



How Does an Entity Acquire Identity? Reassembling Relativistic Physics with Actor-Network Theory

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Abstract

What is it that determines the identity of an entity? Processualism is a theoretical perspective that offers a startling answer to this question. The identity of an entity—whether human or nonhuman, animate or inanimate—depends on the set of relations in which this entity is located. And as the sets of relations are several, so are the identities that an entity can take. This article discusses this conclusion by integrating processual accounts from different fields of inquiry, such as relativistic physics and actor-network theory. According to a processual interpretation of relativistic physics, speaking of states of things is but an abstraction. For states come from the introduction of arbitrary (physically meaningless) breakups of the spacetime continuum. Therefore, processes precede states, a process being a set of relations that confers identity on a physical state. According to a processual interpretation of actor-network theory, the same holds true for actors. Again, speaking of states of actors is but an abstraction. For what really acts is heterogeneous networks. When one describes actors in isolation, one is neglecting a whole array of relations with other actors whereby that actor can act or is made to act in such and such a way. These strands of processualism come to the same conclusion as to the identity of entities. These are not characterized by individuality but by individua(bi)lity: they can be differently individuated according to the set of relations one is able to take into account. The main methodological consequence is that, if one intends to describe what an entity is, knowledge of this entity—whether human or nonhuman, animate or inanimate—should be based on progressively less narrow localizations and mappings of the relations it has to other entities.

Keywords Actor-network theory · Haecceity · Processualism · Quiddity · Relativistic physics

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1 Introduction

The relation between the study of natural reality and the understanding of the entities that comprise it (whether human or nonhuman, animate or inanimate) is hardly a new subject throughout the history of philosophy.¹ One should only think of such leading figures in 17th-century philosophy as Spinoza, Leibniz, Berkeley, whose philosophy of nature was bound up with full-fledged theories of entities that challenged everyday notions of how both the human subject and everyday objects should be conceived. It should then come as no surprise that pre-Kantian natural philosophies still inspire not only contemporary metaphysics but also theoretical physics.² However, contemporary cutting-edge research in the field of theoretical physics leads to no less startling consequences on the understanding of entities. To mention a couple of striking examples of well-established interpretations of physical theories, one could think of the issue of the nature of elementary particles in the philosophy of quantum field theory, where some scholars go so far as to deny the existence of self-identity,³ or the so-called “many-worlds interpretation” of quantum theory, according to which there is only one, real wave function for the entire universe and when an event occurs, the other possibilities contained in the wave function bring about new worlds, in which each possibility gets actualized.⁴ Both these strands of theoretical thinking drawing from the most significant outcomes in quantum theory come to astonishing conclusions on what exists and how it should be conceived.

The aim of this article is to bring to surface the theoretical consequences of a particular research line within theoretical physics on the understanding of entities and how it invites us to rethink what both the human subject and everyday objects are. This research line lies within the broader family of theoretical paradigms that take stock of relativistic physics, and thus endeavour to show that spacetime is far away from the way we experience it in our daily life. While this family is very broad, and some theorists are well-prepared to reject all dynamical aspects of physical reality such as motion and change,⁵ the research line we will

¹ In this article, we will stick with the term “entity”. For we want to be vague enough to encompass any natural entities, whether human or nonhuman, animate or inanimate, natural or cultural—our methodological assumption being that no such differences are truly justified if not in terms of approximation. This assumption will become clearer as we go along.

² Leibniz’s impact on contemporary science is unmatched. His works on mathematics and natural philosophy, as well as his enduring polemic with Newton, has influenced a number of scholars, such as those who advocate relationalism against substantivalism. But Spinoza’s metaphysical themes, too, though less easily translatable into contemporary physical parlance, can be read as anticipatory to existing debates on monism and the relation between material objects and spacetime regions (see, e.g., Schaffer, 2009, Lehmkuhl, 2018).

³ The lively debate on this issue has spawned a voluminous literature. As a reliable entry point to it, see French and Krause (2006), Lam (2015), Lam and Esfeld (2012).

⁴ A pioneering work on this is Everett (1957). For a philosophical discussion see Saunders, Barrett, Kent, and Wallace (2010). A very accessible introduction to this interpretation of quantum mechanics is Carroll (2019).

⁵ An enlightening example is Julian Barbour’s shape dynamics, an influential neo-Leibnizian and neo-Machian reformulation of relativistic theory and quantum physics where becoming and motion are ultimately described as illusions (see, e.g., Barbour, 1999; Barbour 2012—respectively a more accessible and a more technical introduction to Barbour’s theoretical enterprise). On Barbour’s view, all that exists is a three-dimensional ensemble of particles fixed in their position which form spatial configurations. Another recent example, closer to the lesson of relativistic physics, is Silberstein, Stuckey and McDevitt (2018), which claims contemporary physics to be still beset by a dynamical bias whereby physical theories are alleged to explain the evolution of systems, whereas—the authors argue by implementing the so-called “Lagrangian schema”—systems do not evolve over time.

look at is one that seeks to account for the dynamical features of reality while accommodating a relativistic account of spacetime. This line can be dubbed “processualism”.⁶ On a processual view, as we will detail in this article, an entity does not possess an identity of its own, but acquires it from the interaction with other entities.

An interesting aspect of processual physics that we aim to explore is that it bears surprising resemblances to other contemporary philosophies of nature developed within other fields of inquiry such as sociology and anthropology. In particular, Bruno Latour’s (1988) “irreductionism”, which he developed as a methodological and metaphysical appendix to his work on what he calls “the Pasteurization of France”, and more generally, the broader strand of thinkers who collaboratively developed so-called “Actor-Network theory”.⁷ We will construct the case that there is a shared, basic intuition behind processualism in physics and actor-network theorists’ project. From different perspectives and most likely with different objectives, they come to a shared notion of what an entity is and how it takes shape within broader sets of relations. The main difference between them is that, while physical theorists commence with the problem of how to define the states of a physical system and arrive at a quite counter-intuitive understanding of entities, Latour and actor-network theorists begin with how an entity should be conceived and come to a processual view of natural reality.

Before going into the details of the argument, it is worth expanding on the view that we contend is agreed upon by these two processual traditions. With a hyperbole that speaks volumes about the consequences of processualism, Latour (1988, 206) writes that “actors do not stand still for long enough to take a group photo; [...] alliances are forged not *between* nice discrete parties but in a disorderly and promiscuous conflict that is horrible to those who worship purity”. While we will return to Latour’s view, here we just wanted to make the point that this conclusion is quite in line with some interpretations of reality within both relativity and quantum theory (though in the present context we will only look at the former). The mainstay of this view is that one can hardly speak of permanent states endowed with permanent self-identity. As we will explain in the subsequent section, the idea of there being permanent states is a *partial* and *approximate* grasp of something that exceeds this condition by far. When one thinks one is experiencing a self-identical entity existing through time, one is making an abstraction. This is not to say that this is an illusion. Rather, this is to say that while one experiences isolated self-identical entities, one

⁶ It is imperative to remark that there are many processual views within theoretical physics, which advocate conflicting physical principles. In the present article, we will concentrate on a processual view that builds on relativistic physics. Other processual approaches, on the contrary, arrive at a notion of process that does away with both the assumptions and the consequences of relativistic physics. For one thing, Lee Smolin (2001, 53) avers that the world is a “history of processes”, where dynamical change is primary. But Smolin’s processual view pivots on time being fundamental and space being emergent. Accordingly, in a way that is at variance with general relativity and the metaphysics of the block (see below in this article), his process view implies time in the sense that the process is an activity generating a *thick present*, that is to say, two events that can be causally related to each other in a present that is continually growing by addition of new events.

⁷ The idea that relativistic physics (but also quantum theory) is conducive to a processual view of reality can be traced back to one of the founding figures of process philosophy, Alfred N. Whitehead—see in particular Whitehead (1978[1929]). Whitehead is also one of the inspirers of actor-network theory (see Stengers (2011)). In this article, we can not even allude to his thick philosophical theory, if only because it also advances a whole new lexicon to approach reality, along with a novel metaphysics and various physical speculations. However, this is a pointer to the fact that the link between the two processual views we are discussing in this article is more than circumstantial.

is cutting out a whole array of relations with other entities that make that entity be what it is—to such an extent that, if one could apprehend that entity within the whole set of relations in which it is embedded, one would hardly perceive an isolated self-identical entity. One would perceive a *process*.

To get to grips with the notion of process, a preliminary word on what we mean by “isolated”, “self-identical” entity.⁸ This is quite an intuitive notion that applies to potentially any entities in the way we are accustomed to. Let us imagine an old man standing close to a grave and feeding pigeons and squirrels at the foot of a statue.⁹ Though nothing surprises us in this very common life scene, from a physical standpoint this is an amazingly complex state of things. Or, better, it is neither a state nor a series of things; and certainly not an ensemble of things that stand still. When we conjure up the scene, we isolate single snapshots, but this “isolation” hardly accounts for what is really going on. We have a grasp of someone who is feeding pigeons and squirrels. However, we do not know anything about the loved one who is a few feet away from him, or how his/her death yielded his need to spin nuts and crumbs out in the air in order to distract his injured brain and unconscious. We do not know anything about the war between pigeons and squirrels to get food. If we isolate that scene, we certainly cannot know what it was that made it happen in the way it happened. We fail to see how the act of tossing food in the air is tied up with the man’s need to perform it as a therapeutic ritual; and fail to see that that ritual can hardly be severed from what hurts the man at that moment. Nor can the man’s identity be severed from that ritual and its broader meaning as well as the broader meaning of rituals in his geo-cultural context. We could break down this example up to the point that anything would lose its meaning if severed from the rest, including the urban condition that allows the coexistence of pigeons and squirrels in a park, the location of the cemetery in the city, the loaf where the crumbs came from.

This apparently simple everyday example is an entry point to much more complicated “states” where the main entities are not pigeons and squirrels, but something like 10^{23} particles vividly interacting with their neighbours. Of course, one could object that it is one thing to describe particles in an atom; quite another to describe entities such as human beings and animals. But the main gamble of the processual view we are expounding is to show that this is mistaken. If one cuts deeper into the nature of physical states, however big or small in scale they may be, one comes up with an idea of

⁸ We should like to clarify the reason why we stick to the notion of entity and avoid other terms such as “objects”, “states”, or “things”. We think it is important to utilize the most general term in order not to pre-determine what an entity is within the set of relations that gives it identity. By entity we generally mean a *precipitate* of a process, while a process is not an entity. In order that an entity may be identified, it needs specific boundaries, such as a system of coordinates, whereas a process cannot “be counted by identifying discrete spatial or temporal regions in which they occur” (Seibt, 2018, 137). With reference to an ontological process theory that fits quantum field theory, Johanna Seibt makes this point quite nicely. She argues that, unlike (what in this article we call) entities, processes are not particulars, that is, they can be indeterminate, in the sense that they are not identifiable in terms of spatiotemporal coordinates. Says Seibt: “They are individuated in terms of their descriptive thisness, not by spacetime location, and may occur in a multiply disconnected spatiotemporal region with fuzzy boundaries. Their spatio-temporal location may even be indeterminate. For, second, free processes are not necessarily fully determinate. Just as there are more or less specific stuffs and common activities, so free processes occur in different degrees of determinateness” (Seibt, 2002, 87).

⁹ We deliberately draw from Williams’s (2011) enlightening example while he makes sense of Gilles Deleuze’s philosophy of time. While we cannot go into the details of Deleuze’s quite refined view of time and Williams’ nice analysis of it, we think there are many interesting parallels between the processual view we are advocating in this article and Williams’ take on Deleuze’s take on time.

entities that makes no room for states of things that are isolable and self-identical over time. The mainstay of this view is that all one can get when one thinks that one has to do with macro-entities is the approximation we mentioned above—one that cuts out all the elements that make that macro-entity what it is.

In sum, if a particular entity is isolated from the rest, one cannot produce a reliable description of that entity. As we will clarify in the successive section, an approximation is always a partial, abstracted knowledge that has to feed into progressively broader knowledge that takes into account as many relations as possible—in a way that no scrutiny of isolate entities would be able to secure. This entails that those that we perceive as macro-entities are abstractions and approximations of something that inevitably exceeds them by far. Needless to say, there are circumstances, depending on the specific purposes of a specific type of inquiry (whether in physics, chemistry, or other types of sciences, also so-called “soft” ones), where one *must* utilize such abstractions and approximations, if only because one can hardly hope to manage the intricacy of the universe of relations. However, one should be wary of mistaking those abstractions and approximations for what entities really are.

To make our case, this article addresses the issue from the point of view of relativistic physics in the first place and then brings it to bear on actor-network theory. Accordingly, the second section will approach a processual interpretation of the theory of relativity. Here processes are distinguished from states of things comprised of isolated entities, as spacetime is represented by a continuum that can be broken only ideally and for specific descriptive purposes. Where spacetime is regarded as a dynamical entity, no natural breakup of spacetime into spaces and times is admitted. A breakup only results from the introduction of an arbitrary frame of reference whereby a given state of an observed system arises. In this sense, the state of a system is but a partition of a continuous process by means of a frame of reference which does not belong to the system.

The third section will return to this very same theme from the perspective of actor-network theory. This methodology within the field of sociological and anthropological inquiry seeks to explain what happens when we see actors as *isolated entities*, whether they are macro-actors (a government, a court, a newspaper) or smaller ones (a human being, a microbe, a stone). The fundamental insight that actor-network theory shares with a processual reading of relativist physics is that, just like the ideal breakup of the spacetime continuum, a single actor is always an idealization which leads to approximate knowledge. When one perceives actors as if they were isolate bearers of agency, one neglects the web of relations that is the genuine source of agency.

The conclusive section will advocate the notion of individua(bi)lity. While human beings are accustomed to entities that are self-identical and thus pertinently isolable based on intrinsic properties, processualism problematizes this everyday assumption. The main characteristic of entities is their individua(bi)lity, in the sense that they can be identified only when they are placed within (always partial) sets of relations. Roughly put, then, a macro-entity is always composed of other entities that form different webs of relations with other entities that do not necessarily belong to that macro-entity, and that, furthermore, can always be the bearers of multiple identities, depending on how many sets of relations they are embedded in. Drawing from this view, we arrive at two methodological conclusions. First, gaining knowledge of a given entity requires localizing webs of relations and mapping connections with other entities. Second, the process cannot be observed from a bird’s-eye view. Localizing and mapping are processual interactions—so much so that gaining knowledge of a given entity involves engaging in a relation with it.

2 Processualism in Relativistic Physics

The idea that physics is not comprised of isolable states of things is a claim that physicist and philosopher of physics John Stachel (2005, 2006, 2014) raises based on his works on relativity theory.¹⁰ He contends that the conclusion that one should speak not of *physical states* but of *physical processes* is a main consequence of relativistic physics. It is difficult to explain these aspects to those who are not familiar with the insights of relativity, but the game is worth the candle if one wants to understand why the theory that has revolutionized our understanding of the world and enabled an unprecedented technological breakthrough also promises to remould our understanding of both natural and social entities (if this distinction ever holds).

One of the most compelling consequences of relativistic physics is the idea that time is not linear—certainly not in the way we are used to thinking of linearity.¹¹ Relativistic physics rejects the idea of there being an inherent ontological difference between what we call “past”, “present” and “future” events—and thus the possibility of ordering events in terms of a unique, linear temporal sequence. The principle of “relativity of simultaneity”, which encapsulates the main lesson of special relativity, states that two spatially distant events can be ordered in a temporal sequence only with respect to a reference system. To put it otherwise, it is impossible to determine if one of the two events is anterior or posterior to the other unless such a reference system is specified. Based on this principle, most scholars in the field of physics and philosophy of physics have concluded that our universe is to be conceived as a four-dimensional manifold in which all past, present, and future events coexist (see e.g. Dieks (2006), Price (1996), Wüthrich (2010)). If an event can be said to be present, past, or future according to a specific frame of reference, the argument reads, this is because there is no preferred or global “now” based on which events can be univocally ordered as previous, simultaneous, and successive. The metaphysical counterpart to this physical view states that the universe is to be visualized as a “block” in which all events are given once and for all—this position being termed “the block view” (for a thorough discussion on the topic see, e.g., Petkov (2006), Savitt (2002), Silberstein et al. (2012)). Any such sequence of events acquires an order in terms of pastness, presentness, and futureness only locally—which is to say, indexically, from a specific perspective—while the same events can be ordered in different sequences from different perspectives.

The view that we have summarized so far is rooted in special relativity. However, if one draws one’s attention to general relativity, the picture gets even more complicated. Not only

¹⁰ It goes without saying that Stachel is not the only who made this claim. As we noted, the idea of processes being at the heart of physics is agreed upon by other leading contemporary physicists—see Smolin (2001), Smolin (2020), Hiley (2001), Hiley (2011), Rovelli (2019), Rovelli (2020), Rovelli & Vidotto (2014). Furthermore, within the field of the philosophy of physics that expands on some of the consequences of quantum physics, a vivacious debate exists on the idea of relations being on a par with (or even more primitive than) physical entities (French & Krause, 2006; French & Ladyman, 2003; Ladyman, 1998; Ladyman & Ross, 2007; Lam, 2014). The reason why we rely on Stachel’s perspective is that he nicely combines insights from both relativity and quantum theory and puts forward a robust version of processualism grounded in physical theory rather than other metaphysical attempts to provide the rationale for processualism.

¹¹ The relativistic revolution in theoretical physics took place in two different steps, that is, special relativity (1905) and general relativity (1915). Various conceptual differences characterize them, which obviously cannot be properly addressed in the present context. For those who are interested in a more comprehensive account of the topic, highly recommended textbooks are Zee (2013) and Carroll (2014). For an instructive philosophical analysis, see Nick Huggett (2010) and Craig Callender (2017).

does general relativity dismiss temporal linearity. More than that, it also does away with the geometrical structure of special-relativistic spacetime. According to general relativity, geometrical properties arise out of the interaction between the gravitational field and the material content of the universe. On this view, it is impossible to fix a spatio-temporal background geometry. More radically than special relativity, within general relativity the understanding of spacetime breaks with Newtonian physics and its reliance upon a fixed background, in that spacetime is to be conceived as a dynamical entity whose structure is determined by the material content of the universe. As Carlo Rovelli (2006, 28) has it, “in Newtonian physics, if we take away the dynamical entities, what remains is space and time. In relativistic physics, if we take away the dynamical entities, nothing remains”. And this four-dimensional understanding of physical reality, in which the spacetime structure is to be conceived as a dynamical entity rather than a static reference background, is precisely the one that leads Stachel to endorse a processual interpretation of general relativity.

While the ramifications within the philosophy of physics are several—depending on whether scholars seek to conceptualize time, or spacetime, or the so-called principle of general covariance, and so on—Stachel brings relativity to bear on the conceptualization of physical entities. He first clarifies the notion of a process by distinguishing genuine processes from the mere sequence of instantaneous snapshots. To simplify the matter, let us go back to the example offered above. Based on Stachel’s understanding, it is erroneous to think of a process as an ordered sequence of instantaneous scenes: the man picks up some crumbs from a bag, then raises his hand, then releases the crumbs in the air, and so on. This erroneous conception is affected by two interlaced problems.

First, if one accepts the description of reality provided by general relativity, where spacetime is portrayed as a dynamical entity in which the spatio-temporal linearity of Newtonian physics fades away, then one cannot cut reality into slices that have a physical meaning of their own. Second, one’s looking at a given slice as a self-identical, isolable physical entity neglects the set of relations in which that entity is embedded. In doing so, one may delude oneself that the identity of that slice is an internal property of the slice itself, viz., something that can be better analyzed by singling out that slice and isolating it from the rest. Stachel’s opposite conclusion is that the elements comprising the continuum only acquire meaning from the whole set of relations they are embedded in. The elision of some relations—what happens when a snapshot gets isolated from the rest—leads to partial knowledge of what (thereby) becomes a state of things. Consequently, knowledge that only relies on self-identical, isolable entities is inevitably partial—or better, it can be correct for the limited purposes of a theory that posits a truncated system to be the whole; but, since a truncated system can hardly be the whole, from the perspective of the whole it is a knowledge that is inevitably partial, or even mistaken.¹²

As to the first problem, general relativity warns against the attribution of any physical meaning to those that we called “snapshots”, that is “arbitrary identifiers” in terms of isolable, self-identical, frozen states of things. Whether it involves one entity (the old man) or more than one (the old man, the statue, the pigeons, etc.), for convenience one can take a snapshot as a temporally unextended hypersurface; and yet there is no such thing within

¹² As we will clarify later on, this does not entail the pre-eminence of the whole over its parts. By “whole” here we do not mean the total set of relations from the beginning of the universe all the way down, but the total set of relations that make a given entity that entity. This article will not tackle the related but different question of whether the “total set of relations that make a given entity that entity” is the total sum of relations in the universe. We think that on this point processual thinkers of the various strands part ways.

physical reality. From the point of view of relativistic physics, this snapshot can only be taken as the ideal limit of a continuous process: “In theories, in which space–time is represented by a continuum, an event can be thought of as the limit of a portion of some physical process as all the dimension of the region of space–time occupied by this portion are shrunk to zero” (Stachel, 2005, 6). As we hinted above, the idea of a physical event whose dimensions are shrunk to zero can be utilized within physical theories that hold onto fixed spacetime. But where spacetime is regarded as a dynamical entity, no natural breakup of spacetime into spaces and times is admitted. Any such breakup comes from the introduction of an arbitrary frame of reference (a time-like fibration or a space-like foliation of the region of spacetime) whereby a given state of (what hence becomes) an observed system arises. In this sense, the state of a system is but a partition of a continuous process by means of a frame of reference which does not belong to the system. For Stachel, this means that in physics processes precede states of things.

This leads us to the second problem mentioned above, that is, how isolate entities acquire their identity and physical significance. Stachel’s analysis gets underway with the discussion of the so-called “hole argument”, which dates back to Einstein himself. The general theory of relativity is *generally covariant*, which, put simply, means that the significant laws of the theory do not depend on the adopted system of coordinates. If one commences with one model of general relativity and applies what is technically called a *diffeomorphism*, namely a permutation of the elements of the model, then a certain physical process can be described in two different manners, respectively corresponding to one or the other model. The hole argument is the way this problem has been thematized since Einstein’s first reflections on it (for a recent presentation, see Pooley, forthcoming). In Stachel’s view, the main consequence of the hole argument is that any future theory aiming at combining the results of relativistic and quantum physics should be background independent. If this is the case, the two different models mentioned above are *generally covariant* in the sense that, though in a different manner, they describe the same physical process. It is worth briefly expanding on this, as it explains why entities get their identity from sets of relations.

Stachel (2014, 6) observes that the hole argument is of particular theoretical import insofar as it “shows that, for any theory defined by a set of generally-covariant field equations, the only way to make physical sense of the theory is to assume that the entire equivalence class of diffeomorphically-related solutions to the field equations represent a single physical solution”. Based on this, he provides the foundation for his processual account of physics. He starts off by differentiating algebraic and geometric structures. If one considers a set of elements $S = \{1, 2 \dots N\}$ together with a set of relations between its elements, call it R , there is a significant distinction between a geometry and an algebra. In a geometry, the elements of $S = \{1, 2 \dots N\}$ display the same *quiddity* (i.e., the same nature) but no *haecceity* (i.e., non-inherently individuated properties).¹³ The differentiation between the elements originate from the set of internal relations R between them. If one omits these

¹³ Stachel adopts here Teller’s (1998) terminology. For the sake of clarity, we quote Stachel (2006, 56) at some length: “‘Quiddity’ refers to the essential nature of an entity, its natural kind; and—at least at the deepest level which we have reached so far—entities of different natural kinds exist, e.g. electrons, quarks, gluons, photons, etc. What distinguishes entities of the same natural kind (quiddity) from each other, their unique individuality or ‘primitive thisness’, is called their ‘haecceity’. Traditionally, it was always assumed that every entity has such a unique individuality: a haecceity as well as a quiddity. However, modern physics has reached a point at which we are led to postulate entities that have quiddity but no haecceity that is inherent, i.e. independent of the relational structures in which they may occur”.

relations, then the set $S = \{1, 2 \dots N\}$ is invariant under the permutation group. The set of relations specifying a geometric structure on S is termed R_G . The maximal subgroup of R_G for which all the relations between the elements of S is preserved is called the symmetry or automorphism group of this geometry. In the case of geometry, the identity of a certain element can only be defined in terms of the relations it bears. Quite the opposite, in an algebra, each element of a set $S = \{1, 2 \dots N\}$ displays both quiddity and intrinsic haecceity, as it is put in a one-to-one correspondence with a numbered coordinate system.¹⁴

In sum, while a geometric structure only allows individuating its elements in terms of the mutual relations between them, an algebraic structure does not need to consider the whole set of relations to individuate one of its elements. Put otherwise, algebraic structures as applied to the geometry of spacetime assign individuality to each of its elements and thus their inherent lack of haecceity gets lost because of a coordinatization procedure that attributes each geometrical element an algebraic coordinate. Stachel (2014, 20) adds that, from Descartes's introduction of analytic geometry, it is generally convenient, or even necessary, to employ algebraic methods in the solution of geometrical problems. However, this coordinatization conceals the homogeneity of the geometrical structure. If one wants to restore it, the class of all admissible coordinatizations of the geometry, based on the given algebra, must be considered. In this way, each geometric point is assigned every admissible element of the algebra as a possible coordinate in at least one admissible coordinate system. A transformation between two admissible coordinate systems is called an *admissible coordinate transformation*.

This reasoning has bearings on the hole argument as long as general relativity is a generally covariant theory. Indeed, Stachel believes that points of the spacetime manifold do have physical character even before a certain metric tensor is chosen. Yet, spacetime points lack haecceity. This is the view that he dubs *dynamic structural realism*.¹⁵ Based on this type of theoretical realism, processes have priority over states. This shines further light on the meaning of process. A process has to do with the acquisition of identity of a given entity within a set of relations, short of which that entity would not be identifiable. This means that the issue of process is tied up with the issue of whether or not entities can be extrapolated from broader set of relations among more entities that confer identity upon each of them. This type of processualism deems the identity of an entity to be contingent upon the set of relations with other entities—none of which is distinguishable based on intrinsic properties. It is precisely in this sense that the distinction between algebraic and geometric structures brings to light the problem of the identity of entities. Algebraic structures give the idea that relations among spacetime points are extrinsic and thus do not bear on their intrinsic individuality, so much so that a spacetime point can be individuated with no reference whatsoever to the others. Quite the reverse, within geometric structures the only distinction between spacetime points emerges from internal relations between them, so much so that the individuation of a spacetime point is possible only via an activity of identification that conceptually (i.e., abstractly, for certain descriptive purposes) isolates it from its nested set of relations.

¹⁴ For a nuanced critique of Stachel's reasoning, see Pooley (2006).

¹⁵ This view leans towards a form of structuralism, different from the version of structural realism advocated by Ladyman or by French (see e.g. Ladyman, 1998; French & Ladyman, 2003; French, 2014).

3 Processualism in Actor-Network Theory

It is from this perspective that we will attend to the main lesson of actor-network theory¹⁶ and Latour's (1988) irreductionism. In an early article, John Law (1992) does a very good job in showing that the main problem of actor-network theory is how we get to see actors as *isolate entities*, whether they are macro-actors (the UNO, NGOs, the Supreme Court) or smaller ones (an old man, a pigeon, a crumb). The fundamental insight is that, just like the isolation of a slice of the spacetime continuum, a single actor is always an idealization which provides approximate knowledge. This is something that Law gestures to in terms of *heterogeneity vs. punctuated actors*. When one perceives actors as if they were isolate bearers of agency, one misses out on the web of relations that is the genuine source of agency. Let us make this point with reference to our discussion above.

If we hold onto Stachel's terminology, we can easily apply the actor-network view on the ordinary example of the old man. As we already emphasized, certainly the meaning of the act of feeding pigeons cannot be extracted from the snapshot of the act itself; let alone the significance of the act within the man's psychic life; let alone the ongoing struggle for food among aves and rodents in an urban area. So, we can take each of these elements as points endowed with quiddity but no haecceity. For example, the (individual) hand casting crumbs can be described as a quite different thing depending on the system of coordinates that we choose: a mechanism to cope with grief or an undesired incentive for dangerous virus carriers to colonize a public park. But again, what is the single entity within these two different descriptions?¹⁷ The hand catching crumbs in a bag has an individuality but

¹⁶ This article cannot obviously hope to account for actor-network theory in any satisfactory manner, as it only aims to pinpoint the notion of entity and its identity that it leads to. The literature on this approach—or family of approaches—is voluminous. For present purposes, we limit ourselves to mentioning pioneering works such as Callon (1986a), Callon (1986b), Callon and Law (1997), Latour (1988), Latour (1996), Latour (2005), Law (1992), Law (2008).

¹⁷ It is important to clarify that when we refer to the “meaning” of the action, or to the possible descriptions of it, we refer to the various identities that the action takes within different sets of relations. More precisely, we are not distinguishing between an ontological level, where entities *are*, and an epistemological or descriptive level, where entities *are described*. We think that the problems of what an entity is and of how it can be cognized are inextricably tied to one another. In this sense, the problem of the “meaning of the action” does not simply concern how one can gain knowledge of that entity and how detailed this knowledge can be. One of the main tenets of process philosophies generally is the dismissal of the chasm that is posited between being and describing, the ontological and the epistemological realms. As we will insist at the end of this article, describing an entity already and always involves a relation to that entity, to such an extent that the only way to gain knowledge of an entity is through that relation. This explains why Whitehead employed the term “prehension” to describe how entities are related to each other and how they are further related to other entities, while all entities are related. Still, one does not need to subscribe to Whitehead's thick ontological lexicon to make this point. Even in the domain of physics, Rovelli & the correct syllabication is Vidotto (2014, 50), for example, lament the “anthropomorphic language” of physical methods for describing processes in quantum theory as they make reference to “preparation” and “measurement”. With more than a processual nuance, Rovelli and Vidotto write: “The boundary of a process can be any physical interaction of the system with another—generic—physical system. Quantum mechanics describes the manner in which physical systems affect one another in the course of these interactions”. Accordingly, not only is quantum theory the description of how quantum systems affect each other, but quantum states are descriptions of the ways in which a system can affect another system. This also applies to general relativity, especially in the processual reading we favour. Rovelli's is just a telling example of how the distinction between the ontological level of processes and the epistemological level of describing processes is not tenable within processualism. As Rovelli (1996, 1650) comments, “a universal observer-independent description of the states of affairs of the world does not exist”, and should be replaced with the idea that “the properties of the systems are to be described by an interrelated net of observations and information collected from observations” (1669).

cannot be meaningfully described unless it is put in relation to the pigeons, the squirrels, the cemetery, the loss of a loved one, and so on. Or better, it could be ideally described (ideally in the sense that it *is* an idealization) as nerves, tissues, and bones moving in such and such a way—and probably this would be meaningful enough for the limited purpose of the biomechanics of the hand but hardly enough to account for what the old man is busy with. In other words, is the isolation of the distinct entities in any way helpful in understanding what is going on in the scene described above? And again, what is the limit to which the scene can be shrunk? The park with various animate and inanimate entities, the old man, his hand, its fingers, its tissues, the muscle contraction arising out of the interaction between actin and myosin?

This all entails that a single snapshot is populated by a myriad of “punctuated” actors that can be isolated for different purposes and are subsumable under different descriptions answering to different types of inquiry. But it is evident that the isolation of the single punctuated actor leads to a very partial knowledge. The narrower the punctuation of the actor, the narrower the scope of the knowledge we can come up with. Quite the reverse, different, less partial types of knowledge can be gained if we put the punctuated actors within broader and broader filaments of relations. As we insisted, these filaments depend on the type of inquiry one is pursuing. It is one thing to try to understand why the old man is coping with grief by feeding pigeons and squirrels; it is another thing to explain the overpopulation of pigeons based on the bad habit of feeding them. The same entity, say, a crumb, can be put within different sequences of relations, where it acquires different identities—thus exerting different effects within different chains of agency.

The bottom-line of this discussion is what Law puts in terms of *simplification*. As his argument goes, all phenomena are the effect of *heterogeneous networks*, or, in our lexicon, relations among entities possessing individuality but no haecceity. Most of the time “we do not cope with endless network ramification” (Law, 1992, 385). Most of the time we are not even in the position to detect such complexity. We happen to see isolated actors acting *as if* they were self-identical entities doing things over time. When we have this type of experience, it is *as if* a network could be broken down into single blocks, single punctuated entities that make the network *disappear*. At that point, the network is “replaced by the action itself and the seemingly simple author of that action. At the same time, the *way* in which the effect is generated is also effaced: for the time being, it is neither visible nor relevant” (Law, 1992, 385).

This fundamental insight lies at the heart of Latour’s irreductionist methodology. His ban on reductionism, as is the case with Law’s own version of actor-network theory, is meant to give the lie to social explanations that involve mechanisms or structures as (invisible) causal factors. Within reductionist theories,¹⁸ single phenomena are explained away with reference to abstract entities that cannot be observed in the scene and yet are endowed by the theorist with causal agency. Explanations invoking, say, capitalism, inequality, or patriarchy to account for specific circumstances actually explain nothing. The only thing they do is subsume highly differentiated entities under the same causal relations. To stick with our by now familiar example, such “macro-structures” as neo-liberal capitalism and

¹⁸ The array of authors who are charged with reductionism is very broad—all too broad, one might argue. Indeed, the limits of Latour’s critique is that often it seems to target a straw man under the general label of “sociology of the social” or its most depraved version “critical sociology” (see especially Latour 2005). As this is not of our concern in this article, we will not point the finger at this flaw. Rather, we will concern ourselves with the constructive side of Latour’s metaphysics.

its proclivity for self-entrepreneurship is what could be used to explain both the old man's coping mechanism and his recurring visits to the cemetery to befriend pigeons and squirrels: the reduction of spaces for social interaction as party to the neoliberal strategic urban spatial planning teams up with the individual-based remoulding of social life whereby social exclusion is an inevitable effect of the retreat of the welfare state within western countries. This is but an example of the explanatory reductionism Latour bemoans.

However, the focus of this article is not so much the set of criticisms that Latour and, more generally, actor-network theorists level at structural explanations. Rather, we are concerned with the notion of entity and its identity that stems from this irreductionist perspective. Our claim is that, in conjunction with the broader notion of heterogeneous networks advanced by Law, Latour's irreductionism leads to a processual understanding of individual entities in terms of (what we will dub here) *individua(bi)lity*. This notion conjures the idea that non-haecceistic entities are amenable to a process of identification, that is, to the acquisition of identity only with respect to the filaments of relations that are picked up. The example of the old man's hand illustrates that, as more than one filament can be taken into account, an individual non-haecceistic entity can get more than one identity.

This is the twofold lesson that we should learn from irreductionism regarded as a form of processualism. First, no entity possesses an intrinsic identity of its own, nor is its identity comprehensible if this entity is abstracted from its web of relations. Second, every entity stands in various webs of relations where it gets different identities, so much so that an entity is in fact many entities at the same time. In short, when one starts with an isolate entity, actor-network theory and irreductionism remind one that the single entity makes the network disappear. Since the overall network ramification comprising the whole universe is hardly manageable, one should progressively broaden one's mapping of the network along one or more of its various ramifications. Therefore, a truncation of the overall network is sooner or later inevitable. Yet, one should make an effort not to truncate the ramification too soon. One should localize the set of relations that confers a given identity on a given entity and try to expand one's knowledge of it as far as possible. This is of course a thankless job with possibly no end point. Yet, the progressive expansion—certainly contingent on the type of inquiry one is pursuing—calls one to go down this road.

This view is nicely encapsulated in a series of junctures of the first chapter of Latour's "Irreductions" (Latour, 1988), where he explains how one can map entities and how these entities can only be mapped within webs of relations. It is interesting to notice a series of parallels with our discussion in the preceding section, especially the impossibility of establishing unique series of events in absolute spatiotemporal sequences and how this impossibility opens the door to a dynamical understanding of reality (in a way that casts out the conventional bipartition of the natural and the social—an old chestnut in actor-network theory).

"Nothing is, by itself, either knowable or unknowable, sayable or unsayable, near or far" (Latour, 1988, 167). This resonates with our previous conclusion on the non-identifiability of an entity irrespective of its broader set of relations. Interestingly, also relations of distance are put under the same umbrella. As is the case with the dynamical structure of spacetime within general relativity, distance relations cannot be accounted for in absolute terms. And even more interestingly, for Latour the same applies to the dimension of time. For time is not a linear ordering of separately occurring events. Rather, it is the outcome of a local ordering from a local perspective: "Time is the distant consequences of actors as they each seek to create a fait accompli on their own behalf that cannot be reversed. In this way time passes" (Latour,

1988, 165).¹⁹ Therefore, not unlike theories that take stock of relativistic physics, time is not understood as something that flows in the sense of a moving now that shifts in keeping with a univocally defined arrow, this shifting resulting in an absolute distinction between past, present, and future. Rather, many local temporal sequences can be defined from local perspectives. In this sense, time “does not pass” (Latour, 1988, 165).

This entails that webs of relations not only determine the identity of an entity. They also put the entity in different (local) temporal sequences. Latour articulates this intuition as follows: “Of course, one force may overtake the others, but this can only be local and temporary because permanence costs too much and requires too many allies” (Latour, 1988, 165). In our lexicon, as the same entity can be party to different sets of relations, the temporal sequences in which this entity can be located are more than one. This leads to a truly dynamical understanding of reality that, with reference to the preceding section, could be defined “background independent”. Says Latour (1988, 166): “There is no external referent. Referents are always internal to the forces that use them as touchstones”.

Although Latour’s use of “force” may sound metaphorical (in a way that would look less so if one cares to read the whole book), this term simply stands for the relations between entities within the various webs. In the example above, the old man’s hand tossing crumbs in the air stands both in a relation to a psychic state and in a relation to the dangerous overpopulation of pigeons in an urban space. In both these filaments of relations, the hand belongs to different chains of agency as part of different heterogeneous networks: it can successfully (or not) lessen the psychological suffering due to the loss of a loved one and can effectively increase the risk to the health of humans and animals due to the presence of cryptococcosis in the feces of pigeons. These filaments of relations that endow the hand with different identities insert that very hand in different temporal sequences. In a way, one may say that temporal sequences and filaments of relations are one and the same thing.

This leads us to the core of irreductionism. Latour writes: “Nothing is, by itself, the same as or different from anything else [...]. In other words, everything happens only once, and at one place” (Latour 1988, 162). As an entity acquires more than an identity, depending on how many sets of relations it is embedded in, an entity has many unique identities. This is an extreme but highly interesting consequence of processualism. Saying that the old man is the same old man in the various snapshots that (approximately) depict the sequence of his actions, in the end, is far from correct. As we wrote above, a single snapshot is populated by a multitude of seemingly distinct entities that can be isolated for different purposes. Accordingly, saying that the old man who grasps crumbs in a bag is the same as the man who feeds crumbs to pigeons and squirrels is an approximation based on the set of relations that one picks up, while (whether deliberately or not) omitting a whole lot of relations that tie the various entities comprising the broader entity “old man” to other entities.

This is more difficult to describe than to experience in everyday life. For this is what we do when, for one thing, we intend to describe a man performing a ritual as an unconscious therapeutic practice, or, for another thing, to analyze a bad habit that contributes to the overpopulation of pigeons in an urban area. Irreductionism is nothing other than an invitation not to stably locate the old man’s hand in this or that camp. For example, let us imagine that another man is standing nearby to feed pigeons and squirrels, whereas this second man does not have any loved one buried in the cemetery and is not performing any ritual. At first sight, they are doing the same thing, whilst the filament of relations in which the two men’s hands are located lead to entirely different identities. This explains why Latour (1988, 164) writes that “there are neither wholes nor parts”. The old man is a composition of entities that in their

¹⁹ On this point, also see Harman (2009, 17).

turn are composed by many entities, while he himself is composed by just as many entities—all these compositions being amenable to different descriptions that have different wholes and different parts depending on the filaments of relations that are taken into account.²⁰

4 Individua(bi)lity

From different routes we have come to the same conclusion. While human beings generally think of entities as self-identical and durable, that is, as persisting through time while keeping a stable identity secured by intrinsic properties, processualism problematizes this assumption. The main characteristic of entities is their *individua(bi)lity*. Entities can only be identified when they are grasped in the relation they have to other entities.²¹ And, as we have emphasized, identities can be multiple.²²

²⁰ It is worth noting, though only in passing, that this irreductionist conception does away with the deep-seated difference between social and natural entities, because the “social” is no longer regarded as a special domain or field. As Latour makes clear in many of his writings, all entities are hybrids made up of “social” and “natural” stuff. In truth, if we think of our example in this article, it is difficult to establish, for instance, whether the action of the hand performing a ritual to cope with grief is a social or a natural entity, whether grief as an acute pain accompanying loss is a psychological notion or is an actual biochemical, physiological mechanism. The distinction between social and natural domains can be the effect of a description, as one, for example, brings out the relation between the coping mechanism and some traumatic memories that have been repressed, or rather how the activity in a part of the brain changes because of neurotransmitters involved in the stress response. The main methodological tenet related to the processual conception that we are advocating here is that the boundaries of the theoretical framework are set by the types of relations the researcher is tracing. This is generally a key acquisition of ANT methodologies, as Ignacio Fariás, Anders Blok, and Celia Roberts (2020, xx) underline: “ANT has been at the forefronts of conceptualising new predicaments beyond the ‘modern divides’ between nature and culture, the technical and the social. In ANT, processes and relations run deep and literally stretch the world, also undoing scalar modes of conceiving the social as a dialectical articulation of agency and structure, the local and the global, the big and the small” Needless to say, this problem would need deeper scrutiny, as it relates to the vexed question of separation of nature and culture, which Latour and many other scholars with him have questioned –

²¹ An interesting comment by one of the three readers was that the idea of non-isolable physical entities amounts to relationism, not to processualism. We do not think this is the case. While processualism implies relationism in the sense that the identity of entities depends on the set of relations they stand in and their properties are relational properties, not all versions of relationism are processual. For one thing, as we pointed out in footnote 5, Barbour’s (1999, 329–330) configurational relationism strongly rejects the idea of a process as it is not compatible with his adynamical image of the universe comprising a set of N point-like particles fixed in their position. However, the most important reason why processualism cannot be reduced to relationism is not that there are relationisms that are not hospitable to the notion of process. For the idea itself of process contributes something valuable to relationism that is not entailed by the idea of relation. The type of processualism we advocate here in both relativistic physics and ANT combines relationism with the anti-essentialism typical of all process philosophies, insofar as we make the claim that processualism does not assume stable entities as its primary target and hence does not try to explain what we talk about when we talk about “things”. The primary explanatory target of processual physics and social theory are the processes that make things acquire their multiple identities—these processes being, in our reading, intersecting sets of relations. So, as Stachel points out, the lexicon of stable things or states should be replaced for a study of processes, and this is a claim that relationism alone can hardly vindicate.

²² It is worth noting that Lam (2014, 1169) comes to a very similar conclusion drawing from a different theoretical framework. In the subject area of non-relativistic quantum mechanics, Lam argues that the relational (he also writes “contextual”, though we are more sceptical of this term) conceptualization of fundamental physical objects “possess an existence that is dependent on the physical structures they are part of; in particular, they do not possess any intrinsic physical identity and individuality”. Importantly, the article tackles the possible objection of the circularity of *relata* and relations. In our jargon, we can put it as follows: while non-haecceistic entities exist and are necessary for relations to obtain (otherwise they would be

Individua(bi)lity conjures the relationist and non-essentialist nature of entities, whereby what entities are does not depend on any intrinsic property. Entities, as it were, are amenable to multiple processes of individuation, as one considers a given set of relations to which they are party, while they are party to several sets. Within sets, entities individuate themselves and make themselves identifiable *individuales*. This means that, whether in the field of exact or social sciences, the method to gain knowledge of an entity is a twofold *localizing-and-mapping* activity. One should localize as many links of an entity with other entities as possible for one to be able to map the filaments of relations that give that entity a specific identity. Haecceity—the possibility of saying “that is that”—emerges only once the set of relations is brought to surface. As we have insisted many a time, different inquiries might pursue different objectives. But the principles of localization and mapping, we believe, should invite all researchers not to truncate the procedure by which they circumscribe their research object too soon.

This first methodological conclusion should be supplemented with a second one—a conclusion we can just allude to, as it opens the door to a whole new set of problems. The idea that both physicists and actor-network theorists are well-aware of is that any inquiry yields a perturbation of the process that is being investigated. No process can be studied from a neutral point of view. The analysis of a process is a process that interacts with the process that is being analyzed. Therefore, one of the relations that should be taken into exam is the one that gets created between the inquirer and the object of inquiry. The conclusion is an interesting one, though. Any one’s inquiry is also an inquiry of oneself.

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Footnote 22 (continued)

purely phenomenal or even illusory), their identity is not primitive, as it is established only in the light of the set of relations.

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