Damiano Costa - transcendentism - chapter 2 - a puzzle about persistence

Costa, Damiano

Chapter 2

A puzzle about persistence

Persistence is often claimed to be a puzzling phenomenon. Some of the paradoxes regarding persistence proposed so far rely on the idea that things change their properties through time, others rely on the idea that things change their parts through time, others again rely on the idea that some things seem to spatially coincide for a while. In what follows, I shall present a new puzzle afflicting the phenomenon of persistence. The basic informal idea of the puzzle is as follows. If a thing persist, it is not instantaneous. If it is not instantaneous, it must be temporally extended. But since it is extended through time, it must divide into a special kind of parts – temporal parts. However, things intuitively lack this kind of parts. Something has gone wrong somewhere. The puzzle will need some hypotheses to go through, so that in the end it will be constituted by a set of five principal theses about persistence and related concepts, which are easily shown to be jointly inconsistent. Throughout this chapter, I shall present the five theses and give an intuitive grasp of their plausibility, without the ambition of giving a full-fledged justification of them, since the aim is only to get the paradox going.

I think that the new puzzle is more interesting than the others at least in two respects. The first one is that it does not need to involve additional phenomena that are extrinsic to that of persistence to go through: the simple assumption that a thing persists through time, no matter if changing properties or parts, no matter if coinciding spatially with something else, will do. The second one is that, depending on which thesis is dropped to solve it, it allows to reach all theories of persistence present on the market – as well as new ones.

The chapter is divided into four sections. In the first three, I shall introduce the five claims generating the puzzle, viz. persistence [§1], immanentism, functionality and arbitrary partition [§2]

and endurantism [§3]. In the fourth one, the puzzle itself will be presented both in an informal and a formal way, and its possible solutions will be sketched.

1 Persistence

1.1 Existence at a time

Existence is said in many ways. One of these ways informs us about the presence of a thing – like a chair, a tree, a human being – at a given time. In natural language, the given time is usually picked out thanks to the use of tenses and adverbs, like in [1] and [2]. Nevertheless – in its technical use in metaphysics – it works more as a relation, linking the given thing to the given time, like in [3]. It is on this notion – call it "existence at a time" that we will focus in what follows.

[1] The Twin Towers do not exist anymore.

[2] Joyeuse – Charlemagne's sword – still exists.

[3] Thing x exists at time t.

In order to fully grasp the meaning of existence at a time, it is of crucial importance to contrast it with another technical sense that existence has in metaphysics. We can call this second sense "existence simpliciter". Existence simpliciter is the existence of the existential quantifier, $\exists$. According to many, it is a primitive notion. Nevertheless, we can use some paraphrases in order to delucidate its meaning and contrast it with that of existence at a time. (It goes without saying that such paraphrases will end up being circular.) Existence simpliciter is the mark of what is part of our ontological catalogue, of what we think is part of the world, makes up the universe that surrounds us. There are several ways to illustrate the prima facie difference between the two meanings of existence:

(i) Existence simpliciter is usually taken to be second-order (FREGE 1884; RUSSELL 1905; QUINE 63; 80), whereas existence at a time is first-order.

(ii) Existence simpliciter is monadic and tenseless (TORRENGO 2012), whereas existence at a time is either a relation – like in [3] – or tensed – like in [1] and [2][1].

In what follows, I will take the following terminological choice. I will speak of existence at a time only when time and things are involved. I specify: (i) any and (ii) only the members of the ontological category of things, aka substances, aka objects. In making this choice, I distance myself – someone might believe – both from natural language and common philosophical practice[2]. Nevertheless, the choice has a precise strategic rationale. (ii) In reserving it to things only, I aim to preserve the possible peculiarity that this relation has with respect to other relations of presence. It is in principle possible that the way in which things are in time is crucially different from the way in which e.g. events are in time. Using the same term for other cases could prevents from spotting such a possible peculiarity. (i) On the other hand, I use term to any member of the ontological category of things - rather than just a subclass of it – because I think that all things relate to time in the same way.

1.2 Weak vs total existence

There is an ambiguity that existence at a time has – and shares with any relation that informs us about the presence of an entity at a region of a dimension (CASATI AND VARZI 1999; PARSONS 2007; GILMORE 2006). It is better to disentangle this ambiguity from the very beginning. Consider for example Bertrand Russell. In a loose sense, he existed during the XIXth century, even if there are parts of it in which he does not exist, and even if he existed also

[1]Several metaphysicians carefully contrasted the two meanings. The list includes: MOLTMANN 2013, SIDER 2001, LOWE 2005 abstract obj, TORRENGO 2012.

[2]As regards to natural language, someone might doubt that existence at a time is naturally attributed (i) to all things, because it is not attributed – at least when the proposition has an assertive function – to e.g. living beings, and (ii) only to things, because we also apply it to kinds of things (MOLTMANN) – when we say, for instance, that some dinosaurs existed only in the Cretaceous. As regards to common philosophical practice, the domain of existence at a time is usually extended to cover a large variety of entities, like e.g. events or properties (LEWIS; PARSONS).

outside it [4]. In a nutshell, Russell exists at a time in this sense just in case this time "is not completely free of him". Call this sense "weak existence". In a stricter sense, Russell existed at the interval delimited by its birth and its death, its geometrical shadow in time [5]. Call this sense "total existence". Total existence is intended to be unique.

[4] Bertrand Russell existed during the XIXth century.

[5] Bertrand Russell existed at the interval delimited by his birth and his death.

This list is not intended to be complete. For example, one might want to add a distinctive sense of existence that links Russell to each instant composing its total existence, or to the intervals containing it. Nevertheless, the two senses distinguished above will suffice for our aims. To make these distinctions clearer, let us introduce some formal machinery. Let t, t', ... be variables for regions of time – be such regions instants or intervals. We shall write

$WE(x, t)$ for "x weakly exists at t",
$TE(x, t)$ for "x totally exists at t".

The formal definition of such senses of existence at a time is a delicate matter. Each choice of primitives and definitions will have its own pros and cons, the discussion of which is postponed to Appendix II. With these two concepts at hand, we are finally in a position to define the central notion of this section, i.e. persistence.

1.3 Persistence defined

Persistence is a technical term elected to denote a common phenomenon, that of an entity's continuing to exist through time. LEWIS (1986) famously defined persistence as existence at various times. If "various" simply means "numerically different", such a definition will not do. It will not do with total existence, because the total existence of an entity is unique. Neither will it do with weak existence: even an entity that does not persist will be weakly located at various times, e.g. the times that include the instant at which it weakly exists (PARSONS 2007).

Two proposals to circumvent this problem have been recently put forward. The first one adopts weak existence, and says that an entity persists just in case it weakly exists at two mereologically disjoint times (PARSONS 2007). The second one adopts total existence, and says that an entity persists just in case its total existence is not instantaneous (GILMORE 2006). Let us write

Px for "x persists", and

It for "t is instantaneous".

Then, let us define persistence as follows:

[D1] $Px := \exists t, t'(WE(x,t) \wedge WE(x,t') \wedge t \wr t')$

[D2] $Px := \exists t(TE(x,t) \wedge \neg It)$

Notice that since we reserved existence at a time to things, we are now only able to define the persistence of things, and not, e.g. that of events. Hence, for the time being, x in [D1] and [D2] ranges exclusively over things.

Curiously enough, the two proposals are not equivalent. For example, suppose that time is made up by extended – hence non-instantaneous – simple regions. Take one of such regions t, and suppose that a thing x totally exists at this given t. According to [D2], x persists, because it totally exists at a temporal region that is not instantaneous. On the other hand, according to [D1], it does not persist, because there are no two disjoint times in which it weakly exists. I shall extensively come back to the issue in the Appendix II. For the time being, sufficies it to say that – exotic cases excluded – the two definitions seem to align with one another.

The introduction of the notion of persistence allows to state the first claim – which I label [P] – that contributes to generate the puzzle that will be introduced in section 5, namely the claim that some things persist through time. Let O be the category of things. Then

[P] $\exists x \in O(Px)$

[P] is the basic phenomenon that any theory of persistence has to explain – or to explain away. It is not the time to justify its assumption – more on that later, in section X.X. But just to get a firmer

grip on it, we can say that [P] is so ubiquitous that is even difficult to find an example of a thing that does not persist through time. We all believe that we continue to exist through the interval delimited by our birth and death. We take also all nonliving things that sorround us to persist through time. This is not only confirmed by our intimate beliefs and manifest actions, but also by the spirit of our moral intuitions and laws. For example, we consider a human being responsible for what she did in the past under the supposition that she did that in the past, and hence that she persisted through time. For these reasons [P], rather than its negation, seems the natural assumption to start with.

Traditionally, the concept of persistence has been cashed out in terms of another notion, i.e. that of location. The next section is dedicated to the exploration of this connection, commencing with the introduction of the concept of location.

2 Immanentism

2.1 Location

Space, time, and regions thereof are, in a sense, receptacles: they are made for something to be hosted by them. And the variety of entities being hosted by them is rather large: things, events, tropes, properties, relations, states of affairs, ... are all, in a way or another, present in some given regions of space, time, and spacetime. Let us introduce the term "presence" to indicate the generic relation that links an entity to the regions that host it.

Presence is no uniform phenomenon. In particular, there is a crucial distinction that has to be traced from the very beginning between derivative presence and direct presence, a.k.a. location. The key point here is that derivative presence reduces to other facts involving location. An example will help clarifying the distinction. Let us consider the way in which a chair that I have in front of me and the universal redness that it exemplifies. Both are, in a sense, present at that region. Nevertheless – at least according to a popular view – the chair is there directly, whereas the universal redness is there only derivatively: it is not really the case that redness is located in space; rather, its being there is reducible to the fact that it is exemplified by a thing – the chair – that is, in turn, located there.

This reduction talk is to be taken seriously here. It is not merely the case that, according to that view, the location of the chair explains the location of redness, so that both are located there, but one is in virtue of the other. According to the present view, redness is not located in space, and its alleged presence is reducible – explained away, definable, nothing over and above – its being exemplified by a thing that is located there. In order to fully grasp this point, it might be useful to contrast it with another one. Take the case of the chair and its parts. In that case, both the chair and its parts are present at a place, but one – presumably the chair – is present there in virtue of its parts being located there. Nevertheless, it is not the case that the location of the chair is reduced: the chair really is located there. Only, it is there in virtue of the location of its parts. In other words, derivative presence is not a case of grounding, it is a case of reduction.

Following these considerations, it is possible to offer a definition schema for derivative presence [DS1]. Of course, not all relations will do, otherwise some weird consequences will follow. For instance, I would be derivatively present in 400 BC only because I think of that time, even if nobody could find me in 400 BC, and blackness would be present here because I'm thinking of it, even if no black thing is present here. I have no general criteria for selecting the suitable R, and I would leave that selection to be made on a case by case basis. For example, in the case of universals, the obvious R is exemplification [ID1].

[DS1] x is derivatively present at r := there is an y which is located at r, and R(x,y), for some suitable relation R.

[ID1] universal F is derivatively present at place r at time t := there is a thing y that is located at r, and y exemplifies F at t.

In § 1.1., I argued that existence at a time is an ambiguous notion, and that the same ambiguity is shared by any notion that informs us about the presence of an entity at a region of a dimension. As a consequence, also location – and derivative presence – is afflicted by it. The case of the spatial location of things is particularly vivid, and using it as an example will allow us to distinguish five meanings of location – usually called "modes of location" (VARZI; PARSONS; GILMORE). In the weakest sense, an entity is located at a place

iff that place is not completely free of it, like in [6]. I shall call this "weak location". In a stricter sense, an entity can be located at a region in the sense that it is completely within that region, like in [7]. I call this "entire location". In a yet stricter sense, an entity is located at a region when such a region is delimited by its boundaries - like [8]. I cal this "exact location". Still in another sense, I am located at a region that I completely fill, like in [9]. I call this "pervasion". Finally, there is an exotic case. Suppose that I enter a time machine and I visit myself in the past. The region delimited by the boundaries of the younger Damiano is different from the region delimited by the adult Damiano. Suppose that the two are numerically identical, and hence identical to me. There is a sense in which I am located at the fusion of the two regions [10]. I call this "total location". My total location is my geometrical shadow in the given dimension.

[6] I am located in my office (even if I reach an arm outside of it).

[7] I am located completely within my office.

[8] I am located in the place delimited by my boudaries.

[9] I fill the region of my left foot.

[10] I visited myself in the past. I am totally located at the fusion of the regions delimited by my younger self's and my adult self's boundaries.

Usually exact and total location are extensionally equivalent, and if they differ, it is only in these exotic cases of having multiple exact locations. One could even object that in such cases, my fusion counts as my only exact location. I am not rejecting this way of putting things. I simply concede a label to those that – perhaps sticking to the intuition that one's exact location corresponds to one's boundaries – have a different intuition.

Total location is unique. Still, it can be made unique relative to a dimension. For example we can speak of the total temporal location vs. the spatial location of the same entity. The first is going to be a region of time, the second a region of space.

Let us introduce some formal tags for these modes of location. Let r, r', ...$\in \delta$ be variables for regions of a dimension δ. We shall write

$x@r$ for "x is exactly located at r",

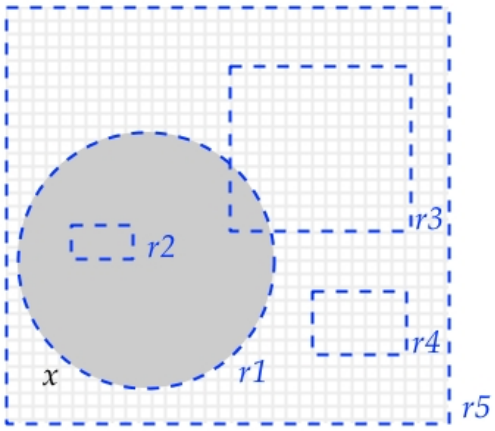
$x@_{\circ}r$ for "x is weakly located at r",

$x@_{<}r$ for "x is entirely located at r",

$x@_{>}r$ for "x pervades r",

$x@_{T}r$ for "x is totally located at r".

A model for these modes is given in Figure 1.



	r_1	r_2	r_3	r_4	r_5
$x@_{o}$	+	+	+	−	+
$x@_{<}$	+	−	−	−	+
$x@$	+	−	−	−	−
$x@_{>}$	+	+	−	−	−
$x@_{T}$	+	−	−	−	−

As in § 1.1., the precise definition of such modes of location is a delicate affair that will discussed in the course of the next chapter and, more extensively and organically, in Appendix II. Nevertheless, it is possible to offer a first set of definitions that will do more good than harm. Take exact location as a primitive. It is possible to conceive total location of x as the mereological sum of all x's exact locations [D3]. Also, it is possible to conceive generic, entire and pervasive location as any regions that overlap, mereologically include, and are mereologically included in, x's total location [D4], [D5], [D6].

[D3] $x@_{T}r := r = \sigma r'(x@r')$

[D4] $x@_{\circ}r := \exists r'(x@_{T}r' \wedge r' \circ r)$

[D5] $x@_{>}r := \exists r'(x@_{T}r' \wedge r < r')$

[D6] $x@_{<}r := \exists r'(x@_{T}r' \wedge r' < r)$

Since total location is a mereological sum, it is provably unique. As a consequence, we can also introduce a function – let us call it "path" (GILMORE 2006) – from an entity to its total location:

$$\pi(x) \qquad \text{for "the path of x".}$$

Having distinguished and defined such modes of location, I will now turn to the discussion of two intuitive principles governing their behaviour.

2.2 Two locative principles

Two fundamental questions regarding presence and mereology have received a significant amount of attention in recent years. The first one is whether there can be an entity that is extended without having parts, i.e. whether there can be extended simples. The second is whether an entity can be exactly present at more than one region of a dimension, like in the aforementioned case of the time traveller.

Notice that, as the two questions stand, no mention is given to the distinction between derivative presence and location. But this distinction is – I think – crucial here. In the case of derivative presence the two questions either (i) do not have a precise meaning, or (ii) have a trivial reply.

Let us begin with extended simples. I say that perhaps the question whether there can be an entity that is (i) extended at a region, (ii) derivatively present there and (iii) atomic could not have a precise meaning because I am not sure that we can apply the concept of extension to entities that – strictly speaking – are not located in the given region. Is it appropriate to say that if redness is exemplified by an extended thing, is itself extended? I doubt it. If saying that redness is extended in space means anything at all, I think it might only mean that it is exemplified by something extended in space. And this, in turn, might mean that every part of that thing exemplifies redness. But this does seem to be trivially possible, since the very nature of universals is to be multiply exemplifiable.

Let us now turn to multiple exact presence. In that case, I doubt again that the question makes sense at all, because I fail to see what does it mean that redness is exactly present at a region. I can make sense of regions in which it is weakly present and of the region where it is totally present, but not of regions in which it is exactly present.

Remember the intuitive glosses presented before. There, exact presence was distinguished from total and weak presence by appealing to the spatial boundaries of things. But redness does not have spatial boundaries itself. As a consequence, multiple presence has to be intended either as multiple weak presence – and given the meaning of weak presence this is trivially possible: if x is weakly present in r, it is also weakly present in any other region that overlaps r – or as multiple total presence – and given the meaning of total presence this is trivially impossible: total location is unique.

One might object that such considerations are made relying on the case of universals and, therefore, cannot be generalized to any case of derivative presence. I do not think so. My considerations relied in fact on two features of universals: (i) the fact that the reduction of their derivative presence involves a relation – exemplification – which can link the same universal to entities located at different regions; (ii) the fact that universals lack boundaries in the region in which they are derivatively present. As a consequence, these considerations are generalizable insofar as other derivatively present entities share these features with universals.

The two questions are much less trivial in the case of location. In that case, the application of the concept of extension seems to be perfectly appropriate – when such entities are exactly located at an extended region. And the same goes for boundaries. So, can an entity located at an exteded region lack parts? And can an entity be multiply exactly located? I share the intuition that many philosophers have according to which both questions have to be answered negatively. I have to admit that I cannot conceive of an entity which is both extended and atomic. As regards multilocation, one can mention the fact that no adequate definition of exact location is present in the literature, and the assumption of multilocation leads to an impressive battery of paradoxical conclusions. We shall return to both issues in the next chapters, but these reasons will suffice to justify my temporary answers.

A symbolic rendering of the two answers can be given in the form of the two following principles. The first one states that entities divide into parts in the way their exact location does. This principle – sometimes also called the "doctrine of arbitrary undetached parts" – will be labeled here "arbitrary partition", or simply "partitio", [AP]:

[AP] $\quad x@r \rightarrow \forall r'(r' < r \rightarrow \exists y(y < x \wedge y@r'))$

The second one, which is supposed to block multilocation, is usually labeled "functionality", because it makes exact location being a function.

[F] $\quad x@r \wedge x@r' \rightarrow r = r'$

2.3 Immanentism defined

In § 2.1., I introduced the distinction between location and derivative presence, and I illustrated this distinction by describing a plausible view according to which universals are only derivatively present in space. More generally, for every entity that is present in regions of a dimension, it is possible to wonder whether the relation of presence is a direct one or not. I shall call "immanentistic" the views that answer affirmatively, and "transcendentistic" the views that answer negatively. As a consequence, the plausible view on the presence of universals in space that I described before is transcendentistic with respect to the relation between universals and space, and immanentistic with respect to the relation between things and space.

Now, take existence at a time on board again. Is existence at a time a form of derivative presence or of location? Is the relation between things and time a direct or a reducible relation? Most of the contemporary metaphysicians assume that one and the same kind of relation links things to space, time and spacetime, and that such a relation is direct (e.g. GILMORE; PARSONS). In my terminology, this means that current metaphysicians are immanentist with respect to the relation between things and time: for them to exist at a time is to be located at that time.

How can we formally render this immanentistic view? First, we have to remember that we distinguished two senses of existence, viz. weak and total existence. The reader has already surely spotted the similarity between weak and total existence and weak and total location. This similarity can be exploited to frame the immanentistic view, so that weak and total existence will be defined in terms of weak and total location, as follows:

[D7] $\quad WE(x,t) := x@_\circ t$

[D8] $\quad TE(x,t) := x@_T t$

I select [D8] to state the immanentistic view under scrutiny:

[I] $TE(x,t) := x@_T t$

Notice that once that we defined existence at a time in terms of location, we can finally relate persistence with location, in two ways:

[D9] $Px \equiv \exists t, t'(x@_\circ t \wedge x@_\circ t' \wedge t \wr t')$

[D10] $Px \equiv \exists t(x@_T t) \wedge \neg It)$

Suppose we want to follow contemporary metaphysicians also in thinking that things are also located, and not merely derivatively present, in space and spacetime. It will then be possible to define persistence in spatiotemporal, rather than only temporal, terms. The easiest way to do that is – I think – by postulating a principle that ensures that if a thing has a non-instantaneous temporal location it also has a non-instantaneous spatiotemporal location. Let, s, s', ... be variables for regions of spacetime. Then:

[B] $\exists x \in O, t((x@_T t \wedge \neg It) \rightarrow \exists s(x@_T s \wedge \neg Is))$

from [D10] and [B], it follows that, things persist just in case their spatiotemporal path is non-instantaneous:

[D11] $Px \equiv \neg I\pi(x)$

3 Endurantism

Having defined persistence, I will now turn to the definition of another central notion of the debate, i.e. that of temporal part (§3.1.). This will allow me to define endurantism, the thesis according to which persisting things lack proper temporal parts (§3.2.), and to contrast endurantism with another thesis, three-dimensionalism, according to which things are not temporally extended (§3.3.).

3.1 Temporal parts

Temporal parts – an intuitive gloss goes – are what you get when you slice an entity along the temporal dimension (SIDER 2001). Most likely, the best way to get what we mean by this is by considering some entities that, without doubt, divide into temporal parts: events. Take for instance a philosophical conference, a football match or the life of a person; the conference might divide into

a first part – where a keynote talk is given – and a second part – where several parallel sessions are run, the football match typically has two halves, the life of a person divides into different phases. These are instances of temporal parts. In these cases, the cutting is done along the temporal dimension, in the sense that the parts resulting from the cut are located at disjoint times.

How can we convert this intuitive gloss into a full-fledged definition? Here are some unsuccesful attempts which are nevertheless useful to get a better grip of what a temporal part is and is not. First, someone could think that a temporal part simply is a part of an entity that is located at a time. But this definition would not do. Take again the case of the conference. During the parallel sessions part, there will be several talks given at the same time. These are parts of the conference and are located at some time, but are not temporal parts of the conference, because their cutting is not done along the temporal dimension alone. In other words, such smaller parts do not include "all of the whole" that occurs at that time. A second proposal tries to achieve that result by requiring that a temporal part to be of the same size of the whole for as long as the part exists (HELLER 1984; MCGRATH 2007). Concede for a moment that it is possible at all to speak of the spatial size of an event. The proposal seem to exclude the single parallel talks from being temporal parts of the conference, because they are present at a smaller region of space than the conference at that time. Nevertheless, the proposal would fail in case there are events outside space (KIM 1976; GIBBINS 1985; PRICE 2008), like, perhaps, mental events.

A succesfull definition for temporal parts can be reached if we give a mereological reading to "including all of the whole that occurs at that time". The idea is that a temporal part must include, or better overlap, every part of the whole that is located at that time (SIDER 2001). Let us write

$$xTPy \qquad \text{for "x is a temporal part of y".}$$

Then, we can define temporal parts as indicated before:

$$\text{[D12]} \qquad xTPy := x < y \wedge \exists t(x@t \wedge \forall z((z < y \wedge z@_{\circ}t) \rightarrow z \circ x))$$

More precisely, [D12] defines the notion of a proper or improper temporal part. Nevertheless, when an entity divides into temporal

parts, it divides into different, hence proper, temporal parts. Proper temporal parts are easily defined as temporal parts that are also proper parts of the whole. Let

$xPTPy$ mean that "x is a proper temporal part of y".

Then, proper temporal parts can be defined as follows:

[D13] $xPTPy := x \ll y \wedge \exists t(x@t \wedge \forall z((z < y \wedge z@_{\circ}t) \rightarrow z \circ x))$

3.2 Endurantism defined

Do things divide into temporal parts? Surely, this in not the way in which we conceive them. Suppose you meet an old friend. If things divided into temporal parts, what you would have in front of you when you meet her would not be her but, strictly speaking, just a part of her. Even if what you are living right now is just a part of your lasting friendship, what you have in front of you when you meet her seems not to be a part of her, it seems to bejust herself. Of course, this is just a fallible pre-theoretical intuition. Nevertheless, this is sufficient to make the view that things do not divide into temporal parts the standard position until proven otherwise (BALASHOV 2000; MOLTMANN 2013; REA 1998; CALOSI 2010; INWAGEN 2000; THOMSON 1983; LOWE 1987).

I will call "endurantistic" any theory that denies that persisting entities have proper temporal parts. As a consequence, endurantism will here be defined as follows:

[END] $\neg\exists x \in O(Px \wedge \exists y(yPTPx))$

Endurantism is often defined in terms of another notion, that of "whole presence". Interminable and unsuccesful discussions over the meaning of that notion suggest, I think, that it either is senseless, or just means what I mean for endurantism (CIT).

3.3 Endurantism vs three-dimensionalism

Somethimes, endurantism is also called three-dimensionalism. Nevertheless, I will not use them as synonyms. Endurantism as I defined it, is a thesis about things and their parts. On the other hand, the

term three-dimensionalism suggest that it names a thesis about the geometrical shape of an entity.

Three-dimensionalism is – I think – a bad name for a good intuition. The intuition is that most things are extended in the three spatial dimensions but not in the temporal one. Nevertheless, what I think is central in this intuition is not its spatial aspect, but the temporal one. Suppose that there are things that are extended only in one or two spatial dimensions, like the side of a cube, or one of its vertices. Such things will not be extended in the three spatial dimensions, still, they will not violate the basic intuition to which one wants to appeal when he vindicates three-dimensionalism about persistence. As a consequence, I would rather define three-dimensionalism as the thesis that things are not extended in time.

What does it mean for an entity to be extended in a dimension? A precise answer to this question can be given by appealing to its location in that dimension, if any. We can say that an entity is extended in a dimension iff it is exactly located at a point-sized region of that dimension. We already have a predicate to express the fact that a region of time is point-sized or not: instantaneity. As a consequence, for an entity to be extended in time is for it to be exactly located at a time which is non-instantaneous:

[D14] x is non-instantaneous in time $:= \exists t(x@t \wedge \neg It)$

In turn, three-dimensionalism can be defined as the view that things are not extended in time:

[3D] $\neg\exists x \in O, t(x@t \wedge \neg It)$

No appearent implication holds between endurantism and three-dimensionalism. And we shall show that there are logically possible models in which things lack proper temporal parts and are temporally extended and others in which things have proper temporal parts but are temporally unextended.

4 A puzzle about persistence

4.1 The puzzle

There is an quick argument showing that the assumptions presented in the course of this chapter are jointly inconsistent. To recap, the argument rests on the following main assumptions:

[Persistence]	Some things persist through time.
[Immanentism]	For a thing to persist is for it to have a non-instantaneous spatiotemporal total location.
[Functionality]	Entities have at most one exact location.
[Partition]	Entities divide into parts like their exact location does.
[Endurantism]	Persisting things do not divide into temporal parts.

All assumptions seem to state very plausible principles on things, location and mereology. Things persist, are located at spacetime regions and lack proper temporal parts. Exact location is unique and entities located at extended regions divide into parts. Nevertheless, these principles, when taken together, are inconsistent. Suppose that a thing x persists. By immanentism, this means that its spatiotemporal total location is non-instantaneous. By functionality, it follows that x is exactly located at that total location. Since this total location is non-instantaneous, it divides into proper temporal parts. Take one of those temporal parts. This is a part of x's exact location. As a consequence, by arbitrary partition there is a part y of x that is exactly located there. Since x and y have two different exact locations, by functionality they are numerically distinct: y is a proper part of x. Finally, since y is located at a temporal part of x's exact location, y is a proper temporal part of x. As a consequence, there is a thing which is composed by proper temporal parts, and this contradicts endurantism. One of the five assumptions has to be dropped, and all theories of persistence on the market are characterized by which ones they drop.

4.2 The puzzle, more formally

In this section I will present a formal version of the puzzle. This formal version will allow to verify that the five claims are really contradictory, and highlight some ancillary principles that are needed to formally derive the contradiction. Here are the five principles in formal clothes:

[P] $\exists x \in O(Px)$

[I] $TE(x,t) := x@_T t$

[F] $x@r \wedge x@r' \rightarrow r = r'$

[AP] $x@r \rightarrow \forall r'(r' < r \rightarrow \exists y(y < x \wedge y@r'))$

[END] $\neg\exists x \in O(Px \rightarrow \exists y(yPTPx))$

Three of the previously presented definitions are needed. More precisely [D2], stating that to persist is to have a non instantaneous total existence, [D3], defining the total location of an entity as the sum of its exact locations and [D13], defining proper temporal parts as proper parts that are located at some time and overlap all other parts of the whole that are weakly at that time:

[D2] $Px := \exists t(TE(x,t) \wedge \neg It)$

[D3] $x@_T r := r = \sigma r'(x@r')$

[D13] $xPTPy := x \ll y \wedge \exists t(x@t \wedge \forall z((z < y \wedge z@_\circ t) \rightarrow z \circ x))$

Finally, the following ancillary claims have to be assumed. The first one, [$\ll$], claims that proper parts are parts numerically distinct from their wholes. [B] connects temporal and spatiotemporal location. It claims that if a thing has a non-instantaneous total location in time, it also has a non-instantaneous total location in spacetime. [TP I] states that non instantaneous regions of spacetime divide into proper temporal parts. Finally, [TP II] states that if a part of an entity is located at a proper temporal part of another, it counts as a temporal part of that entity.

[$\ll$] $x \ll y \equiv x < y \wedge x \neq y$

[B] $\exists x \in O, t((x@_T t \wedge \neg It) \rightarrow \exists s(x@_T s \wedge \neg Is))$

[TP I] $\neg Is \rightarrow \exists s'(s'PTPs)$

[TP II] $x < y \wedge x@s \wedge y@s' \wedge sPTPs' \rightarrow xTPy$

With these principles in hand, it is possible to run the argument to the inconsistency of the five principles. Here it is:

(1)	$\exists x \in O(Px)$	[P]
(2)	Px	(1), $\exists$-El
(3)	$\exists t(TE(x,t) \wedge \neg It)$	(2), [D2]
(4)	$\exists t(x@_T t \wedge \neg It)$	(3), [I]
(5)	$\exists s(x@_T s \wedge \neg Is)$	(4), [B]
(6)	$x@_T s \wedge \neg Is$	(5), $\exists$-El
(7)	$x@s$	(6), [D3], [F]
(8)	$\exists s'(s'PTPs)$	(6), [TP I]
(9)	$s'PTPs$	(8), $\exists$-El
(10)	$\exists y(y < x \wedge y@s')$	(7), (9), [AP]
(11)	$y < x \wedge y@s'$	(10), $\exists$-El
(12)	$s \neq s'$	(9), [D13], [$\ll$]
(13)	$x \neq y$	(7), (11), (12), [F]
(14)	$yTPx$	(7), (9), (11), [TP II]
(15)	$yPTPx$	(13), (14), [D13]
(16)	$\exists x \in O(Px \wedge \exists y(yPTPx))$	(1), (2), (15), $\exists$-Intr.
(17)	$\bot$	(16), [END]

4.3 Blind alleys and viable routes

Throughout this chapter I claimed that the puzzle rested on five main assumptions. Nevertheless, its formal version showed that it needs in fact seven additional assumptions to go through. From a logical point of view, all twelve assumptions are on a par. Why do I consider some of them more interesting than others? One reason is that the seven ancillary principles are not directly on persistence, but rather on mereology or the mereological structure of spacetime. But the main reason is that I believe that the negation of such ancillary principles would not lead us to a better understanding of the phenomenon, whereas dropping one or more of the five main principles will lead – as I shall show in the next chapter – to full-fledged theories of persistence. In particular, dropping [P] means to deny the very phenomenon of persistence, and leads to a theory that I call "exdurantism", which parallels a model analogue of it – counterpart theory: like counterpart theory denies that the same thing exists at more than one disjoint word, exdurantism denies that the same thing exists at more than one disjoint time. Dropping [END] leads to classical perdurantism, according to which things are extended in time and have temporal parts. Dropping [AP] clears space for extended simples theory, according to which things are

extended in time, but are mereologically atomic, and hence lack proper temporal parts. The denial of [F] opens the possibility of multilocationism, according to which persisting things lack temporal parts and are temporally unextended. It is also possible to drop several of them at the same time. For example, a weak version of perdurantism according to which things have temporal parts, but not as many as the parts of their interval, can be reached by denying both [END] and [AP].

In the next chapter I shall run a master argument showing that all these options are problematic, hence concluding that the remaining one, i.e. dropping immanentism, is an option to be taken seriously.