articulated composite objects. Objects created by fiat boundaries can be genuine truth-makers of propositions according to what we call in the first chapter the *ordinary conception of the world*, but there are no *bona fide* boundaries to be found *inside the ontology room* for composite objects when we consider things such as tables, chairs, planets, and so on.⁹⁷ If 6.3 would be a simplified picture of atoms arranged chairwise in a three-dimensional space, there is no boundary (or

⁹⁶ Our skin, for instance, is the covering part of our body and the *stratum corneum* its outermost and thinnest tissue that protects our organism from pathogens in the external environment. Among other things, the level of hydration of our body depends on how much water the skin can either lose or absorb. Throughout the skin (let's say the natural boundary of our body), some molecules of water become parts of our body and others not. So, a composite object is some kind of living thing that can either lose or gain parts insofar as it has a boundary that indicates what parts belong to it and what parts do not.

⁹⁷ This distinction between being inside or being outside of *the ontology room* is used by Peter van Inwagen (2014: 1-14) to explain a semantic contextualist theory of our talk of ordinary material objects. It holds that while some sentences can express a certain proposition when they are uttered by common sense or in the context of *the ordinary business of life*, the same sentences can express a different proposition when they are uttered by metaphysicians differing in their ontological commitments.

surface) in the contrast of such arrangement and its spatial environment since contrasts in the world do not necessarily involve (*bona fide*) boundaries. If the boundary is just a *fiat* or mind-dependent entity, then there is no need to include both that boundary and the alleged object it belongs to in the ontology room. There are contrasts in the world between the arrangements of things and their surroundings, but there is no really need to postulate *bona fide* boundaries there. However, both concepts ‘contrast’ and ‘boundary’ are semantically close: either contrasts highlight boundaries that separate two things or boundaries separate two things by showing a contrast between them. Therefore, if there are good philosophical reasons to postulate a *bona fide* boundary in the contrast between objects arranged chairwise and their spatial surroundings, then there are also good reasons to postulate a *bona fide* chair to possess that boundary.

Drawing *Fiat* Boundaries on a *Bona Fide* Vague World

We know that nihilism prevents the world from being a vague by accepting simples as the only material beings. However, we also know that a world only consisting of simples does not get rid of vagueness at all. Although simplicity does not show vagueness of *parthood*, it does show vagueness of *location*: it is not indeterminate whether *this* part or *that* part belong to a simple (since simples are partless entities), but it is indeterminate whether *this* world or *that* world actualizes the spatial location of a simple. Simples do not have vague spatial boundaries, but they do have vague modal boundaries.⁹⁸ So, if simplicity leaves a door half open to think of vagueness as an attribute of the world itself, why not fully open that door?

Thinking of boundaries certainly drives us to face the puzzle vagueness and its source. Vagueness is basically a problem of boundaries. In case of sorites paradoxes, vagueness appears when there is no *sharp or fixed boundary* to draw for the application of some predicates, for example: when someone is definitely *bald* or definitely non-bald; whether some grains of sand definitely compose a *heap* or definitely do not; and whether someone is definitely *tall* or definitely not. We can also talk of ‘Mount Everest’ as a vague term insofar as there is no sharp or precise boundary to determine either what rocks are definitely parts of the Everest and what rocks are not definitely parts of it or where the Everest begins and where the valley in the Everest’s skirts ends. Vagueness thus arises every time that predicates have borderline cases, i.e., when the meaning of those terms is not clearly fixed to a boundary that determines their exact application. Where do boundary vagueness come from? Are they *fiat* drawings or *bona fide* imprecisions in the world?

A world having vague boundaries has not been an appealing idea for many philosophers: vague boundaries can only be of the *fiat* sort or every *bona fide* boundary in the world should always be a sharp and very precise boundary. If the genuine constituents of the world and their properties cannot be vague, then vagueness must have a different source. There are two leading views: the *linguistic view* and the *epistemic view*. The linguistic view is the most popular and basically contends that vagueness is a phenomenon that only occurs in language: our words are semantically vague but not their referents.

⁹⁸ For more details about modal vagueness of simples see section B in Chapter Five.

According to this view, vagueness lies on semantic indeterminacy, i.e., when a term has more than two possible referent candidates to satisfy. On the other hand, the *epistemic view* is the thesis in which vagueness arises from the lack of knowledge. It is not a matter of semantic indecision the impossibility to determine the precise truth conditions for all constituents of everyday language, but it is just we are ignorant of them. Take the example of Jupiter's *Great Red Spot*:

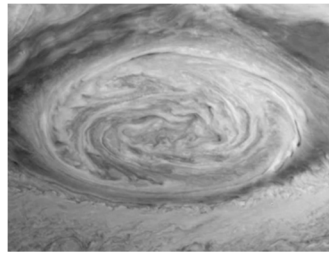


Figure 6.4 Jupiter's Great Red Spot.

Jupiter is the largest planet in the solar system consisting mostly of gas whose atmosphere is covered by scattered clouds across different layers. The Great Red Spot is a permanent high pressure zone that produces an anticyclone storm that is visible from the outer space having an eye shape. It can be observed even with naked eye because of its reddish color given the reaction of some chemical components of Jupiter's atmosphere such as ammonia, ammonium hydrosulfide, and water. The Great Red Spot (Spotty, for short) is easily to identify on Jupiter's surface despite the noticeable vagueness of its boundaries. As it can be seen in 6.4, Spotty's boundaries are not very precise: there are some borderline clouds in which it is indeterminate whether they are or not definitely parts of Spotty. As a result of this spatial indeterminacy, there seem to be many possible boundaries to be possessed by Spotty but none of them is completely justified to be *the* boundary.

According to the linguistic view, the vagueness of Spotty's boundary is given by the incapacity of our language to set a precise semantic criterion to determine the referent of the term 'Spotty'. The term is vague insofar as it cannot determine a precise truth-value in virtue of picking up one exact and exclusive referent from the world. Varzi makes a *de dicto* reading of linguistic vagueness in which saying that Spotty has no sharp boundaries really entails that "the term vaguely designates an object, not that it designates a vague object" (2001: 5). Otherwise, it would be a *de re* case of vagueness in which Spotty itself has indeterminate boundaries.⁹⁹ Thus, the utterance of the term 'Spotty' is a vague way of speaking because it indiscriminately involves many good candidates to refer to an object having the boundaries to be possessed by Spotty.

⁹⁹ Varzi's reading of vagueness in terms of a *de re/de dicto* distinction can be put as follows: *de re* vagueness entails that the referent of 'Spotty' is such that it is indeterminate whether certain chunks of reality lie within its boundaries, whereas *de dicto* vagueness entails that it is indeterminate whether certain chunks of reality lie within the boundaries of the referent of 'Spotty'.

According to Heller, “the world is not a fuzzy place; objects, independent of how they are described, do not have indeterminate boundaries” (1996: 177). In his view (as we saw before), the only physical objects are four-dimensional hunks of matter having precise and sharp boundaries essentially.¹⁰⁰ The vagueness of ordinary objects as Spotty arises not from a four-dimensional world, but from our linguistic conventions. Whatever it is that ‘Spotty’s boundaries’ refers to in the world is contextually agreed through our decisions and preferences. So any vagueness comes from such linguistic behavior rather than some alleged object having vague boundaries in the world. Likewise, from a nihilist point of view, the material world only consists of simples having sharp boundaries due to their lack of parthood. When we say ‘Spotty’ we are really referring to some objects arranged *spottily* but nothing in the world such it is a composite object having vague boundaries. There is no vague boundary for Spotty because Spotty does not exist. The only source for boundary vagueness comes from the beliefs found in the *ordinary conception of the world* where ‘Spotty’ is vaguely used.

The epistemic view contends that the vague appearance of Spotty’s boundary is not due to the semantic indefiniteness of ‘Spotty’, but it is a matter that we are simply incapable of knowing where that boundary is. In every linguistic context, our use of the predicate ‘Spotty’ determines exactly what is the boundary that belongs to Spotty, but we are completely ignorant of it. Put it differently, there is a sharp spatial boundary genuinely possessed by Spotty, but vagueness arises every time we try to know what that boundary exactly is. Notwithstanding that we could build sophisticated logical devices to clean our language of any sort of imprecisions and ambiguities, the sharp boundaries of Spotty would still remain unknowable for us. The vague boundaries ascribed to Spotty are just the consequence of other boundary: the limit of our knowledge.

According to both the linguistic view and the epistemic view, if there is any *bona fide* boundary in the world, it must be a sharp one; vague boundaries are *fiat* drawings made by either semantic imprecision or knowledge inaccuracy. The thesis of a vague world¹⁰¹ has recruited many opponents. Lewis, for instance, posits that “the only intelligible account of vagueness locates it in our thoughts and language” (1986: 212). Russell contends that “vagueness and precision alike are characteristics which can only belong to a representation, of which language is an example” (1999: 62) –and he carries on later: “Vagueness, clearly, is a matter of degree, depending upon the extent of the possible differences between different system represented by the same representations” (ibid). Heller writes that: “If there are any nonconventional objects, then they must not be vague objects. They must have precise boundaries along all dimensions [...]” (1990, 51). Dummett finally writes that “the notion that things might actually *be* vague, as well as being vaguely

¹⁰⁰ For more details about Heller’s four-dimensionalist view on boundaries see sections B and C of Chapter Four.

¹⁰¹ The thesis has had many labels: ‘ontic vagueness’, ‘ontological vagueness’, ‘worldly indeterminacy’, ‘metaphysical indeterminacy’, ‘vague existence’, ‘mereological vagueness’, ‘metaphysical vagueness’, ‘indeterminacy *de re*’, ‘vague identity’, and so on.

described, is not properly intelligible” (1999: 111). *Bona fide* vague boundaries are not therefore easy to accept among philosophers.

Nevertheless, the idea that worldly objects themselves can have vague boundaries is not entirely *unintelligible*.¹⁰² Although there might be cases of both linguistic and epistemic vagueness (after all, our language and knowledge are pretty limited in several aspects), it is still possible to find sources of vagueness in a mind-independent world. That is, *bona fide* vague boundaries can perfectly exist in addition to our vague descriptions and ignorance. We can analyze Spotty as a case of *de re* vagueness: while *de dicto* vagueness expresses that it is vaguely true whether ‘Spotty’ refers to Spotty, *de re* vagueness says that Spotty is such that it is vaguely true whether it is the referent for ‘Spotty’. Among other things, to say that the constituents of the world are genuinely vague implies that Spotty has *bona fide* fuzzy spatial boundaries. The fact that any sharp spatial boundary for Spotty is arbitrarily placed is not a failure of either language or knowledge; rather, the world itself fails to precise the boundaries that ‘Spotty’ refers to.

Ontological vagueness is related to the spatial indeterminacy of boundaries of physical objects and such indeterminacy is committed to vagueness of parthood. We can say that a physical object x is vague if for some y it is indeterminate whether y is a proper part of x .¹⁰³ Michel Tye suggests a definition alike in which a concrete object O is vague “if, and only if, (a) O has borderline spatio-temporal parts and (b) there is no determinate fact of the matter about whether there are objects that are neither parts, borderline parts, nor non-parts of O ” (1990: 536). As we can see in figure 6.4, the indeterminacy about whether some chunks of cloud are part of Spotty is related to whether those chunks are enclosed by the boundaries of the region of space occupied by Spotty. In this respect, “the spatial indeterminacy concerns the boundary between the physical object and its surroundings” (Keil 2013: 155). Compositional vagueness arises in the contrast between Spotty’s spatial boundaries and Spotty’s spatial environment: it is indeterminate whether chunks of clouds are definitely parts of the region of space within Spotty’s boundary or definitely parts of Spotty’s surroundings. Take the definition of composition previously suggested:

The x s compose y =_{df} there exists y and the x s together articulate a discernible boundary to be possessed by y .

The definition above is completely vague to the extent that it is indeterminate what is the *discernible* boundary articulated by the x s to be possessed by y . The contrast shown by Spotty’s spatial boundary is vague because there exist borderline clouds such that it is indeterminate whether they are parts of Spotty’s boundary or Spotty’s surroundings. To include the concept of boundaries in how to define composition leads

¹⁰² Van Inwagen, for instance, accepts that taking life activity as a sufficient and necessary condition of composition could entail borderline cases of compositions where it is indeterminate whether some x s composes an organism: “We must keep clearly in mind that two types of vagueness can enter into discussions of compositions. A borderline life is, by definition, an event of which it is not definitely true and not definitely false that it is a life; but, quite independently of this, there will (no doubt) be simples of which it is not definitely true and not definitely false that they are caught up in that event” (1990: 278).

¹⁰³ A similar definition can be found in Sainsbury (1989).

us straightforward to deal with the possibility of ontological vagueness found in the contrast between the matter-filled region occupied by a physical object and its spatial surroundings. Spatial contrasts can be imprecise matter-filled regions occupied by borderline objects. How can we however make ontological vagueness an intelligible idea?

One way to make sense of ontological vagueness is to incorporate a *modal indeterminacy view* endorsed by some philosophers as Akiba (2000, 2004) and Barnes (2010). It supports the idea that the world not only consists of three dimensions of space, but also a fourth modal dimension¹⁰⁴: physical objects are modally extended over possible worlds. On this respect, vagueness comes from such possible worlds taken to be as *precisifications*.

The concept above is borrowed from a linguistic approach to vagueness called *supervaluationism*. According to this view, it is possible to replace the indeterminacy of the truth-values of sentences containing a given predicate *P* by adopting a precise semantic value for *P* as a fixed boundary between the broad range of the all possible borderline truth-values for *P*. Nonetheless, to choose any one of such ‘precisifications’ or ways of sharpening *P*’s semantic boundary involves different degree of arbitrariness: if one possible precisification of *P* is as good as any other precisification, then the adoption of one of them over the remaining ones is entirely unwarranted. As Keefe and Smith explain it: “[...] our treatment of vague predicates should take account of *all* of them. It is proposed that a sentence is true iff it is true on all precisifications, false iff false on all precisifications, and neither true nor false otherwise” (1999: 23). With respect to figure 6.4, the term ‘Spotty’ is vague because it is undetermined what spatial boundary to be belonged by Spotty it ought to refer to. In the spatial area where the relevant contrast between Spotty and its surroundings occurs, there exist several boundaries for Spotty and all of them are genuine candidates for Spotty’s reference. Each of these candidates are slightly different precisifications of the sharp boundaries to be possessed by Spotty. Taking into account *all* those possible boundary-precisifications, if in all of them a sentence that takes Spotty is neither definitely true nor definitely false, then ‘Spotty’ vaguely grasps the sharp spatial boundary of the matter-filled region occupied by every chunk of cloud that exactly composes Spotty.

The modal indeterminacy view takes a *worldly version of supervaluationism* in which: “[...] the entire world has another dimension: the *precisificational* dimension. This dimension, which concerns determinacy and indeterminacy, is made up of *precisified* worlds, in which everything is precise” (Akiba 2004: 408). For an object having vague boundaries every modal precisification corresponds to a possible world containing a well sharpened version of that vague object. In this respect, Spotty is a material object spread out over all possible precisifications in which each precisified Spotty has sharp boundaries (i.e., no borderline parts where it is clearly determined the chunks of clouds which are included within the matter-

¹⁰⁴ Unlike Barnes, Akiba is explicitly committed to the idea that this modal dimension corresponds to temporal parts of physical objects.

filled region occupied by Spotty). Spotty is a vague object only if it can modally coincide with different Spotties having sharp boundaries, but without being identical with any of them. Every possible Spotty wholly exists in every precisifications having sharp boundaries, but they slightly differ in their locations. ‘Spotty’ thus refers to a modally vague object. Spotty is a material object extended over a vague area of possible precisifications of Spotty’s boundaries, so Spotty is “transworld object that coincides with different precise areas in different precisified worlds” (Akiba 2004: 408). The vagueness of Spotty is therefore given by the possible worlds where Spotty’s boundaries are differently sharpened. The term ‘Spotty’ does not refer to a single object in the world, but it does refer to an object that is wholly present through every possible world where Spotty’s spatial boundaries are precisified in different ways: Spotty thus modally coincide with all of its possible precisifications.

The vagueness of Spotty is not found in each of the possible world where Spotty has different locations because at each of them Spotty has a sharp and precise boundary. If Spotty’s location is given by its boundary (if Spotty cannot exist in space without having a boundary, then wherever Spotty exist in space a boundary will be found there), then Spotty has diverse precise locations at every possible world where Spotty has different sharp spatial boundaries. So what does make Spotty a vague object according to this modal account? As Barnes writes: “[E]very possible world is fully precise, but if there is ontological indeterminacy it is indeterminate which of the possible worlds is the actualized world –that is, it is indeterminate which world, out of the many worlds that represent things to be a precise way, is the one that represents the way the actual world is” (2010: 613). The idea of ontological vagueness can thus be intelligible as follows: Spotty having sharp boundaries satisfies a broad range of possible worlds where Spotty has different locations in space (let’s say a world where Spotty has a determined spatial surrounding and other worlds where it has others), but what is the world to be chosen? Spotty can be interpreted as an object having sharp boundaries, but what is entirely undetermined is the world where that sharp boundary for Spotty is supposed to be actualized. It is determinate that one world actualizes the sharp boundaries of Spotty, but it is indeterminate which one must be *that* world.

There exists a large range of modal vagueness along that area where a boundary sets a contrast between a material object and its surroundings. If there are many modal precisifications of the sharp boundary of an object, then it is ontologically vague why *this* rather than *that* precisification should be chosen to be the world that actualizes the boundary. This can be easily represented by Spotty, but it is applicable to every time that many objects compose a further object (and this includes ordinary material objects, if they existed). Every time that we find a *bona fide* boundary that emerges from the contrast between some spatially arranged objects and their surroundings, it is also found different possible worlds having different *bona fide* sharp boundaries for that contrast. However, the selection of only *one* genuine boundary to be the actual boundary of a material object extended over *many* well precisified worlds is, of course, an arbitrary preference. The geographer C. B. Fawcett illustrates this point:

In nature there are many fluctuating frontier zones, but not fixed boundary lines. [...] Frontiers are thus essentially transition areas –zones in which the characters and influences of two or more different regions or states come together. Yet all regions are in some sense transitional; and it is only where the transitional character is a dominant fact of life in the area that we have a true frontier. The conception of frontiers –between inanimate things, of plant or animal regions, of human races, or cultures, or states– as lines is purely subjective. It accords with the tendency of the normal human mind to keep its ideas in separate compartments, since line boundaries are as convenient for thought as are precise definitions in other matters. But in the world as it is the objective fact is the existence of frontier zones. Of all these regions it is true to say that they pass gradually one into another. (1918: 24)

If we look at nature closer and closer, we would realize that what we call the boundary of things can be blurred transitional zones in space (and time) where a material object gradually fades in into its surroundings. Regardless how sharp or soft a boundary can be, different degrees of vagueness can be found on them if the objects they belong to are entities modally spread out in different worlds. So whereas an object is such that it determinately has a precise *bona fide* boundary at every possible world, it is modally indeterminate which one of those boundaries should be taken as the actual world.

If there is no a precise boundary to set whether *this* world or *that* world should be chosen among all the possible worlds that actualize the sharp boundary of a material object, then the drawing of that modal boundary is a *fiat* process that completely depends on us. Fawcett claims that a natural frontier is a transitional zone where we draw some artificial line that makes it more precise what expresses ‘the tendency of the normal human mind to keep its ideas in separate compartments’. That is, the boundaries of things, in many cases (may be in all), are blurry areas where many boundaries can be *the* precise boundary. We have a natural ‘tendency’ to make that blurry area as sharp as possible by drawing our own boundaries to fill any gap that reality may have. Such *fiat* boundaries are not mere fictions or plain arbitrariness of our decisions. As Smith suggests: “the very possibility of fiat demarcations presupposes the existence of bona fide landmarks in relation to which fiat boundaries can be initially specified and subsequently re-located” (1995: 479). In many cases, *fiat* boundaries are not lines randomly drawn by us, but supervening demarcations on *bona fide* boundaries: most of the boundaries we draw in the world are fixed in some objective underlying joint of reality which gives us the indications (some of them more precise than others) to set a boundary. As much as our frontiers between countries are drawn over physical discontinuities in the earth’s surface and anatomic divisions are drawn over physical features of bodies, *fiat* sharp boundaries are drawn over *bona fide* boundaries in the vague contrasts between objects and their surroundings. Reality only gives us vague coordinates that our metaphysical inclination to make clear-cuts everywhere tries to precise them as much as possible. The world itself is a pretty blurry place that our boundary drawing intends to permanently make sharper.

Final Remarks

Boundaries are everywhere and they can be *bona fide* joints in reality or *fiat* lines as a result of our agreements, preferences, and also impositions. According to nihilism, all those boundaries found in what we called the *ordinary conception of the world* are just fictions or simply a loose way of talking about physical objects. In this respect, boundaries of ordinary physical objects would be as artificial and arbitrary as boundaries drawn on the map. Given that simples are the only existing material beings in a nihilist world, the only *bona fide* boundaries would be the boundaries of simples. If such kind of boundaries existed, they would be sharp boundaries to the extent that simples do not have borderline parts since they are partless beings. The nihilist world would therefore be, for at least two reasons, a place with very precise boundaries. First, there are no vague boundaries to restrict when composition occurs and when it does not since composition does *never* occur. Second, there are no vague boundaries for simples.

However, we found in Chapter Five that simples can have modally vague boundaries in the sense that there are so many worlds where a simple's location in space becomes indeterminate where a simple is actually found. In this last chapter, on the other hand, we found that boundaries can play a relevant role in composition (a necessary one, but not sufficient): if a *bona fide* boundary is reasonably believed to be in the contrast between a collection of objects and its spatial environment, then there might be good reasons to believe in the existence of an object composed of those objects. This idea leads us to accept the idea that if *bona fide* boundaries of composite objects exist, then they are blurry areas where there are many modal precisifications of the sharp boundary that an object can have. There are so many worlds to actualize the sharp boundary of an object that it is indeterminate whether it is *this* rather than *that* world. It is therefore our metaphysical inclination to make things sharper and what triggers us to draw *fiat* boundaries over such blurry 'frontier zones' in the world: we draw a boundary as clear as possible to choose one world over the other that actualize the sharp boundary of an object. The world thus has boundaries that can be vague that we try to make sharper.

CONCLUSIONS

We said in the introduction that boundaries are familiar things to us: everyone has an idea of what a boundary is. We all would agree that the boundary of a physical object is its surface. The closeness of our everyday experience with boundaries comes from a pre-theoretical answer to the Quinean question ‘*What is there?*’. That is, an ontology grounded on common-sense beliefs about what are the items of the physical world and the boundaries they have. This is what we called in Chapter One the *Ordinary Conception of the World*. According to this account, there is a mind-independent world consisting of many mid-sized physical objects which can survive qualitative changes and have all their parts at every time they exist. This research was a metaphysical study of the boundaries of those objects. The upshots of this work are given from the contrast between common-sense beliefs and metaphysics regarding what material beings and their boundaries are:

- i. *There are many boundaries.* Not only every physical composite object has a boundary, but also each of their parts which are potentially detachable has a boundary. By contrast, metaphysical accounts can reduce the number of boundaries by reducing the number of things: while monism conceives only *one* substance, nihilism conceives many simples but *nothing* to be composed by them. There might respectively be only one boundary (if the existence of that boundary does not contradict the monist thesis) or as many boundaries as simples exist but none of the boundaries of composite objects.
- ii. *Surfaces show many of the physical properties and causal relations that material objects instantiate.* However, surfaces are two-dimensional boundaries without thickness at all; so that surfaces do not take up physical space and cannot show any physical property. However, surfaces can be found in physical space insofar as they ontologically depend upon physical objects. Surfaces and physical objects both hold a mutual but asymmetric *de re* ontological dependence: while surfaces *rigidly* depend upon the physical objects they belong to, physical objects *generically* depend upon surfaces.
- iii. *Physical objects are in contact when (parts of) their boundaries meet.* The idea of contact is quite natural with the idea of boundaries. Depending how contact is explained, it can be consistent with two accounts of space either substantivalism or a relationalism. However, contact as real fact of the world is ruled out by quantum physics: the electric charge of the particles composing things repel each other. In that case, contact should be possible only if there is a continuous path between the two regions of space occupied by the two objects in contact and boundaries do not interrupt that path. Among the different views to explain that, we adopt that the idea of two co-located boundaries between two objects in contact is the least harmful for the ontological condition of boundaries as dependent entities.

- iv. *Two physical boundaries cannot be in the same place at once.* However, many philosophers have supported the possibility of materially coinciding objects, i.e., two objects made of the same physical parts at the same time. If this is possible, then the same surface is the boundary of two objects sharing all their physical parts and yet may differ, among other things, in their persistence conditions. This leads us to a different common-sense claim about persistence of things.
- v. *A physical object and its surface wholly exist at every time.* Perdurantism and endurantism offer two different accounts of persistence of physical objects which have different metaphysical implications regarding their boundaries. Perdurantism contends that physical objects persist having temporal parts and, therefore, your mug having a hot surface when you drink coffee is a temporal slice of the mug. On the other hand, like common-sense, endurantism contends that your mug persists by having all its parts and surface at every time it exists and so every property that the mug instantiates are related to different times. If we accept perdurantism, we pointed out two metaphysical drawbacks regarding boundaries: four-dimensional objects would have their spatiotemporal boundaries essentially, and the space/time analogy does not work in terms of the spatial boundaries/temporal boundaries analogy.
- vi. *There are composite objects having their surfaces.* Common-sense believes that things compose other things in some circumstances and not in others. Universalism and nihilism have two extreme accounts of composition: while the former contends that there is no compositional boundary to determine when objects compose other things (they *always* do), the latter contends that there is a precise compositional boundary that restricts composition in all circumstances (it *never* occurs). Both accounts avoid vagueness in composition, but only nihilism entails that boundaries of ordinary physical objects do not exist because there is none of such objects but only simples. If these partless objects have boundaries, they must be sharp since simples do not have borderline parts. However, they are modally vague in terms of location: there is no a precise world that actualizes where a simple spatially found.
- vii. *There are physical objects having entirely sharp boundaries.* There are many borderline tiny particles along the boundaries of every ordinary physical objects such that it is indeterminate whether they are definitely part of the boundaries or definitely part of the objects' surroundings. If this is true, then every physical object has vague boundaries. If a *bona fide* boundary is reasonably believed to be in the contrast between a collection of objects and its spatial environment, then there might be good reasons to believe in the existence of an object composed of those objects. This idea leads us to accept *bona fide* vagueness in boundaries of physical objects. The boundaries of things are blurry modal areas where there are so many worlds to instantiate the alleged sharp boundaries of a physical object that it is indeterminate what world actually does it.

Boundaries is a fundamental topic in metaphysics. Not only it has many philosophical questions difficult to answer which may challenge our ordinary beliefs of the world, but also because philosophy itself

is a permanent enquiry about boundaries: the limits of our knowledge, the limits between good and evil, the limits of language, the limits of the mind, or the limits of philosophy itself. Furthermore, in the globalized world where we live now of many people leaving their homelands for different reasons, the topic of boundaries becomes not only a metaphysical worry but also political. The borders that separate countries, people, and culture are vague boundaries, but, as we saw in this thesis, we have a natural inclination to make vague boundaries as sharp as possible.

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