Response to reviewers of the paper[1]

Towards Representing Change in the BFO

Authors: Werner Ceusters ad Alan Ruttenberg

Dear Werner,

We are pleased to inform you that your paper

9909: Towards Representing Change in the BFO

has been accepted to the main track of FOIS 2025. Congratulations!
Out of 66 full-paper submissions that were not desk-rejected, 20 were accepted, resulting in an acceptance rate of 30%.
You can find the reviews for your paper at the end of this email. Please consider them carefully when preparing the final version of your paper.
Instructions on how to submit the final version of your paper and register for the conference will be sent to you in the coming days.
We remind you that papers producing research artifacts (e.g., ontologies, tools, datasets) must comply with the FAIR for FOIS guidelines (https://www.dmi.unict.it/fois2025/?page_id=303). To assist you in doing so, the FAIR chairs will now assess your paper with regard to these guidelines and contact you directly if any action is required on your side.
We look forward to seeing you in Catania at FOIS 2025!
Sincerely,

Tiago Prince Sales and Claudio Masolo
FOIS 2025 Program Committee Chairs

SUBMISSION: 9909
TITLE: Towards Representing Change in the BFO

---------- METAREVIEW ----------
This paper argues for an extension of BFO to deal with changes, especially changes in individual qualities like the color of an object.

→ This is not accurate. The paper deals with the changes that all types of continuants recognized by the BFO can undergo.

This is important as BFO is a widely used ontology, and its weaknesses around change, process and participation might significantly impair its application.

Pros:
- Well-written and mostly clear.

[1] Responses to reviewers are printed in blue font preceded by '→'

- Good discussion and analysis of the current state and shortcomings of BFO, a widely used ontology.
- Concrete proposal for adding categories and axioms to BFO to overcome some of these shortcomings
- Suggestions for deeper changes in BFO that would help developing the proposal further.
- Important and central topic for FOIS, fostering without doubt interesting discussion.

Cons:
- The paper is not self-contained. It heavily relies on an external file with the axioms for understanding the discussion on those axioms, none of which is formally described within the paper. Different choices of exposition could have been made, for instance focussing on part of the proposal with a self-contained discussion based on explicit formulas, presenting the rest more lightly.
- Comparison with some of the existing literature is missing.
- Lack of enough examples somewhat impair the motivation and readability.
- This is ongoing work and the proposed axioms are still under development. Accordingly, no formal proof (consistence, models, theorems...) is given. Further, no evaluation is done.

→ See our responses below where these issues were raised by the reviewers.

I recommend acceptance, but suggest the authors to pay attention to what the reviewers say in their detailed reviews. In particular, if there is a misunderstanding, this means the paper is not clear enough. Also consider the Cons listed above and the details of the reviews to see whether you can improve the paper beyond what you already acknowledged in the rebuttal.

----------REVIEW 1----------
---------- Overall evaluation ----------

This paper proposes a theory of changes as an extension of the Basic Formal Ontology (BFO). The motivational challenges and the contextual details are clearly explained.
The paper touches upon a relevant topic in formal ontologies common to many domain-specific disciplines. Therefore, the contribution of this work is potentially extensive in terms of reach. The content is situated in a broader ontological discussion, improving the state of the art, and I would like to encourage continuing this line of research, also in conjunction with domain applications.

However, it is not sufficiently articulated to me why there are no more details in the validation section …

→ We added the names of the three theorem provers used. Because the axioms are made available with the paper, reviewers can use them to check for themselves.

… and why the axiomatisation is not complete.

→ We explained this now at the end of section 5

I have some more precise comments to highlight:

1) I recommend using more examples. I found rather little use of them, and sometimes the text was hard to follow and relate in practical settings.

→ we provided more examples throughout, specifically in section 3

2) It would be helpful to compare the approach proposed in the paper with the strategy described in Guarino, N., Baratella, R., & Guizzardi, G. (2022). "Events, their names, and their synchronic structure". Applied Ontology, 17(2), 249-283. I understand that Guarino, Baratella and Guizzardi adopted a semantic approach, however some parts of their article could be discussed under an ontological lens.

→ We mentioned the paper, precisely to point out the distinct strategy they use and the difference between event and process, a distinction currently not made in the BFO.

3) I found the paper lacking central aspects of changes and processes, such as discussions on causality/causation and causal-like explanations. I would like to understand better the reasons behind this choice as, to me, defining changes without explicitly addressing the "why" something has changed is missing a part of the puzzle.

→ Cause is thorny. It is unclear why one would expect to deal with the "why". For instance, when we describe a chemical compound, we don't necessarily feel obligated to describe the synthesis path. Cause is important, but outside the scope of our current work, which focuses on the "what".

4) Also, I would be interested if you could answer the questions: How can the proposed extension be applied to core and domain-specific ontologies?

→ Re application in core ontologies: a principle of the BFO is to be domain neutral, and that holds also for the proposed extension. It is thus already applied to a core ontology, i.e. BFO.

Re domain-specific ontologies: that is a question that can only be answered by the authors of domain-specific ontologies. It gives a means to be precise about processes in domain ontologies. Recent work of the 2nd author: in describing the process of taking an image with a CCD, we can describe changes such as when a photon ceases to exist and a free electron-hole pair is created, when a circuit connecting those to a capacitor is opened, how the charge on the capacitor changes as each electron accumulates, when the circuit is closed at the end of an exposure. When two other processes start: A counter and a voltage ramp, stop of the counter when the voltage ramp produces a voltage equal to that on the exposure capacitor. How the charge in the capacitor changes to 0 when a circuit to ground is opened. These examples are added to the paper.

And would this extension more suitable for certain domains?

→ Obviously, it is only suitable for domain ontologies that are BFO-compatible, irrespective of what the actual domain is. There is no point in using the extension when such ontology does not deal with changes.

---------- REVIEW 2 ----------
---------- Overall evaluation ----------

The paper is relevant for the FOIS community since it describes an effort for the axiomatization of events, an important but ill-defined construct in ontology engineering.
The axiomatization is the first step for the automatization of reasoning about time passing with ontology artifacts.

→ That is already partly present in the BFO2020-FOL axiomatization itself. The goal of the extension is to make the aspect of change explicit.

The proposal refers to the BFO modelling only, but it offers useful lessons for the occurrent modeling in any other top ontology scope.
The paper fails by not provide a good review in the recent work on the topic of occurrent modeling, since this subject is under intense study in the Ontology community recently, besides the good contribution of Toyoshima and Barton.

→ Occurrent modeling is not the topic of our paper. An overview of that is indeed given by Toyoshima and Barton, a paper explicitly explicitly mentioned in our paper and accordingly listed amongst our references. We therefore see no point in repeating the overview. We highlighted in our paper also what we took away from their analysis.

On the contrary, it describes only the evolution of the modeling of events in BFO, justifying why this work is necessary.
Otherwise, the lack of a recent revision suggests that no one else contributed to this difficult problem, common to any modeling approach.

→ Not sure what the reviewer means by this. Although there is indeed no 'official' revision of the BFO-FOL2020 axiomatization yet, perceived issues are reported and discussed on the Github, as does this paper in section 4 re 'process'.

I suggest that the final version include a proper review of the topic of event modelling in general.

→ that is beyond the scope of this paper. Our work is directly focused on improving and expanding BFO and making it more useful for domain ontologies that adhere to the BFO principles. It would also be premature. However, once the axiomatization is complete – with or without the proposed changes in the axiomatization of process in the BFO itself – a comparative analysis with other approaches is definitely worthwhile.

Related to the proposal itself, the axiomatization in the paper:"change = def (occurrent that happens (1) to at least one continuant c that is not a spatial region and (2) in a process p such that in the course of p some particular comes in or goes out of existence or exhibits a difference in some relation to another entity, including differences in instantiation). It seems not to contemplate modifications in intrinsic properties (color, size, etc) as change, since an intrinsic property is an SDC and not a relation, as mentioned in the axiom. The authors should clarify this point.

→ This is an inaccurate observation. "intrinsic properties" such as color, size, etc correspond to "qualities" in BFO, and qualities are continuants; changes therein are thus covered by the definition. Furthermore, 'change' in our proposed extension is NOT a relation, but an occurrent entity. It says so clearly in the cited definition.

Even considering that it is an ongoing work and several points deserve some amelioration or justification, it is certainly a paper that should be part of FOIS program.

---------- REVIEW 3 ----------
---------- Overall evaluation ----------
This paper adds change, its subtypes, and relevant relations, to BFO as first-class entities. It is well-written, motivated, and conceptualized (from my moderate knowledge of BFO) and is in-scope for the foundational stream, making it a good contribution to the conference. The paper also identifies various constraints and potential improvements.

→ we agree

It would be good to hear more about the apparent spatial region limitation, which seems to come from BFO and appears to exclude representation of an expanding / contracting universe in which space and spatial boundaries might be shifting.

→ BFO's perspective on space is thoroughly described elsewhere. BFO's spacetime theory is Newtonian, and so simply doesn't handle expanding or contracting universe. It is a reasonable comment that BFO should amend this, but it is irrelevant to our paper, since we are working in the BFO framework. As far as BFO is concerned, nothing about spatial regions themselves ever change.

---------- REVIEW 4 ----------
---------- Overall evaluation ----------
Paper summary:
Points out some weaknesses in BFO around change, process and participation. In particular, it points out that no SDC can participate by itself in a process.

→ if the reviewer means 'participating without also the independent continuant in which the SDC inheres participating', then that is correct. This is described in the paper.

For example, how to account for a single change in the color of a rose in BFO is left unclear.

→ Better: as stated in the paper, and discussed in the cited reference, it can be represented implicitly. But such change, 'by itself' cannot be a process according to BFO's axiomatization.

Points in favor:

1. Calls out inconsistencies between BFO's axiomatization and elucidation.

   → we agree

2. Calls out BFO's neutrality on how the world ticks

   → we are not sure what this means, and what in our paper would be an argument for this claim

3. This is indeed a problem because it will soon cause interoperability problems as BFO extends into business, planning, and simulation.

   → BFO will never extend into specific domains as it is supposed to be – and remain – an upper ontology, thus domain independent.

4. If BFO is going to allow non-rigid determinate classification, then it needs a general, consistent approach for classification of both individuals and relationships during a time interval, such as what gUFO uses, rather than an approach that only works for some things.

   → We wonder whether this reviewer is familiar with BFO2020-FOL – the axiomatization we use as a basis for our extension – because what he claims that would be needed, is actually already in the BFO2020-FOL axioms. gUFO, at the other hand, is 'lightweight' restricted to DL (https://nemo-ufes.github.io/gufo/).

5. BFO does need some way to track non-rigid determinate classification over time

   → that is already there. For each universal defined in the BFO, it is axiomatically stated whether its instances can change type over time.

   So, our paper does not 'call out' points 2 to 5 in the reviewer's list.

Points against:

1. I am unconvinced that BFO's "process" and "participation" are insufficient

   → We would have loved to see pointers to where in our paper we are supposed to have made that claim, and if so, counter-arguments against such claim that they are insufficient so that we could have addressed this in the final submission. We do explain in the paper that we left BFO untouched, i.e. we avoided modifying core BFO, but we do suggest that BFO perhaps better be modified in the future (if its custodians agree). This is, as we pointed out, because BFO's process and participation are inadequately axiomatized. It is our goal as authors of this paper to have a better explanation of what participation is. Also, participates in doesn't give you a way of distinguishing what one participant does vs another. The only way to do that is with realizations currently. With our proposed extension, it's clear what happened to what.

2. A paper should not require the reader to look elsewhere to piece together the problem and the solution. Without FOL in the paper, understanding the problems and the solution took far too much work.

   → It didn't seem to be a problem for the other reviewers though, and the submission site did allow the use of supplementary files. Furthermore, papers commonly refer in the briefest way to prior work.

3. More space should have been allocated to listing the relevant BFO FOL axioms, not elucidations, and explaining the problems more clearly.

   → The maximum space allowed was set by the call for papers. The axioms of our proposed extension were provided in a supplementary file and each was assigned an ID. These IDs were used in the paper to refer to the specific axioms. Also, BFO-FOL axioms are indexed and we used these indices in our paper as well. We described in the paper the different syntax used in BFO IDs and the IDs of our proposed extension axioms so as to avoid any confusion. The location of the publicly available axiom set of BFO-FOL was also provided.

4. If that would not fit in the allocated page count, then perhaps this should have been two separate papers.

→ Indeed, it didn't fit. But if we would have submitted two separate papers, then neither paper would be self-contained and be against this reviewer's 2nd desideratum.

5. a) From what I can gather, a large part of the issue hinges on both an SDC and its bearing IC having to be participants in one process, …

   → not a large part, though just one element. The main part is the implicitness of 'change' in the current axiomatization, in contrast to what is in the BFO literature described about change.

   b) … which could be resolved by specializing "has participant" into something like "affects" and "happens to"

   → It is not clear to us how the reviewer's proposal, without any further axioms provided, makes the notion of change more explicit.

6. I am unconvinced that the proposal makes sense

   → The text format in which the reviews are received seems to have obfuscated the (possible) indentations this reviewer used in his source document. There are bullet points, but it is hard to identify what belongs to what. We tried to reconstruct the intended hierarchy. We assume that the following bullet points are what this reviewer had in mind as arguments for why our proposal wouldn't make sense. If so, we clarify below, and where relevant in the paper, why we are not convinced that this critique is justified.

   6a. Made up new relations instead of using the Allen relations

   → Allen relations are between regions (time intervals or spatial regions) only. We, and BFO, relate other kinds of entities. We would have welcomed where precisely the reviewer would have expected us to use Allen relations and what problem it would solve that we currently don't.

   6b. In table 1:

      6b1. Specialization and generalization are relations between universals, not between particulars and universals. (E.g., the determinate universal called "dark red" specializes the determinable universal called "color")

         → We assume that this reviewer has another ontology in mind than BFO since BFO does not (yet) relate universals to each other. Or perhaps the reviewer uses the terms 'generalization' and 'specialization' in a different meaning than we define in table 1 and axiomatized in FOL. Furthermore, in our proposed extension, 'generalization' and 'specialization' are not at all relations between particulars and universals, but occurrents! Specializations are so-named (and well defined in the paper) because when a specialization happens the instance that it happens to is in a more specialized class than it was previously. On that note, 'dark red' is hardly determinate as many red colors can be under the banner 'dark red'.

      6b2. An existence change that brings a process into or out of existence would cause an infinite regress

→ We disagree because changes are not processes. IF we would integrate this into BFO and considered changes to be processes, then the issue would stand.

6b3. A process cannot undergo change, so individuation makes no sense.

→ We disagree. Processes don't change indeed, but an individuation marks the coming into existence of a process, not a change to it. While it might as term perhaps be a bit confusing to say individuation happens to the thing individuated, because it doesn't exist until the individuation has happened, the relevant axioms clarify the issue.

Detailed comments:

Section 2: "Qualitative change was said to come in various modes, such as change in determinables (e.g. color changes)" should say "determinates".

→ This sentence in our paper was a shorter, but very close, rephrasing of what is expressed in the paper we cited (ref [5]). We changed the sentence so that it is now clear that we do cite, and that indeed 'determinables' was used in the source. Of course, we cannot change what is written in the paper referenced.

Section 3:

Perhaps I misunderstand, but the paper seems to lump intrinsic changes under "Cambridge change".

→ This is actually a rather unclear point. It seems that the term has become used in a narrower meaning than originally intended. We explicitly used the term as defined in the SEP: 'Cambridge change', i.e. 'a change in a thing is a change in the descriptions (truly) borne by the thing' [11]. It is originally described as the change that must have occurred when a proposition that was true at some time, is not anymore true at a later time. The term is coined to Geach who wrote:

> "I have urged that we need to **distinguish** 'real' changes, processes that actually go on in a given individual, **from among** 'Cambridge' changes. The great Cambridge philosophical works published in the early years of this century, like Russell's Principles of Mathematics and McTaggart's Nature of Existence, explained change as simply a matter of contradictory attributes' holding good of individuals at different times. Clearly any change logically implies a 'Cambridge' change, but the converse is surely not true ; there is a sense of "change", hard to explicate, in which it is false to say that Socrates changes by coming to be shorter than Theaetetus when the boy grows up, or that the butter changes by rising in price, or that Herbert changes by 'becoming an object of envy to Edith' ; in these cases, 'Cambridge' change of an object (Socrates, the butter, Herbert) makes no 'real' change in that object."
>
> P.T. Geach. Logic Matters. Basil Blackwell, Oxford 1972 p321-322.

I printed in bold '**distinguish** […] **from among**' because (1) 'to distinguish x from among y' is not equivalent with (2) 'distinguish x from y'. In (1), x is a subgroup included in y, but different in a certain respect; in (2) x is contrasted with y and is not included in it.

A Google search demonstrates that we find the term ‘Cambridge change’ be used in both ways. As a result, we decided to simply not use the term, but keep the descriptions to make clear what we have in mind and eliminate the confusion.

I think "process profile" was mischaracterized: speed is derived from the distance between two locations of a material participant.

→ that is a fight that should be picked with the author of the cited paper on process profiles, not with us.

Section 3.2.1
I think something is backwards in "Happens-throughout is a relation that specializes exists-throughout to the effect that if x exists-throughout t and x is a change, x happens-throughout t [htr-03]." That which specializes goes on the antecedent side of a conditional, not on the consequent side.

→ Correct. This phrase covered two axioms of which only the second was referenced. It should have been, and we corrected to: "Happens-throughout is a relation that specializes exists-throughout **[htr-02]** to the effect that if x exists-throughout t and x is a change, x happens-throughout t [htr-03]." In [htr-02] the specialized relation is in the antecedent.

"It provides a sense of parthood between changes and processes since occurrent-part cannot be used between them": unclear to me why.

→ This was documented in section 4.1. We added that explicit reference.

Section 3.2.4

Unclear what a temporal layer is. This section needs more introduction.

→ We rephrased the relevant content and eliminated the use of the expression ‘temporal layer’ to avoid the interpretation that a temporal layer would be a type of entity. We only use now the relation ‘temporal-layer-of’ and provided more explanation.

Figure 2 has an unlabeled red line

→ Is corrected

Section 4
Refers to Figure 3 as Fig2.

→ Corrected

This section is confusing with no axioms to look at.

→ As indicated in the paper, the axioms of our proposed extension were provided in a supplementary file, while the referenced BFO axioms could be retrieved from reference [6].

Section 4.2
There is no Fig4.

→ There was, be it mislabeled as a second ‘Figure 3’. That is now corrected.