How Do Processes Work?

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Abstract. This paper focuses upon the notion of process that is allegedly an 'ongoing' continuant-like occurrent (or occurrent-like continuant) and that attracts growing attention in formal ontology and in philosophy. We argue on closer examination that underlying ideas behind processes may be at least as well explicable through a fuller exploitation of existing categories and relations as in terms of the distinctive ontological category of processes.

Keywords. process, time, persistence, action, causation

1. Introduction

Upper ontologies are by nature characterized by various choices, a classical example of which is ontological choices [1]: choices as to whether a given category or relation is adopted. There are two ontological choices that are relatively widely accepted. One is the distinction between universals (aka types, classes) and particulars (aka tokens, instances), where particulars (e.g., Mary) bear the instance-of relation to universals (e.g., *Human*). The other is the distinction (whether within particulars or universals) between continuants (aka endurants) and occurrents (aka perdurants). One typical example of continuants is objects: e.g., molecules, people, and planets. We will speak mainly of particulars unless otherwise specified (e.g., 'occurrent universal').

The goal of this paper is to scrutinize the ontological category of *processes*. Different upper ontologies employ the term 'process' quite differently; but the kind of process on which we focus is allegedly an 'ongoing' occurrent that is typically expressed by the progressive aspect of the English verb: e.g., "Mary is walking." Processes have enjoyed a growing attention both in philosophy [2-4] and in formal ontology [5-7] for the last decade. There are still some thorny questions to be answered regarding their essential nature. For instance, many disputants agree that, although being occurrents, processes are like continuants in some sense; and a few say that processes are conversely occurrent-like continuants. Closer examination of processes will afford us a deeper understanding of continuants and occurrents, and hence of upper ontologies in general.

More specifically, we will examine what we call 'global arguments' (Section 2) and 'local arguments' (Section 3) for processes. The former provide foundational reasons for adopting processes that are closely related to time and persistence. In ontological parlance, they pertain to meta-ontological choices [8] of upper ontologies: choices that are fundamental enough to determine ontological choices. Contrariwise, the latter offer more specific motivations for processes to the effect that processes serve as a useful conceptual tool for analyzing mentality, actions, and causation. Our basic thesis is that,

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instead of introducing the distinctive ontological category of processes, we can specify processes sufficiently well by leveraging more effectively existing categories and relations. We conclude the paper with some brief remarks on future work (Section 4).

2. Global Arguments

2.1. Time and Persistence: Preliminaries

Let us begin by explaining background knowledge of time and persistence before considering arguments that emphasize a specific temporal and persistence-related aspect of processes. Philosophy of time revolves around two issues. One is the dispute over what we may call 'NOW' between the A-theory (aka the tensed theory) and B-theory (aka the tenseless theory).[2] Our experience of time teaches us that there is something special about NOW. We (directly) experience only the present time, but not any past or future time. Additionally, NOW seems to move in one direction and the irreversible movement of NOW appears to be the single most important factor of our experience of the 'passage' or 'flow' of time. The question is whether NOW, the flow of time, and the distinction between the past ('before NOW'), the present ('contemporaneous with NOW'), and the future ('after NOW') are the objective (mind- and language-independent) characteristics of the real world or not. The A-theory says yes: the movement of NOW creates the passage of time from the past through the present towards the future [10]. The B-theory says no: NOW, the flow of time, and the purported past-present-future distinction are nothing more than the features of our experience of time, but not those of fundamental reality of time [11].

The other is the dispute over temporal ontology. Two major positions are eternalism and presentism. Eternalism says that the past, the present, and the future exist [11]. Presentism holds that only the present exists [12]. More precisely, eternalism is the view that past and future times, objects, and occurrents are as real as the present times, objects, and occurrents. Presentism counters that only the present times, objects, and occurrents exist. Imagine that one asks: "Does Socrates exist?" The eternalist says yes; and the presentist says no.[3] A philosophical stance of time is usually characterized by a combination of theories in both controversies. For instance, presentists invariably argue for the A-theory, so that the term 'presentism' is more often than not used to refer to a package consisting of presentism (in our sense of the term) and the A-theory; and eternalists usually, if not always, endorse the B-theory.

Lastly, philosophy of persistence centers on the debate between endurantism and perdurantism [14, pp. 202-204].[4] An object persists if and only if it exists at one time,

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[2] The terms 'A-theory' and 'B-theory' are ascribed to McTaggart's [9] terms 'A-series' and 'B-series' of time in his argument for the unreality of time, respectively.

[3] Note that the eternalist and the presentist both agree that Socrates does not *exist 'now'* (in the ordinary sense of the term) but *existed* approximately 2500 years *ago*. They disagree (as they insist, at least) on the philosophically substantive problem of whether Socrates exists *at the fundamental level of reality*. See e.g., Sider [13, Chapter 11] for more thoughts.

[4] Two caveats. First, we avoid using the terms 'three-dimensionalism' and 'four-dimensionalism' that tend to be highly polysemous in formal ontology as well as in philosophy, although they are sometimes regarded as synonymous with endurantism and perdurantism, respectively. Second, we do not draw a distinction within perdurantism between the worm theory [14] ("A persisting object is a four-dimensional

and also exists at another distinct time: e.g., a frog persists if it existed as an embryo and exists as a tadpole. Note that an object is something that *persists*, whereas an occurrent is something that *happens* or *occurs*. Perdurantism is the thesis that objects persist by 'perduring', i.e., by having (proper) temporal parts: temporal analogues of spatial parts.[5] On the perdurantist account, for instance, a frog has its 'embryo temporal parts' and its 'tadpole temporal parts', just as the frog has the head as its spatial part. Endurantism consists in rejecting perdurantism and insisting that an object persists by 'enduring', which is typically construed as saying that an object is 'wholly present' at every time at which it exists. Notwithstanding controversy as to what this phrase is supposed to mean (see e.g., [16,17]), we can interpret endurantism as the doctrine that objects do *not* have (proper) temporal parts at every time at which they exist.[6]

2.2. Processes as A-theoretic and Enduring Occurrents

It is notoriously difficult to discuss processes, owing in part to the fact that significantly diverse usages of the terms 'process', 'event', and 'state' have been offered in the literature (see e.g., [4]). First of all, the term 'event' can be read at least in three ways: (i) occurrents in general, as many ontologists say; (ii) a typical kind of occurrents, or more specifically non-instantaneous occurrents in contrast with instantaneous ones (e.g., the onset of sleep); and (iii) 'completed occurrents' that would be concordant with the perfective aspect of the English verb (e.g., "Mary walked."), as some advocates ('processualists' hereafter) of ontology of processes claim. Connectedly, the term 'process' can be interpreted either as (ii) or as (iv) 'ongoing occurrents'.[7] From now on we will refer to events and processes in the (iii) and (iv) sense of the terms, respectively, unless otherwise specified. To keep things manageable, on the other hand, we will use the term 'state' while leaving aside its exact ontological nature (but see Section 4).

Let us examine ontology of processes. There is, first of all, some agreement among the disputants (whether processualists or not) over the following statements:

- (A) Endurantism: continuants (objects) 'survive' various changes over time.

'worm' that stretches out through time.") and the stage theory [15] ("A persisting object consists of 'stages' such that the object name refers to different stages at different times.").

[5] There is considerable disagreement on how to define explicitly what temporal parts are meant to be, though. See Sider [15, Chapter 3] for their definition currently most widely used in the literature.

[6] Strictly speaking, we should be wary of the understanding of persistence based on temporal parts. Although temporal parts are traditionally taken to be the crux of the matter of persistence (see e.g., [14, pp. 202-204]), there is nowadays an increasing consensus among philosophers of persistence that the endurantist and perdurantist accounts of persistence should be primarily characterized in light of spatiotemporal location (namely, how objects are located in spacetime) and it serves at best as an auxiliary assumption whether objects have or lack (proper) temporal parts [18-20]. We are justified in regarding persistence as the subject of temporal parts, however, insofar as the discussion on processes is concerned. We nonetheless admit that this recent active re-framing of the endurantist/perdurantist debate over persistence may be impactful enough to bring about a radical shift in the whole argumentation offered in this paper.

[7] For an interesting exception, an upper ontology the Descriptive Ontology for Linguistic and Cognitive Engineering (DOLCE) [1] has the category of processes based on Vendler's [21] aspectual classification of verbs, which fall neither into (ii) nor into (iv). In defining (public) services as activities and discussing the ontological nature of activities, Guarino, Longo and Guizzardi [22, p. 5] comment on DOLCE-processes as follows: "they [activities] would correspond to what in DOLCE are called *processes*. This choice is however not particularly amenable for our purposes, since perdurants in DOLCE are entities frozen in time, which cannot change. This would force us to model services only as historical entities, after they have ceased to be present. On the contrary, the idea of services as activities relies on the intuition that such activities are typically *ongoing*, and can genuinely change in time (…)."

- (B) Occurrents are temporally extended ('unfold in time', 'occupy time').
- (C) Occurrents have temporal parts.
- (D) Occurrents have as participant some continuant (object).[8]

It is not hard to see that (B) and (C) are almost always coupled, as is indicated by the fact that the term 'perdurant' (which we can understand here as an entity having temporal parts) is synonymous with the term 'occurrent'. A few processualists would actually seem to deny (B) and (C) in perceiving processes as occurrent-like continuants, roughly in such a way that, although they do occur, processes satisfy neither (B) nor (C) because they are continuants [3,23]. As Steward [2] convincingly argues, however, this is a considerably pricy view because it may risk us failing to understand what it is like to be an occurrent. We will thus put a main focus on processes as (continuant-like) occurrents.

Processualists' primary motivation for processes would be that existing ontology of occurrents comes down to ontology of events because it has taken for granted the coupling of the B-theory with eternalism, which is sometimes called the 'block universe view' and according to which the 'block spacetime' is a four-dimensional manifold of points that in no way changes or grows.[9] Ontology of events provides only a 'static' picture of occurrents and fails to capture the 'dynamic' aspect of the world. To take Steward's [2] example, suppose that a car travelling was smooth at time t_1 but bumpy at t_2. Intuitively, there seems to be a change in the occurrent of the car travelling from smoothness to bumpiness. Ontology of events leaves this change unexplainable, as processualists say, because the event of the car travelling is 'frozen' in the block universe and it is unchangeable. This requires us to adopt ontology of processes as A-theoretic and enduring occurrents: occurrents that *are 'now' happening* or *occurring*, and also that 'endure' just as objects do (recall (A)).[10] In this second point, processes are said to be continuant-like occurrents.[11] The change under consideration is explicable in terms of the change of the process of the car travelling, which was smooth at t_1 and bumpy at t_2.

This occurrent view of processes is fraught with difficulties, however. One of the most cogent reasons for this is arguably the apparent inconsistency between the 'perdurant' nature of processes (i.e., (C)) and their special, enduring feature. This forces the defender to face a dilemma about whether to accept this contradiction. First Horn: to circumvent it, the supporter needs to abandon the occurrent conception of processes and adopt their continuant view, which above turned out to be highly problematic. Second Horn: to resolve the conflict, she has to postulate a 'surrogate' for the 'enduring identity' of processes, which would yield implausible complexities.[12] In addition, the A-theoretic facet of processes is obscure as well. Processualists would strive to supplement (instead of replacing) ontology of B-theoretic events with ontology of A-theoretic processes; but

[8] It may be sometimes argued that there are processes (or events) without any participant. As some processualists would say, for instance, a process of sound wave has no participant even if it depends on air. Whether (D) can be dropped or not lies outside the scope of this paper.

[9] Guarino's [7] term 'eternalist view' would correspond closer to the block universe view than to eternalism in the terminology of this paper.

[10] Variants of our appeal to the A-theory in characterizing processes include the 'temporal window' [5], the 'perspective from within the happening of an occurrence' [24], and the 'experiential point of view' [25]. Note that Stout [3] mentions A-series (see Footnote 3) and Guarino [7] aims at a 'tensed ontological account' of processes.

[11] There is also the view (e.g., [5]) that processes are, in some sense, 'constituents' of events, just as matter (e.g., a block of marble) is of objects (e.g., Michelangelo's statue *David*).

[12] Cf. Charles's [23] objections to the idea of the temporal window [5].

the A-theory and the B-theory are, by definition, mutually incompatible in the debate over NOW. Furthermore, the block universe view may have the virtue of ontological modeling (e.g., as compared to the combination of the A-theory and presentism), as Guarino [7] implies. Processualists' attempt might be thus interpreted as offering a sort of B-theoretic treatment of NOW in some way or other.[13]

We hypothesize, albeit somewhat boldly, that underlying ideas behind ontology of processes may be largely, if not totally, explicable in terms of occurrent universals. In fact, some recent endeavors to avoid the aforementioned dilemma would provide some considerations in favor of our thesis. While positing that continuants and events have their properties primarily at times and atemporally respectively, for instance, Steward [2] suggests that processes have their properties primarily *between times* and that our capability of *idealization* enable us to think that their 'between time' properties are said to be had *at* the times which fall within the relevant period.[14] Using the car-travelling example, to say that the car travelling was smooth at t_1 (resp. bumpy at t_2) amounts to our idealized paraphrase of the ontological fact that t_1 (resp. t_2) was a moment which falls within a period of time *over which* the car-travelling process was smooth (resp. bumpy).

Some deep concerns arise over Steward's theory of processes. Suppose further that the car travelling was smooth between t_0 and $t_{1.5}$, and bumpy between $t_{1.5}$ and t_3. There are at least two occurrents in this scenario: (a) the process (say P_{CT}) that unfolds itself between t_0 and t_3; and (b) the event (say E_{CT}) that unfolds itself between t_0 and t_3. On her account, P_{CT} is smooth between t_0 and $t_{1.5}$, and bumpy between t_0 and t_3; whereas, this is not the case with E_{CT} because it has properties primarily atemporally. The question lies in the principle of individuation for P_{CT} and E_{CT}. She begs the question unless he delineates why P_{CT} sharply contrasts with E_{CT} although they both span the same interval of time. To see the problem more clearly, let us introduce two more occurrents: (c) the event (say E_{smooth}) that unfolds itself between t_0 and $t_{1.5}$; and (d) the event (say E_{bumpy}) that unfolds itself between $t_{1.5}$ and t_3. We could agree with Steward in the following sense: the fact that E_{smooth} is smooth and E_{bumpy} is bumpy is at best a necessary (but not sufficient) condition for the change in the car-travelling from smoothness at t_1 to bumpiness at t_2 because E_{smooth} and E_{bumpy} are (numerically) different. It is highly doubtful how she can say that P_{CT} (but not E_{CT}) is smooth between t_0 and $t_{1.5}$, *and* bumpy between $t_{1.5}$ and t_3 without falling into the trap of speaking of 'process counterparts' of E_{smooth} and E_{bumpy}.

Steward's [2] work is nonetheless well worth noting in virtue of its unique reference to idealization. Insofar as they satisfy (B) and (C) as occurrents, processes do not have properties at any time instant; but we can idealize 'between time' properties of processes in such a way that, just like objects, processes have properties (secondarily) at times. This observation may direct us further towards the idea of processes as occurrent universals. Our serious worry over her proposal shows the grave difficulty of finding room for processes in the realm of particulars, where processes would be inevitably indistinguishable from events. Ontology of processes would necessitate the abstraction or 'idealization' of processes into universals. At the first attempt, processes and events can be reconceptualized as follows: processes are occurrent universals whose instances

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[13] Guarino [7] seems to characterize processes in terms of what we may call 'A-theoretic properties', which are compatible with block universe worldview. Close examination of his theory of processes requires serious engagement with ontology of properties, which is beyond the scope of this paper.

[14] Following Steward [2] (and hence *à la* the DOLCE [1] upper ontology), we are assuming that, being disjoint from continuants and occurrents, properties are their characteristics. Note that, for instance, an upper ontology Basic Formal Ontology (BFO) [26] classifies properties as a subtype of continuants (dependent continuants) and BFO is skeptical of the possibility of (talk of) properties of occurrents.

are events. On this construal of processes and events, for instance, E_{CT} is an instance of a process (occurrent universal) of the car travelling. More interestingly, the change in the car-travelling from smoothness at t_1 to bumpiness at t_2 would be explained by the fact that a process of the car travelling is instantiated in a 'smooth way' at t_1 (hence the occurrence of the t_1-event of the smooth car-travelling) and in a 'bumpy way' at t_2 (hence the occurrence of the t_2-event of the bumpy car-travelling). Generally speaking, the change in properties of events (occurrent particulars) is attributable to the change in the way of the instantiation of the corresponding process (occurrent universal). In this respect, ontology of processes is certainly complementary to ontology of events.

Galton [25] actually develops a quite similar line of argument: "processes are higher-level, abstract patterns that are realized concretely as states or events" [25, p. 42]. His argument builds upon his distinction of (spatial and temporal) patterns: open patterns (e.g., a wallpaper pattern) and closed patterns (e.g., a dress pattern). The former can have a potentially infinite repetition (e.g., of the motif of the wallpaper pattern), while the latter must have fully specified demarcations (e.g., a particular arrangement of shapes of the dress pattern). Processes are temporal patterns (whether open or closed). In the car-travelling example, E_{CT} is an event that is a realization of an open process of car travelling; but assuming that the car travelled to New York, E_{CT} can be seen as an event of that is a realization of a closed process of car-traveling-to-New-York.

While conceding the high relevance of patterns to ontology research in general [27], we think that occurrent universals may be enough to characterize processes with no help from patterns because universals have a lot in common with patterns: e.g., we can speak of an occurrent universal of the car-travelling(-to-New-York). For one thing, universals (like patterns) have a one-to-many relation towards particulars. For another, just as patterns are analogous with specifications (according to Galton), so are universals. This would be vindicated by the observation that universals are as such normative, just as specifications are.[15] In discussing the source of the normativity of functions, for instance, McLaughlin [30, p. 101] contends: "The type-token distinction can introduce a minimal normativity into any context in which it is used." Galton would seem to offer a counterexample to our identification of processes with occurrent universals, however. As he says, there is no process (pattern) whose realizations are instantaneous events: e.g., reaching the top of a mountain. We would prefer to suspend judgement on this; but we may be able to deal with this kind of case (if true) by softening our claim: processes are occurrent universals whose instances are *non-instantaneous* events (occurrent particulars).

One may suspect that occurrent universals are as mysterious as processes. Suppose for instance that a car travelled one day from Graz to Wien, and another day from Graz to Salzburg. It is not perfectly clear whether there is a unique car-travelling universal that is instantiated in two different days. Although the identity condition of occurrent universals may be indeed elusive, this is an instance of the across-the-board problem of

[15] The ontological nature of a specification remains obscure, but Turner [28] maintains insightfully that a specification is something that has "*correctness* jurisdiction over an artefact" [28, p. 147, our italicization added]. By 'correctness jurisdiction' he means that the specification places "empirical demands on the physical device" [28, p. 144]. If an artifact is not built to a certain specification, the artifact is defective with respect to that specification. Duncan [29] illustrates this point as follows: "For example, if I build a physical implementation of a stack and the device does not allow me to add and remove items from the top of the device, my device is defective relative to the specification of a stack" [29, pp. 16-17]. Quite importantly, Turner considers specifications as intentional: "Our intentional stance determines what we take to be the specification: something is a specification if we give it *normal* force over the construction of an artefact" [28, p. 147, our italicization added].

the identity criteria for occurrent particulars, which even processualists must handle. Therefore, one would not be well motivated to introduce an ontology of processes unless one deals seriously with the identity of occurrent particulars (see [31] for a recent work).

3. Local Arguments

3.1. Processes and Minds/Actions

Let us move onto local arguments for ontology of processes. One main philosophical impetus towards processes is the idea that mental occurrents such as actions and experiences are to be better characterized in terms of 'dynamic' processes than 'static' events or states, the latter of which is often used in philosophy of mind (e.g., 'mental state'); otherwise, we would fail to understand properly the *subjective* aspect of mental phenomena [24]. For instance, Soteriou [32] submits that the experience is an 'occurrrent state': a state that is constitutively bounded up with events or processes (but see Steward's [33] criticism of the contradictory nature of occurrent states).

We doubt the explanatory potency of ontology of processes with respect to mental states and actions, however, although it may sound sensible to ground mentality in A-theoretic processes since the A-theory consists in giving a straightforward explanation of our experience of time. For one thing, one would be obliged to put a central focus on (the mental structure of) agents in order to consider what kind of processes accord well with actions and experiences (see e.g., [34]). To put it ontologically, mental occurrents would be more duly conceptualized from the standpoint (D) of agents' participation in them than from the perspective (B) of their temporal extendedness.

For another, even if the subjectivity of the mind is linked with some kind of dynamism, we suggest that one ascribe alleged mental dynamism not to the 'ongoing-ness' of processes but to the dynamics involved in a complex interaction between mental occurrents such as experiences and actions; and other kinds of mental entities such as agents and the physical basis of mentality (e.g., brains). To be more concrete, consider a dispositional analysis of mentality. A disposition is a property that is linked to a realization, namely to a specific possible behavior of a continuant (including an object) that is the bearer of the disposition [35,36]. To be realized in an occurrent, a disposition needs to be triggered by some other occurrent. Paradigmatic examples include fragility (the disposition to break when pressed with a certain force) and solubility (the disposition to dissolve when put in a certain solvent). Characteristically, dispositions may exist even if they are not realized or even triggered. A glass is fragile even if it never breaks or even if it never undergoes any shock, for instance.

Barton et al. [37] identify two ontological meanings of the term 'belief': a belief disposition and a belief occurrent. The former is a disposition that can be realized in the latter, which is a mental occurrent of taking something to be the case. A belief disposition exists even when we are not actively thinking it, and when we are actively thinking about a belief, we engage in an belief occurrent during which we take something to be the case. This dispositional approach to belief can extend to desire [38] and intention [39], and hence to the basic mental mechanism (see e.g., [40, Section III-C]), given the widespread usage of the Belief-Desire-Intention (BDI) model of agency [41] for practical reasoning and rational actions in the domain of formal ontology of mind [34]. Generally speaking, we would be able to theorize well on minds and actions by exploring a 'connector' (e.g., mental dispositions) between mental occurrents and mental non-occurrents.

3.2. Processes and Causation

Another reason for endorsing ontology of processes is that our description of the causal structure of the world would be incomplete unless we take processes with ontological seriousness. For space reasons we will spotlight only token-level causation and use the term 'causation' to refer to it. As the standard account goes (see e.g., [41, Section II-A]), causation is (or at least can be represented by) a special kind of binary relation between occurrents. Processualists object as follows, however: "Causation (…) was to be understood as a relation (…) between events within a succession of events. This picture of causation had no room for any ongoing causal process of something making something else happen" [24, p. 5].

The first thing to remark is that, if our hypothesis (formulated in Section 2.2) is correct, then processes prove to be occurrent universals and have to do with causation only via their 'being-instantiated relation' with (particular) occurrents. Even if we acknowledge processes in the sphere of particulars, however, ontology of processes may not be explanatorily powerful enough to be indispensable for ontology of causation. To exemplify this point, let us consider Galton's [42] work on different causal and causal-like relations based on ontology of events, processes, and states. In his example of an act of moving a wheelbarrow, the process of pushing bears a causal-like 'perpetuation relation' to the process of moving.

According to Thomsen and Smith [43, Section 2.2], by contrast, this may implausibly entail that moving does not occur if pushing fails; however, it is not the case that moving is *caused* by pushing, but that moving *is* pushing under certain conditions. They propose what they call 'a more accurate causal assay of a movement of this sort' in terms of occurrents, assuming that John pushed a wheelbarrow:[16]

- t'_0: John intends to push and the wheelbarrow is stationary.
- t'_1: John begins to attempt to execute a pushing occurrent against the wheelbarrow; the electrical impulses have not yet contracted his triceps.
- t'_2: John's exertional force exceeds the wheelbarrow's stationery force and the wheelbarrow begins to move; its motion is a part of a successful pushing occurrent.
- t'_3: John's exertional force continues to exceed the force required to move the wheelbarrow and the wheelbarrow continues to move.
- t'_4: John intends to stop pushing the wheelbarrow.
- t'_5: John's exertional forces drop below the level of the wheelbarrow's stationary forces and the wheelbarrow ceases to move.

On our view, one cannot determine unconditionally which is a more suitable causal explanation of the scenario of moving a wheelbarrow. Some may prefer the former description because it is more simple and intuitive, while others may justify the latter account on the grounds of its rigor and meticulousness. In general, we presume that intuition plays such a vital role in ontology of causation (see e.g., [44]) that different domain-specific assumptions and knowledge may furnish fairly different criteria for an appropriate example analysis of causation. Therefore, general thoughts about causation *per se* do not provide a sound reason for adopting ontology of processes.

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[16] Put precisely, Thomsen and Smith's analysis [43] employs the BFO [26] category of processes, which would correspond approximately to events in the (ii) sense of the term according to our terminology.

4. Conclusion

To summarize, we examined global arguments (relating to time and persistence) and local arguments (relating to mentality, action, and causation) for the notion of process that is purportedly an 'ongoing' occurrent. A general lesson from our study is that underlying ideas behind processes may be at least as well explainable through a fuller deployment of existing ontological resources as in terms of the conceptualization of processes as a special subtype of occurrents. This does *not* mean however that we deny altogether the status of processes in upper ontologies. We would rather prefer the 'republican strategy' to offer different ways of modeling processes (e.g., [7]) according to different domain-specific needs, while recoiling from the 'monarchial strategy' to introduce the distinctive ontological category of processes to every upper ontology.

There are a number of different directions in which ontology of processes can proceed. First and foremost, careful formal-ontological consideration of time and persistence is clearly warranted, granted that, as Galton [45] reports, little in-depth investigation has been conducted into time in formal ontology, and arguably much less into persistence. It will be also a noteworthy line of research to examine states (which we omitted to discuss directly) since they are intimately connected to processes.[17]

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[17] For instance, Galton [25] identifies two kinds of states (which would be concordant with the multiple usages of the term 'state' in a biology textbook [46]). (i) *States as continuants*: An 'instantaneous state' of some thing or situation, as given by the values assumed at one time by some of its variable properties. E.g., the position and momentum of a particle in physics. (ii) *States as occurrents*: A 'state situation', described as unchanging with respect to some selected. property or combination of properties. E.g., the state of the water temperature being 50 degrees Celsius.

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