Definitions of Disorders in SNOMED CT: Should there be Room for Interpretation?
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Dear Werner,

Thank you for your submission 5337 to the 13th International Conference on Formal Ontologies in Information Systems (FOIS 2023). After a very thorough review process with at least 3, for many papers even 4 or 5 reviews, and a discussion of all reviews and rebuttals, we have selected only 25 papers of 62 submissions for presentation at the conference.

We are pleased to let you know that your paper is accepted for a presentation at the FOIS conference, and that it will be included in this years' FOIS proceedings. Given the preferences that you had selected and the number of papers to be presented, we accept your paper for presentation during the on-site conference that will take place at the University of Sherbrooke (Canada) from July 17th to 20th, 2023.   [C1] We attach the full reviews (with scores) at the end and hope that they will help you prepare an improved version of your work.

➔ We believe we did so. See below the details for actionable and rebutted comments and how we took care of them in the final paper.

We thank all the PC members and additional reviewers for their time and expertise to provide this critical feedback.

---------------------- REVIEW 1 ---------------------

----------- Overall evaluation -----------

SCORE: 2 (accept)

This manuscript analyses the possibility of relating SNOMED CT and BFO content, focused on SNOMED CT disorders. The manuscript provides a nice description of SNOMED CF, BFO, and OMGS which will be helpful for readers unfamiliar with biomedical knowledge resources. The summary of related studied is also interesting, and clarifies how this work builds on previous studies of the community.

Proposing to map SNOMED CT disorders to BFO constructs makes sense and is in line with the idea that different knowledge resources may play different roles and be designed and thought for different types of users. SNOMED CT can be very useful for the clinician, but may not encode the knowledge in the best way for machine processing in a semantic interoperability context.

The authors propose to express those mappings using FOL instead of OWL due to the limitations of description logics.

[C2] I am aware that this is more a theoretical/formal work, but the potential impact on practical applications should be briefly discussed, given that OWL resources are commonly used in this domain.

➔ The possibilities for practical applications re EHRs are indeed very briefly mentioned; explaining it in an understandable way would take up too much space. See also response to [C5]. We are not sure whether this reviewer is suggesting that the practical application of our work is limited because we use FOL and not OWL as is indeed – in our opinion unfortunately – commonly used. If so, it might be good to keep the advance of science and technology in mind and to ponder the following objection that a 19th century medical scholar might have been faced with: "*the potential impact of proposing intravenous antibiotics on practical application should be briefly discussed, given that blood lettings are commonly used in this domain*".

The ideas are clearly expressed and the reading is enjoyable, setting the stage for the potential development of automatic methods for making that mapping and stating the difficulties for that automation.

[C3] Providing files with the results of the study would also be helpful for the community, especially for those interested in the development of such mappings.

➔ That is work in progress. See response to [C13]

== post rebuttal response ==

I have read the response of the author, and I stay with my assessment.

----------- Relevance SCORE: 5 (good)

The paper is relevant for the FOIS conference, since it focuses on the formal representation of medical knowledge in different resource and on how that knowledge is comparable or interoperable. The work is more a feasibility study, which makes it also relevant for the conference, given that it analyses foundational aspects of the resources studied. Given that biomedicine is a community of high interest for ontologists, I think the article is interesting for the FOIS audience.

----------- Novelty (originality) SCORE: 5 (good)

The paper is not novel in the topic addressed, since the semantic alignment of the content of SNOMED CT and BFO has been studied in previous, related work, but the novelty relies in the proposal for the alignment or mapping of a part of these resources.

----------- Presentation SCORE: 6 (excellent)

The paper is easy to follow and read, the structure is appropriate, and it includes examples describing the different situations.

----------- Technical soundness SCORE: 6 (excellent)

There is no concern about the soundness of the approach.

----------- Context SCORE: 5 (good)

The readers are provided with a context in biomedical knowledge resources, and the relevant related work is described.

[C4] It might have been interesting more final comparative discussion on the findings of the different studies.

➔ We added this to the conclusion which was rightfully reviewed as being incomplete (see also [C28]).

----------- Evaluation SCORE: 3 (acceptable)

I would say that there is no real evaluation of the work done, since there is no information about who has validated the mappings studied by the authors. However, given the nature of the paper, I do not find this a major limitation, it does not reduce the interest of the paper.

----------- Adherence to FAIR principles SCORE: 4 (n/a)

I would say this criterion is not appropriate for this paper.

---------------------- REVIEW 2 --------------------

----------- Overall evaluation SCORE: 2 (accept)

This manuscript describes a preliminary approach to align SNOMED CT (SCT) and BFO/OGMS. The approach is rooted in the FOL version of BFO. The approach is contrasted with a recent approach by Schulz which involves simple mapping and interpretation of SCT top level concepts while staying within BFO EL++. The manuscript does a good job of describing the relative benefits of SCT vs BFO (coverage vs semantic precision).

[C5] I am not completely convinced by the hypothesis that a BFO interpretation would lead to fewer errors with EHRs but I think the work here is a good step forward in laying the framework from which a more empirical investigation can determine these things.

➔ Examples of the sorts of error that can be prevented with proper implementation of BFO- and OGMS-based technology is discussed in the referenced papers 26, 27 and 28. A pre-print of 27 is available here: https://osf.io/q8hts.

The approach described is largely qualitative –

[C6] CLIF axioms are provided but there does not seem to be a downloadable axiomatization of any branches.

➔ Correct, see response to [C13]

The manuscript seems to posit some problems with the Schulz "having" approach but either these are not clearly articulated or I am not understanding. Perhaps it is just that the Schulz approach is less philosophically satisfying.

[C7] It would be better if the authors demonstrated incorrect entailments that come from the Schulz approach.

➔ That would be a different paper, wouldn't it? And to a certain extent, we did; see the discussion on 'fracture of radius and ulna'. However, the goal of this paper was not to discredit Schulz's proposal, but to highlight the differences with our approach since both are based on the insight that the distinctions between disease-related entities made in OGMS are real, though lumped together in SNOMED CT. Since the SNOMED CT authors – Schulz is not one of them, by the way, and we are aware of and truly appreciate his tremendous efforts in trying to convince the SNOMED CT authors to increase the quality of their product – most likely do not want to untangle their clinical findings hierarchy because it is considered too much effort, a consensus between Schulz and these authors might be to settle for the much weaker 'clinical occurrent' interpretation. We are not part of these discussions but we do see problems if the proposal were to be accepted; we stated this at the end of section 5.1.

I am not sure the Schulz approach is adequately represented in all cases; e.g. the manuscript says: This is because we want all relations in the consequent part of the axioms to be BFO-based, and not a mixture of SNOMED CT and BFO relations as proposed by Schulz et.al. But in fact slide 31 of the cited presentation by Schulz says:

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'Having fracture of Radius' EquivalentTo:
  'Clinical Occurrent'
    and 'bfo:has occurrent part' some
      ((bfo:'located in' some 'Bone structure of radius') and
      (bfo:'has participant' some Fracture))
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[C8] This is in fact entirely BFO relations.

➔ It is indeed the case that in this specific example only BFO relations are used, be it two of them crippled: 'located-in' and 'has-participant' require time-indexing. However, on slide 31 referred to by this reviewer, Schulz writes also as last bullet point: "*Substituting SNOMED CT relations by bfo relations (at least the relation 'role group')*" [underline added], which means that he still would allow this mixture. Nevertheless, we are glad this reviewer made this comment. By "*... not a mixture of SNOMED CT and BFO relations*", we didn't mean "*... not a mixture of SNOMED CT relations and BFO relations*" but rather the stronger "*... not a mixture of SNOMED CT concepts and BFO relations*". We do see that the word '*relations*' in '*... because we want all relations in the consequent part ...*' contributes to the non-intended interpretation of the

rest of the sentence. We therefore changed it as follows: '*This is because we want all <u>predicates</u> in the consequent part of the axioms to be BFO-based, and not a mixture of SNOMED CT <u>terms</u> and BFO relations as proposed by Schulz et.al.*'.

One of the purported drawbacks of the Schulz approach is the use of OWL and thus binary relations. It is well known that BFO proper uses ternary relations, and to my knowledge none of the varying approaches to overcoming this impedance mismatch have been fully accepted or are without drawbacks.

[C9] Nevertheless, I don't think it's made clear why this is a problem *specifically for the Schulz proposed SCT axiomatization*.

➔ We checked our paper and didn't find any claim stating that the exclusive use of binary relations is specifically a problem for the Schulz proposal. It is indeed a problem for ALL approaches that reduce BFO ternary relations to binary ones. We made that very clear by using the word 'crippled', the topic of this reviewer's next comment.

[C10] As an aside, I find language like: "it continues to see BFO through its crippled OWL rendering without doing justice to the underlying theory" to be overzealous, imprecise, and ableist. It is better to be precise and state that using a simplified axiomatization may lead to incorrect interpretations or entailments (ideally demonstrated in the text).

➔ It is odd that using language which makes it very clear what somebody stands and strives for in terms of quality, precision and faithfulness of representation is described as 'overzealous', 'imprecise' and even 'ableist'. Let me explain why this 'explicit' language is used. The FOL rendering of BFO does not have definitions on the basis of 'subClassOf' as ontologies describable by means of OWL need to resort to to create a taxonomy. BFO creates its type hierarchy on the basis of axioms of the form: *forall x and forall t, if x is an instance of type A at time t, then x is an instance of type B at time t*. OWL-renderings of such axioms become 'A subClassOf B' which does not capture the full BFO semantics as time is lost. It is therefore that we argue that BFO OWL is a 'crippled' rendering. This reviewer seems to interpret this as a negative statement about OWL, rather than about BFO OWL. Our argument in the paper is not that OWL should not be used at all, but rather that BFO OWL should not be used when these distinctions matter. Unfortunately, they matter more than one would think as exemplified by expression (7) discussed in our paper, and some difficulties in interpretation reviewer 4 expresses in some of his comments. So we do not consider it overzealous to argue for the use of a carefully crafted BFO rendering in FOL rather than a watered down, indeed 'crippled' rendering of it. For sure we do not consider it 'ableist' in its standard definition in the context the word 'crippled' was used. The Oxford Dictionary of Language teaches us: '*adjective: crippled; 1. severely damaged or malfunctioning: "the pilot displayed skill and nerve in landing the crippled plane", 2. OFFENSIVE•DATED (of a person) unable to walk or move normally; disabled.*'. Suggesting or implying that we used 'crippled' in the ableist second sense could however be interpreted as using language which exemplifies one of the alternative meanings given to 'wokeism': '*weaponizing personal grievances masquerading as a genuine social concern*'.

There is some nice discussion of some of the issues of representing things like congenital abnormalities involving missing body parts. This is a nuanced issue. I don't think this is simply a matter of SNOMED using a subset of DL that excludes ComplementOf. Naïve axiomatizations of phenomena like agenesis are worse than no axiomatizations; "absence" is shorthand for complex morphologies and disruptions of morphological processes.

[C11] The OBO phenotype ontologies originally avoided patterns like the SCT ones for reasons of realism, but in fact they have reverted to expressions like (absent and inheres-in ...) as these are practical and give the right inference and there are defensible representations.

➔ It is true that OBO ontologies – not just the Phenotype Ontology – moved over the years more away from the realism-based approach, with decrease of ontological quality as a consequence and becoming closer to a terminology than an ontology. What we appreciate in SNOMED CT is that it indeed is not anymore marketed as an ontology, but as a terminology quality-controlled using a DL. Prior to the axiomatization of BFO in FOL, it was hard to verify whether its principles were adhered to, and it became indeed more 'practical' to

Despite some of these reservations, I think this is good work that helps build a path for increased interoperation between concept ontologies and realist ontologies. The overall approach of providing a mapping to BFO rather than forcing into one ontology is a good one. The work on bridging OWL to FOL with temporal indexing is a valuable part of a complex and sometimes sprawling discourse.

----------- Relevance SCORE: 5 (good)

relevant

----------- Novelty (originality) SCORE: 3 (acceptable)

[C12] a lot of this ground has been covered before

➔ We disagree, would have liked to see the arguments for this claim and the papers that we might have missed to include. We also note that another reviewer differs in opinion, see [C32].

----------- Presentation ----------- SCORE: 5 (good)

[C13] generally good but there is too much extended intro for my taste

➔ In response to some other comments for further explanations [C15] and an expanded conclusion [C28], we removed some sentences from the introduction and the descriptive parts of BFO and SNOMED CT.

----------- Technical soundness ----------- SCORE: 3 (acceptable)

mostly relies on argumentation that something evaluable

 ----------- Context ----------- SCORE: 5 (good)

good

----------- Evaluation ----------- SCORE: 3 (acceptable)

I don't normally review FOIS so I don't know what the bar is.

[C14] I would have liked to be able to download some CLIF, run a reasoner, see quantifiable resylts...

➔ Several case-studies will be published in the near future and will come with associated data and CLIF files.

----------- Adherence to FAIR principles ----------- SCORE: 4 (n/a)

n/a

---------------------- REVIEW 3 ---------------------

----------- Overall evaluation ----------- SCORE: 2 (accept) -----

This paper (in the METHODS track) proposes to reconcile disorder concepts from ENOMED CT with the ontological framework of BFO. The authors study axiom patterns to assess feasibility.

Pros

- in scope for FOIS
- relatively few papers discussing biomedical ontologies
- appropriate background on SNOMED CT and BFO

- in-depth analysis of the issues and potential solution

Cons

[C15] – no clear statement on specific contribution, especially with respect to the work by Schulz et al. [16] that is cited and addresses a very similar topic

➔ We added such statements to the conclusion of our paper.

[C16] - no discussion section * no discussion of potential limitations of this work * no discussion of the practical benefits of this work for the users of SNOMED CT - relatively narrow in scope with no obvious opportunities for generalization

➔ Although we indeed don't have a section labelled specifically as 'Discussion', we disagree that there is no discussion. Section 5 is 10% observation and proposal and 90% discussion. We did not explicitly use the word 'limitation' in our reviewed version but mentioned throughout the paper several complexities that our approach has to deal with. Discussing practical benefits would be premature in absence of a complete evaluation, but some directions are provided in response to [C5]. We see many opportunities for generalization: replace SNOMED CT with any non-realism-based disease ontology or classification system. Since SNOMED CT attempts to provide links to several such systems, they would become immediately accessible through our platform, once completed, too. But here also, before making any such claim, we prefer to do some case studies first (see response to [C14])

Overall Interesting and thorough work on biomedical ontologies, although it remains mostly an academic exercise at this point.

Other comments

- [C17] the title does not really reflect the work being done and no clear or direct answer is proposed for the question asked in the title

➔ We replaced the first part of the title "Definitions of Disorders in SNOMED CT:" with "Axiomatizing Disorders in SNOMED CT:". Concerning the second part of the title "Should there be room for interpretation?", it is standard for rhetorical questions not to be answered.

- [C18] the specific version of SNOMED CT under investigation should be specified, including whether the OWL statements are from the stated or inferred version

➔ We did specify which version of SNOMED is used on page 2: "International version of November 2022 (from here on abbreviated as 'sctiv2211')" and used this ad hoc acronym throughout the paper. We also wrote at the beginning of section 2.2 "*SNOMED CT authors craft the definitions as dictated by the concept model [19]. Some of these definitions are available in an OWL 2 dialect which in sctiv2211 is restricted to …*". "Definitions being crafted" indicates that they are 'stated'. SNOMED CT's OWL expressions come with the official distribution file labelled as "sct2_sRefset_OWLExpression Snapshot_ INT_20221130.txt". The distribution files don't give any specifics about whether they are 'stated' or 'inferred'. Comparing the expression used in our paper re "cholangiocarcinoma of the biliary tract" with what can be seen for this concept using 'https://browser.ihtsdotools.org/', also suggests they are the 'stated' ones.

- [C19] the paper requires careful proofreading, e.g.,

➔ Done. Thanks for the two spelling and grammatical mistakes found.

* "to prevent SNOMED CT's proprietary OntyLog classifier to misclassify concepts" -> to prevent SNOMED CT's proprietary OntyLog classifier *from misclassifying* concepts *

"We therefor argue" -> We therefor*e* argue

----------- Relevance ----------- SCORE: 5 (good)

- in scope for FOIS

----------- Novelty (originality) ----------- SCORE: 3 (acceptable)

- [C20] relatively few papers discussing biomedical ontologies

➔ It is not clear what this reviewer tries to convey here. Is it an observation about the sort of papers that typically are submitted to FOIS? Then there is nothing to respond from our side. Is it a complaint that we do not discuss or provide citations to papers discussing other biomedical ontologies? But that is clearly not the topic of our paper. No action taken.

- [C21] no clear statement on specific contribution, especially with respect to the work by Schulz et al. [16] that is cited and addresses a very similar topic

➔ See response to [C15].

----------- Presentation ----------- SCORE: 5 (good)

- appropriate background on SNOMED CT and BFO

- in-depth analysis of the issues and potential solution

----------- Technical soundness ----------- SCORE: 5 (good)

- in-depth analysis of the issues and potential solution

----------- Context ----------- SCORE: 5 (good)

- appropriate background on SNOMED CT and BFO

----------- Evaluation ----------- SCORE: 2 (fair)

- no discussion section * no discussion of potential limitations of this work * no discussion of the practical benefits of this work for the users of SNOMED CT

➔ Same comment as [C16]

----------- Adherence to FAIR principles ----------- SCORE: 4 (n/a)

---------------------- REVIEW 4 --------------------

----------- Overall evaluation ----------- SCORE: 3 (strong accept)

This paper proposes the use of a logical framework to link the SNOMED CT clinical terminology to realism-based ontologies such as BFO and Ontology of General Medical Sciences (OGMS) using bridging axioms written in a first-order language. The paper is well-structured and easy to read. The analysis presented in the paper is novel and informative.

The authors provide masterly summaries of SNOMED CT concepts and their definitions through fully specified names and logical expressions, and of BFO and OGMS. They point out, quite correctly, the many anomalies in SNOMED CT's hierarchies and naming of disorders and related concepts. These naming issues, this reviewer suspects, derive mostly from SNOMED CT's focus on clinician documentation, resulting in concept names that are not consistent with the SNOMED CT's taxonomic hierarchies. (The alignment of the subtypes of neoplasm with ICD-O classification reinforce this assessment of SNOMED CT's design.) These naming anomalies certainly present a difficulty in lexical mappings of terminologies.

The author's assertion that OWL SubClassOf denotes a "concept-oriented approach" that means only a "more specific" relationship doesn't seem to be consistent with the statement that OWL's set-theoretic meaning of individuals being instances of class expressions. It is true that OWL 2 Web Ontology Language Structural Specification says that "Roughly speaking, [SubClassOf] states that CE1 is more specific than CE2" [1]. However, one should not take such explanatory description as normative statement of the semantics of the axiom.

[C22] I don't see how OWL 2's formal semantics of a class as being a collection of individuals that are instances of the class is different from BFO's instantiation.

➡ It was not our intention to clarify the distinction only by means of the sentence this reviewer cites. More explanation followed in the rest of the subsection. However, to draw the attention already to the atemporality of OWL's "SubClassOf" in contrast to BFO's instantiation-based taxonomy, we replaced in the sentence "*The first one is that A is not just more specific than B – i.e. the rather broad OWL meaning of SubClassOf, typical for the concept-based approach – but only in terms of the ontological instantiation-relation between particulars and types, not to be confused with OWL's set-theoretic meaning of individuals being instances of class expressions*", the word "*instantiation*-relation" with "*instantiation-at-a-time*-relation".

The "sct:fracture of radius and ulna (disorder)" example the authors used is probably taken from the paper "Competing interpretations of disorder codes in snomed ct and icd" which the authors cited. In that paper, Schulz et al. gives an interpretation of such "combination" entities as denoting "situations" where fracture of radius and fracture of ulna exist. [C23] Thus, such an example really points to how SNOMED CT diseases and disorders should be interpreted, not a statement about OWL 2's meaning of SubClassOf (as the authors discuss the example later).

➡ This comment really nails what we didn't want to state explicitly, but phrased as a rhetorical question in the title of our paper: "*should there be room for interpretation?*" Our view is: absolutely not! Why would there be re SNOMED CT or in any 'ontology' that deserves such designation? In SNOMED CT's documentation and marketing brochures it is literally stated that the fully specified name of a concept serves to '*represent a unique, unambiguous description of the concept's meaning*' (reference in our paper). Yet, how to interpret many of its concepts is still a problem as witnessed by the various distinct interpretations that Schulz has tried out over several papers throughout the years, thereby masterfully demonstrating that none really works, though some have less exceptions than others. That holds also for his current proposal about how SNOMED CT's 'clinical finding' concepts should be interpreted in light of the BFO. It is therefore that we believe that it is NOT possible to merge SNOMED CT with BFO, but that a better way forward is to bring them under one formalism which is capable to preserve the distinct perspectives.

The other limitation of OWL 2 that the authors allude to OWL's lack of time-indexing. The authors cite [3] ([25] in authors' bibliography). However, Flügel et al. explicitly remove temporalization in BFO ("Secondly, the axioms in BFO 2.0 FOL are temporalized, leading to ternary predicates which are not compatible with OWL ontologies. [C24] Therefore, we removed this temporalization"). Thus, the reference doesn't demonstrate the need for time-indexing.

➡ Whereas this reviewer is correct in stating that Flügel et al. transformed BFO's ternary relations into binary ones and thus removed the temporal-indexing, it is not correct to state that we used their paper as an argument in favor of temporal indexing: our use of the reference was at the very end of section 3, thus arguing for full BFO in FOL rather than BFO OWL. Hence we did not change our original submission with respect to this comment.

The other place the authors discuss temporalization related to 'state' is rather opaque. [C25] How does one interpret the second predicate in '(and (instance-of x 37°C-temperature t) (instance-of t temporal-interval t))?

➡ Like any instantiation relation in BFO: t is an instance of the universal temporal-interval at time t. The change we introduced because of [C22] makes this perhaps more clear.

It seems to this reviewer that the justification for using FOL is in the form of bridging axioms (e.g., Expression 7) [C26] The bridging axioms are quite elegant and incorporate the basic insight of Schulz et al. that SNOMED CT

diseases/disorders are situations or occurrents and that role groups are occurrent parts, albeit in a form different from Schulz et al's formulation (Expression 5).

➔ We agree that our bridging axioms are elegant, but it is NOT AT ALL the case that we incorporate Schulz's re-interpretation. On the contrary. Schulz uses the insights of the OGMS on the basis of which it becomes clear that SNOMED CT lumps different sorts of disease-related types together in its 'disease (disorder}' hierarchy, OGMS types of which Schulz acknowledges the existence. Schulz tries to find amongst these types the one that would lead to the least amount of oddities and that would not require any change in SNOMED CT. Because it doesn't work, he has to move up higher in the OGMS/BFO hierarchy and settles on 'occurrent'. That also does not work, as exemplified in our paper by referring to what he calls 'states', but there are more problems we didn't address since we do not see our paper as a Schulz versus Ceusters debate. For sure, that debate will come IF and WHEN the SNOMED CT authors would accept his proposal. That we do not incorporate his solution is further witnessed by expression (7): the 'x' in the antecedent side of the axiom which is an individual of sct-disease does NOT figure in the consequent side of the axiom, hence is not provided a BFO/OGMS counterpart.

The discussion of different patterns of SNOMED CT disorders in terms of their attributes (post-coordination axes) is really very interesting and informative. However, the results seem to be that for most sct:disorder entities, manual inspection of their definitions are necessary if the bridging axioms are to be written. [C27] The authors seem to have identified only one safe pattern in the definition of infectious diseases formed by sct:infectious process and sct:causative agent. In view of this result, the statement in the Conclusion "Our analysis indicates that it is possible to identify patterns in SNOMED CT's disorder concept definitions on the one hand, and definitions and axioms in BFO and OGMS on the other hand, that would make an automatic translation possible for a fair amount of disorders" seems to be overstating their results. (How many SNOMED CT infectious diseases satisfy the 3 requirement in Section 5.3.3)

➔ We identified other patterns as well as discussed in section 5. The reviewer cites the first sentence of our original conclusion accurately, but omits the sentence thereafter: "*Unfortunately, there are many exceptions which require manual scrutiny*", a sentence which provides further context to "fair amount". Further, what we didn't mention because we did not test it yet but believe it to be the case, is that many erroneous automatic translations will be discovered by a reasoner operating on the collection of axioms by detecting inconsistencies which can be classified automatically as belonging to a type which is indicative for a pattern thus far not manually identified.
Hence, we decided not to make a change here.

[C28] The Conclusion of the paper only mentions the second part of the paper dealing with patterns in SCT entities. To this reviewer, it's the logic framework that the authors presented is equally, if not more, interesting.

➔ We agree. We expanded our conclusion to this effect, as also requested in [C4].

From an ontological perspective, the authors' arguments are quite persuasive. However, their case can be immeasurably strengthened by demonstrating a small case study of how the bridging axioms can actually work in practice in bringing value to support of clinical work (beyond examples of "possible" in the paper). [C29] Such evaluation perhaps is not necessary for a conference paper. I look forward to seeing further work on this line of research.

➔ We agree, but it falls outside the scope we intended for this paper. Several case-studies will be published in the near future.

p. 10 "the sct:disorder is a bfo:material- entity, the attribute may be translated into bfo:continuant-part-of when its range is a bfo:material-entity too." [C30] maybe should be "When the sct:disorder is a bfo:occurrent, the attribute may be translated into bfo:continuant-part-of when its range is a bfo:material-entity too."

➔ No, that would be a mistake. bfo:continuant-part-of relates continuants to continuants, so cannot be used when the sct:disorder corresponds to an entity that BFO would consider an occurrent.

p. 10 "Hence the introduction of p in the consequence part of expression (7). It might very well be that a patient's cholangiocarcinoma breaks through the boundaries of what qualifies as the biliary tract" [C31] My interpretation of this constraint is handled by expression 7's existential qualifier of p during the temporal interval t. If that's the case, the authors can be more explicit about it. (It justifies the temporalization).

➔ That is correct, except that it is not – and should not be – specified that t is a temporal-interval, although in almost all cases it would be the case. It is sufficient that t is a temporal-instant. The introduction of p is to specify that there exists a time during which a part 'p' of the sarcoma is located in the biliary tract, while other parts might be outside the biliary tract. We therefore added the following sentence to the end of that paragraph in which the argument is made: 'But when it happens, there would still be a part *p* of the carcinoma which is located in the biliary tract at time *t* while other parts are outside the biliary tract.'

----------- Relevance ----------- SCORE: 6 (excellent) -----

Possible integration of SNOMED CT and BFO-based ontologies is very relevant.

----------- Novelty (originality) ----------- SCORE: 6 (excellent) -----

[C32] The logic framework presented in the paper is novel and the analysis is insightful and definitely goes beyond the current literature.

➔ We agree, but note that another reviewer differs in opinion, see [C12].

----------- Presentation ----------- SCORE: 6 (excellent) -----

The paper is well written and easy to follow. A few places need clarification, as noted in the overall review

----------- Technical soundness ----------- SCORE: 5 (good) -----

The analysis presented in the paper is technically sound mostly, although this reviewer disagrees with the authors' characterization of OWL's SubClassOf axioms.

----------- Context ----------- SCORE: 5 (good) -----

The authors gives a good overview of related work and specifically compare their work to that of Schulz et al., the main competing interpretation of SNOMED CT.

----------- Evaluation ----------- SCORE: 3 (acceptable) -----

There is really no evaluation of the bridging axiom logic framework presented in the paper in terms of the beneficial uses that the framework enables. However, the analysis of different patterns of SNOMED CT can be seen as a kind of evaluation.

----------- Adherence to FAIR principles ----------- SCORE: 5 (good)