

Response to reviewers of the paper
History in the Basic Formal Ontology
by Werner Ceusters and Alan Ruttenberg
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Reviewer #1

This manuscript describes significant limitations in BFO2020's definition of 'history', and proposes solutions to the issue. It does a nice job of analyzing the problem. I especially like the assessment of current usage of the term by domain ontologies in BioPortal and OBO.

- ➔ We only reported on ontologies in the BioPortal. We tried to do similarly for ontologies on the OBO Foundry site by using Ontobee but were prevented by a bug in the system that returns an error when trying to 'view class in context' [1]. It was reported on the issue tracker [2] but still existed on Oct 16 2025.

[1] https://ontobee.org/ontology/BFO?iri=http://purl.obolibrary.org/obo/BFO_0000182

[2] <https://github.com/OntoZoo/ontobee/issues/210>

It is innovative. One weakness is the lack of clarity in definition E1+ as it is not clear how processes can depend, either directly or mutually, on one another.

- ➔ E1+ does not mention dependence between processes at all, rather temporal parthood. This is axiomatized in BFO2020-FOL. But I assume the reviewer means E1+*. See below.

Major comments:

This manuscript contrasts the discussion of the BFO type “history” (a subtype of occurrent) in various BFO documentation, manuscripts, etc. versus how the type is defined and axiomatized in the ISO standard version of BFO (which hereafter I'll just denote as 'BFO2020' following the authors lead).

Before I read any further discussion by the authors, upon reading the BFO2020 definition of 'history', denoted by the authors as 'E1', I see that only the material parts of a material entity count as participating in the history. Thus, all my stomach contents do not seem to be participants in the history of my stomach. Which I find strange indeed. Reading on...

- ➔ That is correct, and one of the reasons for why we have performed the work reported on in this paper.

And yes, the authors note the consequences to “Site” immediately as I did. Sites do not have a history. Thus the cavity of my stomach would not have a history per the current BFO2020 definition.

The further implications of E1 as elucidated and described / discussed by the authors are also compelling as to E1's stark limitations and motivate well the work reported here. A fix of some sort is needed.

- ➔ That is what we suggest.

As a side note, the text "...the now outdated BFO 2.0 Specifications and User Guide..." answers definitively a question that had been lingering in my mind, namely whether BFO2020 supersedes and obsoletes BFO 2.0. A definitive "yes!"

In the definition of 'occupied by', clause 4 introduces the variable t a second time, which as I understand it, could be a different instance of "Temporal region" than the variable t in clause 2 denotes. Perhaps differentiate them as t_1 and t_2 ? Of course one might say those variables are scoped by the clause in which they appear, but other variables are not scoped as such, so it can be confusing.

- ➔ It is indeed clear from the text that they are separate quantifications and therefore, if one is familiar with the notion of scoping, there is no interpretation possible where something said about one applies to the others. Reciprocally, for someone not familiar with scoping, using t_1 and t_2 might suggest that they have to be different, while that is not the case because they are separately scoped, so have nothing to do with each other. No action taken.

The text at the end of page 7 and top of page 8, introducing section 4, is extremely well stated. I am particularly referring to the issue of intended models, whether the axioms describe the theory completely, etc.

The authors introduce the notion of "suitably related processes", and offer some examples, and note that what is "suitable" is likely to vary depending on the type of entity. It is certainly understandable to structure the analysis and its discourse in this manner. It does leave one guessing about the ultimate potential success of such an approach; in this reader, it incurs doubts. If one must figure out what constitutes "suitably related" and axiomatize those in every domain ontology that uses BFO2020 as top level, that creates a burden on users and could be done inconsistently across ontologies.

- ➔ We did not propose 'suitably related process' as subtype of process. Rather we use the term 'suitably related' as standardly used in philosophical discourse. There is no paper that discusses this use specifically, but using the prompt 'Use of the expression "suitably related" in philosophical discourse', Google AI returns the following explanation: *"The expression 'suitably related' is a non-technical phrase used in philosophical discourse to indicate that a specific, often complex, relationship or set of conditions must be met for a given philosophical concept to apply or hold true, without explicitly defining the exact nature of that relationship in the immediate context. The phrase acts as a placeholder for a more detailed theoretical commitment, which is usually either assumed within a specific debate or has been previously established by the author."* Google AI provides also several examples of its in a variety of contexts and concludes by stating: *"In all these cases, 'suitably related' serves as a way to acknowledge that a connection is required by the theory, while the specific, often controversial, details of that connection are the subject of the broader philosophical debate."* One principle of BFO is to include ONLY and ALL entity types and relationships that are relevant to ALL domains, thus not to include anything that is only relevant to some domains. Of course, if there is a form of suitably relatedness that is applicable to all domains, then BFO needs to describe it in its theory and, if possible, axiomatize it on the basis of one or more axioms. Of course it is the job of domain ontology developers to specify what is relevant in their domain, and what 'subproperties' in OWL jargon they should define.

There is a problem with E1+*. E1+* explicitly says "...changes that happen-to, or directly depends on what happens-to, a continuant." There is no relation "directly depends on" that I can find in BFO2020 (it's not in the files in the common logic directory or the files in the documentation directory), and I don't see how BFO2020 supports the notion that one occurrent can depend (ontologically, either specifically or generically) on another. I looked for any such axioms and found none.

- ➔ It is correct that there are no such axioms in the BFO, and that only s-dependence and g-dependence are axiomatized in BFO2020-FOL. But it is stated in the theory that, for example, processes are dependent on their participants – though not s- or g-dependent, and that sites are boundary-dependent on some material entity (See the Arp-book, page 109).

Furthermore, none of the relations from the change theory intro'd in [11], that the authors bring in, is "directly depends on". They bring in happens-in, happens-to, and happens throughout. But not "directly depends on". I also referred to [11] and no clarification was there. So as written, E1+ raises the how does change directly depend on what happens to a continuant?

Did the authors mean to say: E1+* (revised): A history+* is a change sequence comprised of all changes that happen-to a continuant and that happen-to any entity specifically dependent on that continuant.

- ➔ That definition would be implied by the definition we propose, but does not include many other intended cases.

But the authors go on to provide an example of mutual dependence among processes: "The decision and the role acquisition are mutually dependent, and would constitute a change sequence,...". How processes "depend on" other processes is not clear, and is not something in BFO that this reviewer is familiar with or can even find in the axioms, documentation, Arp BFO book, etc.

- ➔ Not quite, we suggest in that example dependency between changes, not between processes. From there, it would be not a far stretch to define at least one sort of dependence between processes, f.i when some change c happens-in two processes p1 and p2 that are not occurrent part of each other. While BFO2020 has amongst its entities only relational quality, the theory also commits to relational processes like kissing (Arp book p122) and buying and selling. Arp p104 discusses 'reciprocal dependence among realizable dependent continuants'. In the change-theory, 'change-sequences' are the proper vehicle to do so.

Further explanation / clarification is ultimately required here for a clear understanding of the proposed E1+*.

- ➔ Agreed. So we therefore replaced in E1+* the 'directly depends on' by 'suitably related to' and adjusted the description of the example accordingly.

Minor comments:

I am not sure why the title has an asterisk at the end, which would seem to indicate a footnote. There is no associated footnote, and at the conclusion of my review, I am still unable to apprehend its significance.

- ➔ We don't know either but simply followed the instructions on the template we were forced to use.

There is a rogue question mark at the end of 'Ruttenberg' in the list of authors.

→ Deleted.

Page 4, halfway down, immediately after citation [8]: The word 'therefore' is missing its final 'e' ('therefor').

→ Corrected

Page 4, in this clause of definition of 'occupied by' – "(2) at any temporal part *t* of *mtr*" the letter '*t*' should also be italicized (temporal part *t* of *mtr*). Page 4, near the bottom – "...and spatially occupy *msr* at *t*, *c* and *c2*...": I believe all the variables here (*msr*, *t*, *c*, and *c2*) should be italicized "...and spatially occupy *msr* at *t*, *c* and *c2*..." Ditto the following sentence, "...*c* and *c2* are identical" -> "...*c* and *c2* are identical..."

→ Done.

Page 5, first full paragraph – "...BFO2020-FOL axiomatization, amongst which Sites;...", should be "...BFO2020-FOL axiomatization, amongst which is Site;...",

→ Corrected, but differently for even more clarity.

Page 6, first word – exist: should be exists

→ Corrected

Page 6, near the bottom – "...when it is used, inappropriately, with only one exception.": should be "...when it is used, it is used inappropriately, with only one exception."

→ Changed

Page 7, section 4., second sentence – "It's perspective on reality," (possessive) : should be "Its perspective on reality, "

→ Corrected

Page 9, Section 5, first sentence: the word 'History' at the end, should it be italicized? (I think so...)

→ Indeed, corrected.

2. Recommendation (please use the "Borderline" option sparingly): accept

→ We truly appreciate that this reviewer spent time and effort to check all aspects of this paper!

Reviewer #2

This paper discusses two limitations of BFO:History: only material entities have a history, and what contributes to their histories is restricted to what takes place in the spatiotemporal region 'occupied by' the material parts. This excludes some processes in which a material entity participates from being part of its history. The paper proposes two alternative versions for 'history' inclusive to various sorts of continuants.

I think the paper discusses an important point of BFO, in a very clear and solid (and sometimes humorous) fashion, and strongly deserves to be presented and published at ICBO. I have only few comments.

p. 5: "the history* of an Object Aggregate can never be identical with the history* of an Object": This raises questions about granularity. Does it imply that (say) an apple cannot be both an object and an object aggregate? (as a sum of cells, molecules, atoms, particles, depending at which level of granularity we look)

- ➔ Hard to say, as you did not temporally qualify what you suggest to be implied by that part of the original sentence – i.e. "But because an *Object Aggregate* must have during its existence at least one time at which it has two distinct *Objects* as member parts (axiom [ibd-1]), **the history* of an Object Aggregate can never be identical with the history* of an Object.** [bold added]". The question is thus ill-formed. BFO's instantiation is temporally indexed and, per the axiomatization, something can be an object at one time and an object aggregate at another, or both an object and object aggregate at the same time. Neither "history of an object" and "history of an object aggregate" makes sense in such cases, unless asserted at a specific time and in that context "history of *that* object". Although there is no BFO2020-FOL axiom that prevents a particular to instantiate both Object and Object Aggregate at one and the same particular time. That is still an ongoing debate as some believe that it is not possible to satisfy the distinct causal unity criteria for both these types at that time, while some others don't. Can a particular which is at some time an instance of Object become at other times an instance of Object Aggregate and vice versa? Also about that the BFO is silent because of problem cases – like apples in case you want to combine two distinct granularity perspectives (see section 7 of [3]).

[3] https://ontology.buffalo.edu/smith/articles/Material_Entities.pdf

But that said, we agree it is appropriate to change that sentence so as to include the possibility for such special cases.

A point I'm unclear about: at time *t*, unless John is floating dead in outer space, the inside of John's mouth is filled by matter, namely a portion of air *a(t)*. Is it clear in BFO's framework that *a(t)* is not part at time *t* of the material entity John?

- ➔ BFO is silent about this. It is the job of the domain specialist to decide on the parthood relation in that case, as in many other cases (does a bullet becomes part of the body in which it is shot?) Note that BFO is also silent about whether the other interpretation of 'inside of the mouth', i.e. the site itself, is part of the material entity. BFO states that material entities can have immaterial entities as parts, but not the other way round. There are however no axioms that specify conditions or circumstances under which immaterial entities must be part of some material entity or mustn't. All that is left to be specified within domain ontologies and for appropriate cases. It is an anatomist who has to decide whether the inside of a human being's mouth (a site boundary-dependent on the mouth) is an immaterial part of a human being either all the time, or for some times. BFO specifies that material entities *x* can be located-in sites *s*, whether or not these sides are parts of a material entity *m*, but is silent about whether such *x* is part or not of *m*. If in some ontology some axiom would assert this for certain *m*'s and *x*'s, then such ontology can further be silent about whether such *x* then becomes an Object Aggregate or make a specific claim about it.

(I realize that if this was the case, it would imply that some parts of John are constantly changing, but that might be acceptable)

If $a(t)$ is part of John at t , then some statements in the paper might need to be revised.

- ➔ Indeed, some parts of John are constantly changing. BFO has it that continuants can change. However the kind of change where different oxygen is in the mouth as one breathes is not explicitly handled in BFO currently.

Changing history

I find section 5.2 on changing history very interesting but sometimes a bit hard to grasp. Some examples of what would be a history+ but not a history+* or vice-versa (and explaining in case one is subsumed by the other) could help.

- ➔ The answer is in definitions E1+ and E1+*: a history+ would be a process, while a history+* would be a change. The definition of change is given in D1. Changes or not processes!

p. 11: What is the connection (if any) between 'a temporal-layer-of b' and a being a process profile of b? (I believe that process profile have now been abandoned, but they have been quite heavily discussed at some point).

- ➔ The former is a relation. When process profile was a type in BFO, it was a subtype of process. It was introduced in <https://pmc.ncbi.nlm.nih.gov/articles/PMC3718480/>, together with various subtypes. There was however no 'process profile of' relation defined. It seems, however, that on the basis of that paper, the in the change theory proposed 'temporal-layer-of' relation – which would also be a useful additional definition for BFO itself – would qualify to assert that a process profile at least would stand in the temporal-layer-of relation to some process.

(forall (a b)
 (iff (temporal-layer-of a b)
 (exists (t)
 (and (occurrent-part-of a b)
 (not (instance-of a temporal-region t))
 (exists-throughout a t)
 (exists-throughout b t))))))

p. 11: "A history+ is a Process that is the sum of the totality of temporal parts of Processes in which a change happens to a Continuant.": I presume that the continuant must always be the same for a given history+. This could be clarified by rephrasing the definition.

- ➔ Yes. It would be specified in the corresponding axioms, but we changed the definition by referring to some instance of Continuant.

Minor

p. 2: "Kissing one's girlfriend can under these terms not be part of one's History": Maybe "one's partner" for wider gender inclusivity?

- We made it even more general by dropping 'one's girlfriend' altogether – thus 'Kissing can ...' – so as to avoid that therians would feel offended.

p. 4: "at any temporal part t of mtr , str spatially-projects-on Spatial Region msr ": I think it would be clearer to write this " $msr(t)$ ", since there is a (possibly) different Spatial Region at each time t .

- Agreed; we used this notation and also changed the verbiage to make it even more clear..

p. 11: "directly depends on what happens-to ": I'm not sure direct dependence has been defined before?

- Correct. See our response to reviewer 1 who had a similar comment.

Typos

p. 4: "therefor"

- Corrected. See our response to reviewer 1 who had a similar comment.

p. 9: "defined.."

- Corrected.

2. Recommendation (please use the "Borderline" option sparingly): accept

- We truly appreciate that also this reviewer spent time and effort to check all aspects of this paper!

Reviewer #3

It is an excellent piece and should definitely be accepted

I have some comments:

When listing types of change they should refer to analogous lists in <https://philarchive.org/rec/SMICPA-5>

- That paper discusses processes, not changes as defined as a distinct type of occurrents in our paper referenced as [11]. It is also in [11] that we draw on insights from the suggested paper. No action taken.

2. D1 is sloppy (every time I move to a different place, President Trump undergoes a change because he exhibits a difference in some relation to another entity)

- Correct, except for the 'sloppiness': that is what sometimes is referred to as a 'Cambridge Change'. Also that is covered in [11], including in the response to reviewers document in which we point to some distinct interpretations about what Geach – who coined the term – actually intended.

See <https://www.referent-tracking.com/RTU/files/FOIS2025-response-to-reviewers.pdf>

2. Recommendation (please use the "Borderline" option sparingly):

accept