Responses to Reviewers for: **Functions in Basic Formal Ontology:**

An Elucidation and Defense

REVIEWER ONE

General comment:
(1) There are a few descriptions which are not clear how they are helpful for claiming how the authors' definition of function is good, instead, it seems to me that they simply explain requirements of function as if they are what their definition of function satisfies.
A typical example is found in Conclusion: "Conversely, when an individual does not instantiate its function (because it is totally or completely malfunctioning) this implies that something about the physical structure of the individual, specifically some of its dispositions, has itself changed or been lost, and this explains its lack of causal efficacy." which misses the point, it looks good at first glance. Instead, the issue is how you can talk about the function of an object according to your definition of function when the object has lost the capacity to perform the function. In other words, the issue is how to differentiate between an object doesn't have the function and it is just malfunctioning.
Another example is found in page 10: The paragraph in page 10 discusses mainly what malfunction is which we all know. What you need to discuss is not what malfunction is but how your definition of functions properly explain malfunction in more detail as well as the above differentiation.

AUTHORS: Thank you for these and for the below comments and suggestions. We have thoroughly revised the entire paper to make all descriptions as clear as possible. Specifically, we have added Sections 2.2 – 2.4, which situate the BFO account of function in relation to the literature and explain our preference for the etiological view. We have also expanded the response to Röhl and Jansen in 3.2 onward to reply to the specific examples that you give.

(2) Roughly speaking, discussion made in the paper is shallow and needs more detailed discussion. In addition to the above, more concrete comments are shown below. I strongly recommend the authors to read Artiga's paper "Re-organizing organizational accounts of function. Applied Ontology, 2011, 6:105–124".

AUTHORS: We have gone into much greater detail on the literature on function and situated our account in relation to it. We have structured much of the early discussion of function (section 2.2 – 2.4) around some of Artiga's discussion. Thank you.

Concrete comments:
(3) It is not clear that what is your definition of function. Is it one in page 12 or one in page 15, or composite of the both? In my review, I take the one in page 12 is your definition and the one in page 15 is an auxiliary explanation.

AUTHORS: That is correct. We have added a footnote explaining this.

(4) Unfortunately, this paper misses the major issue which is found in Table 3 in Röhl and Jansen's paper, that is, their claim that disposition is internally grounded, while function is externally grounded, and these two are incompatible with one another, and hence disposition can't subsume function. The authors didn't answer this explicitly.

AUTHORS: We take the dialectic to be the following: Röhl and Jansen offer a criticism of the BFO classification of dispositions as functions, then they propose their own account of functions as something other than dispositions (essential but externally grounded realizable features of their bearers). Our primary project in this last part of the essay is to respond to their criticism. Malfunction does not pose any special problem for the BFO view that functions are dispositions. A further project would be to provide a detailed critique of Röhl and Jansen's own view. Since their view is motivated by a critique of our own that we think is unsuccessful, we focus on that critique in responding to them. We now respond to Röhl and Jansen's critique in sections 3.2 & 3.2.1 and briefly provide some reasons for preferring our account to their own in 3.2.2.

(5) As you say, function is end-oriented (dependent), while disposition is not and is end-independent. That is, a function is purposeful, while disposition is not. For engineers point of view, what disposition manifests is more or less behavior as you see in a typical example such as fragility of a glass which just breaks into pieces, when it is hit, with no purpose/goal which contrasts with what a function manifests. Apart from whether or not your definition covers it appropriately, this difference of what are manifested is the key to differentiation between the two. You need to convincingly discuss how an end-independent type can subsume an end-dependent type. Not only Rohl and Jansen but also myself believe it is inappropriate or impossible.

AUTHORS: As noted above, we now include a lengthier discussion of the function literature and explain our preference for the etiological view of function, so our answer to the question of where the normativity comes from is essentially that of the etiological view. Very simply put, a function is a disposition with a certain type of history and the normativity of the function is a result of that history. 2.2 – 2.4 addresses some of this, while we now work out the consequences in more detail in 2.5-2.7. The engineering case is dealt with more thoroughly in our treatment of artifacts.

(6) What you mean by being end-directed in the explanation of BFO function or what is "end" are not discussed properly. This issue should be seriously discussed in more detail, since it is the heart of function and it successfully differentiates function from other types such as disposition, behavior, etc. The authors should be aware of how much enthusiastically engineers who have been working on function long years have been struggling with how to distinguish function(ing) from behavior (behaving). Some of the examples are found in the reference of Rohl and Jansen's paper.

AUTHORS: We agree that it is a difficult issue, but we know of no alternative account of "goal" or "end" with any degree of ontological coherence. Moreover, our treatment of biological functions is expressed without any ontological commitment to anything like "ends". As noted above, our view is a version of the etiological view and we now address this in more detail in the essay. We also now consider what we take to be exemplary of the literature from the engineering

perspective in 2.3.1. This was a lacuna in the original essay.

(7) "Intuitively, function is what is supposed to do", which is correct. But it can't inhere in an object. That is, although to pump blood is what a heart is supposed to do, it can't inhere in a heart. What inheres in a heart is capacity/disposition to pump blood. You are right in saying that a function inheres in a function bearer, but to pump blood can't. Clarify this matter in the paper and improve all wordings which would cause such a misunderstanding.
You should be aware of the fact that most engineers who worked on definition of function have tried to capture "to pump blood" as a function. So, they might think you talk about the same thing as what they do in your papers on function. But it is not the case. You explain what a function is using examples like "to pump blood is a function" has been very misleading because by it, you mean "capacity/disposition to pump blood" which can inhere in a heart.

AUTHORS: We have checked the wording throughout and are at particular pains to clarify this point in Section 2.1 where the possibility of viewing processes as functions or as having functions is now briefly discussed as well.

(8) When you introduce "historical element" and "contribution" in your definition of function, you need to explicitly defend it against criticisms given to etiological and contribution approaches found in Artiga's paper.

AUTHORS: We consider the objections from Artiga's paper, specifically the issue of epiphenomenalism, at the end of Section 2.3.2 and especially in 2.4.

(9) What about coagulation of blood? You say it is a disposition. I'm afraid all dispositions of organs are there because of evolution, and hence your definition deduces they are functions, since "it comes (they come) into being through evolution"

AUTHORS: In a very broad sense of 'because of' this is probably true. However, on the etiological account of function that we endorse this is not so. For a disposition to be a function it must be the result of relevant dispositions (and underlying physical structures) having proven successful in relation to survival and reproduction in ancestors of its current bearer. The disposition of blood to coagulate under certain circumstances can clearly count as a function under this account. As noted above, we have expanded the discussion of the etiological account and its consequences in the current essay.

(10) I don't think "it comes into being through evolution" means functional contributions of function bearers are there.
AUTHORS: It is not entirely clear what the objection is here, but we do now discuss some examples in 2.5.1 – 2.7 that seem close to this point.

(9) Anyway, you are highly recommended to discuss how your definition of function in page 12 entails all what you claim about characteristics of functions together with defenses against all known criticisms to existing approaches.

AUTHORS: We take this to be a summary of the previous comments. We have added sections

and much expanded the discussion in others to address these points.

(10) No related work is given. This paper is just an explanation of what BFO function is, which is not appropriate as a scientific paper.

AUTHORS: a discussion of some of the main views of function is now included and BFO function is placed in relation to them. Röhl and Jansen's critique, which we respond to as one of the main tasks of the paper, is itself formulated largely within the BFO framework, making it the central topic of the paper. Additionally, we have added some explanation of why we think it is useful to look at the development of a particular ontological category, such as function, against the background of an existing top-level ontology, such as BFO, in order to further motivate the essay.

Thanks once more for the excellent comments. They have helped us greatly in rewriting the paper.

REVIEWER TWO

TECHNICAL COMMENTS
One overall issue with the BFO approach to functions is that it does not acknowledge the primitive nature of functions. There are no objective and measurable criteria using which we could determine that A has function B. Best we can do is to offer helpful guidelines about when we can state that A has function B. BFO's use of structural characteristics and evolutionary history are two excellent examples of such guidelines.
The primitive nature of functions can be illustrated using the chopstick example considered in the paper. A chopstick is an artifact built specifically to have the function to enable eating. A pair of physically identical sticks lying in the forest, and brought into the restaurant, cannot be said to have acquired that function. Artifacts are designed for a specific function, and it is not appropriate to associate those functions for unrelated things. If one does that, it is possible to make many bizarre assertions. For example, the function of hammer is to hit things. Almost any physical object (e.g, chair, water, pen, etc.) could be used to hit things, but it is inappropriate to associate hitting as a function of that object. Similarly, in the chopstick example, the sticks brought from the forest could be said to play a "utensil role" in eating. One could also be more specific and associate "chopstick role" with those sticks, but it would not be appropriate to say that the sticks from the forest have the function of to "enable eating".
Acknowledging the primitive nature of function, and recognizing that an ontology is simply a tool for unambiguous communication, make it clear that appeal to evolutionary history and relationship to structure are merely guidelines, but not strictly definitional. For many biological entities, the evolutionary history may not be known or irrelevant to an information scientist for the task at hand. For many biological entities, the relationship between function and structure is either not known or not well-understood. For these reasons, it is difficult to use evolutionary history and structural dependence as the defining criteria for functions. For both biological entities and engineering artifacts, there are specific conventions for associating functions with them, and it is those conventions that establish what counts as a function of those entities.

AUTHORS: Thank you for these comments and suggestions, and for the ones below. We have added a brief section (2.2) addressing the sense in which what we are providing is an elucidation rather than a definition of function. We take this to capture what you have in mind by calling functions primitive. The second concern here is addressed at the end of Section 2.5. Etiological views of function are sometimes charged with creating problems for what we might call the "epistemology of functions", the question of how or when we know that f is the function of some bearer B (e.g. Both Amundson and Wouters seem to view answering this question as particularly important in an account of function). Our own view is that the first task in accounting for function is to elucidate it correctly and to assign it to the correct ontological category. This makes the epistemological issues somewhat orthogonal to our main concern. We acknowledge that these issues are a concern, but responding to it would take a great deal more space than is available in the current essay.

It is not clear if the functions should be considered as entities at all. A function such as "Pump Blood" is a verb phrase and refers to a process. It seems more appropriate to create it as a subclass of an Occurrent. Many examples of dispositions considered in the paper such as fragility, conductance, etc. have a word in English that is distinct from the processes such as Break and "Flow of Electricity" that realize them. No such word in English exists for the examples of functions considered in the paper. That is another argument against making the functions a subclass of Dispositions. It is more appropriate to represent a function as a a process in the ontology and relate it to the entity for which it is a function using a relation such as has-function.

AUTHORS: We now address this objection in Section 2.4. It is a crucial feature of BFO's account that a distinction is made between functions (continuants) and function*ings* (occurrents), both of which are first-class entities in the BFO ontology. This distinction has proved of considerable value to many different communities of users of BFO.

The primitiveness of functions is also suggested in statements such as "A function is a special kind of disposition" on page 15. It will be good elucidate further what do authors mean by "special kind of disposition". I agree with the discussion about the persistence of function on page 17.

AUTHORS: See the expanded discussion of the literature on function (2.3-2.4) and the expanded discussion of some of the implications of the BFO view of function (2.5-2.7), which are designed to address this concern.

On page 20, the authors address the criticism of Rohl and Jensen by imagining two alternative arguments. Neither of those arguments gets at the central point in the criticism of R&J. At least, it is not clear if R&J would have come up with the two arguments considered by the authors.

AUTHORS: Röhl and Jansen do not explicitly provide an argument, only an example which they suggest is problematic for the BFO view of functions as dispositions but without providing further elaboration0. The two arguments we provide are our best attempt at reconstructing what they may have had in mind.

I find that in the example function that "lungs provide oxygen" any existence of a disposition that enables this function, seems to be imaginary because there are no words for such a disposition in English, and the domain experts apparently do not have any need to talk about such a disposition. As I stated earlier, in my view, there are two problems with making Function a subclass of Disposition.
- A Disposition usually has a English word associated with it, while a function does not.
- A Function is usually named by a verb phrase which makes it a process while a disposition is an entity.

AUTHORS: as noted above, Section 2.4 now addresses this objection.

I encourage authors to consider the following issues that may help sharpen their representation of functions.
- What is the relationship between structure and function, and how it can be modeled?
- How should the representation of function relate to the realization of the function through execution of a process? Should there be a taxonomy of functions separate from the taxonomy of processes that realize them? If yes, why, and how should the two be maintained?
- How should functions be represented in more detail than simple text strings of the sort that we see in the Gene Ontology?

AUTHORS: Concerning the first point, the relationship between structure and dispositions in BFO is discussed in more detail in Section 3, with obvious implications for the treatment of functional dispositions. The second point here is addressed in Section 2.1. We take the third point under advisement but do not make specific proposals about it here as we take ourselves to be engaged in the more general task of elaborating and defending an account of function.

There has been quite a bit of work on representing functions in artificial intelligence that the authors seem to be unaware of. I recommend that they should read up on the following references.
1. B. Chandrasekaran and John R. Josephson, "Function in Device Representation," Engineering with Computers, Special Issue on Computer Aided Engineering, (2000) 16:162-177.
2. Goel, A. K., Rugaber, S., & Vattam, S. (2009). Structure, Behavior, and Function of Complex Systems: the Structure, Behavior, and Function Modeling Language. AI EDAM, 23, 23–35.
3. Chaudhri, V. K., Dinesh, N., & Heller, C. (2013). Conceptual Models of Structure and Function. 2nd International Conference on Advances in Cognitive Systems.

AUTHORS: Thank you for these. We now discuss Mizoguchi, R., Kitamura, Y., and Borgo, S. (2012) “Towards a unified definition of function” as an example of the “systems” or engineering approach to function in Section 2.3.1, and because the mentioned discussions present a view of function similar to Mizoguchi et al. we have not explicitly discussed them here for reasons of space. In addition, these papers are discussing specific modeling languages, a topic which goes beyond the scope of the current essay

Thanks once more for the excellent comments. They have helped us greatly in rewriting the paper.

REVIEWER 3

The paper presents an account of functions based on Basic Formal Ontology.
For the most part it is a sort of summary of the relevant parts of the previous work of its authors, mainly of Building Ontologies with Basic Formal Ontology published this year by R. Arp, B. Smith, and A. Spear.
The main, and effectively only one, extension, is the discussion of a recent paper by J. Röhl and L. Jansen, where the latter argue against the account developed by R. Arp, B. Smith, and A. Spear.
Thus, the novelty and the added value of the paper under review are low - particularly because the aforementioned discussion is sketchy and sloppy.
In my opinion there are two major problems with the paper:
1. It almost completely neglects the past and current research on functions - both in philosophy and in applied ontology. The account presented in the paper is roughly a version of the etiological approach, so the paper should answer to the main criticism raised against this approach, e.g., by Amundson and Lauder, Bigelow&Pargetter, Houkes & Vermaas, or Wouters, among others.

AUTHORS: Thank you for these and for the below comments and suggestions. We have added Sections 2.2 – 2.4, which situate the BFO account of function in relation to some of the literature and explain our preference for the etiological view by responding to what we take to be some central objections to the etiological view. We have also expanded the response to Röhl and Jansen in 3.2 onward to reply to the specific examples that you give.

As far as applied ontology is concerned, this issue is even more troublesome: why do the authors ignore theories of function by Y. Kitamura and R. Mizoguchi, G. Kassell, or by S. Borgo and L. Vieu? An elucidation and defence of the BFO notion of function requires at least comparison with these other attempts – even if the authors think that their own definition is superior.

AUTHORS: Section 2.3.1 now includes discussion of Kitamura et al. under the heading of systemic/causal contribution accounts of function. Our main concern with such a view is that it will be incomplete unless factors outside of the causal role of an element in the system are appealed to in order to determine the functional context.

2. It is not formal, i.e., it is not properly formalised. I find this a main issue because the informal definitions provided are cast in such terms that are handy, but hardly formalisable, e.g., 'is in some special physical circumstances', 'physical make-up', 'in virtue of', or 'in order to realize processes of a certain sort'. We know from philosophical logic that the task of providing a logical theory of such relations as 'in virtue of' or 'in order to' is not trivial. I would expect that a research paper submitted to Applied Ontology should at least state how these definitions can be flashed out in the BFO terms with the help of some logical background theory (or theories). As of today the BFO project's website does not provide such formalisations (they were not available for the earlier versions of the ontology either.)

AUTHORS: The current essay aims primarily to elucidate BFO function, to defend it from the objections of Röhl and Jansen, and now also to relate BFO function to existing literature and

critiques of the etiological view. We acknowledge the desirability of a more complete formalization, though see it as beyond the scope of the present work. In this connection, we note that, due to its location in the BFO hierarchy, function is governed by the axioms governing relations such as *inheres_in* and *realization_of*. BFO 2.0 is extensively documented in English (with axioms and definitions throughout) and in OWL 2 DL. A FOL / CLIF formalization is nearing completion.

A minor issue is the quality of the discussion with Röhl and L. Jansen's paper.
Consider the following part:
"Both of these arguments fail, however, as arguments against the thesis that functions are a subtype of dispositions. For the BFO elucidation of function says that all functions are dispositions, not that all dispositions are functions. A function is a disposition with a particular history of intentional selection or design and the chopsticks have, while the sticks in the woods lack, a history of this sort. We thus reject the first premise (P1) of Argument 1; for on the view defended here having all dispositions in common is not sufficient for having all functions in common. To have the same function, the objects in question must also have the same histories of selection or design. In Argument 2, for similar reasons, we reject the second premise (P2). It is not always true that to gain a new function requires that an entity also acquire a new disposition." (p. 20)
This is self-contradictory.
If each function is a disposition, then having all dispositions in common is sufficient for having all functions in common.

AUTHORS: We agree that this and the following is the line of argument on offer from Röhl and Jansen. However, we reject the above claim and have expanded discussion of the significance of history in the BFO elucidation of function in sections 2.5 – 2.7 to more clearly explain this. Two objects that have all dispositions in common may not have the relevant histories in common and this will make a difference to whether or not the dispositions of each object are functions. We take this to be the case for chopsticks and the otherwise qualitatively identical (but as yet not selected) sticks in the woods.

Suppose that continuant x has three dispositions: a, b, and c, and suppose that c is a function.
Then if continuant y has the same dispositions as x, i.e., a, b, and, c, it also has the same function, i.e., c.
For the same reason if each function is a disposition, to gain a new function requires that an entity also acquire a new disposition.

AUTHORS: See the extensive discussion of the glycogen system in 2.5.1 to see where this goes wrong. That the argument is flawed becomes clear when it is reformulated to do justice to the distinction between particulars and universals:

> Suppose that continuant x has three dispositions of types: *a*, *b*, and *c*, and suppose that the disposition of type *c* that inheres in x is a function.
> Then from the fact that continuant y has dispositions of the same types as x, i.e., *a*, *b*, and, *c*, it does not follow that the disposition of type *c* that inheres in y is also a function.

Thanks once more for the excellent comments. They have helped us greatly in rewriting the

paper.