Responses to Reviewers for:

**Functions in Basic Formal Ontology:**

**An Elucidation and Defense**

**REVIEWER ONE**

REVIEWER 1:
Severe issues of this paper.
(1) "to pump blood"
A scientific paper can't include self-contradictory statements. The following two propositions are in the paper:
1. A function is a dependent continuant which inheres in a function bearer.
2. To pump blood is a function of a heart.
Then the following is deduced:
3. To pump blood inheres in a heart.
But, proposition 3 is incorrect, since it is an occurrent which can't inhere in an object. This is not just a terminological issue or a simple mistake but a theoretical issue. Therefore, this logical inconsistency is not negligible and hence this paper is not appropriate as a scientific paper.

AUTHORS:
The issue here seems to us to be linguistic, not theoretical or logical. In English there are not always pre-existing adjectives for dispositional properties, which include, on our view, functions understood as dispositions inhering in continuants. Thus, whereas we do have 'soluble' to refer to the solubility of, e.g. salt, which is realized in the process (indicated roughly by the verb: 'to dissolve') of dissolving when placed in water under appropriate conditions, there are not similar correlates for all disposition and function terms. For this reason we adopt the locution "the disposition to pump blood" in order to refer to the relevant functional disposition of the heart, while the verb 'to pump' or the substantive 'pumping' are taken to refer to what we call processes, which on our view can be realizations of but are not identical to the function of an entity. The suggested contradiction is a result of conflating these two kinds of function talk. We are careful to clarify this at various points in the essay and include a discussion of the natural language issue in section 6.2.

REVIEWER 1:
(2) Distinction between function and behavior
"Legs have the function to walk" indicates that "(capacity) to walk" is a function according to the proposed definition. Apparently, however, to walk is not a function but an action which is a kind of behavior. According to the proposed definition of function and explanations about it, any behavior X about which we can say "He lost his X-ing function" is a function. (He lost walking/singing/speaking/eating,... function). Such a definition and discussion about function is very insufficient for a talk about artifact function. One of the key features of artifact function is the property of "realization-independence". That is, a function is realized by a behavior and the same function can be realized by multiple behaviors in multiple ways. For example, to cool your body (a function) can be realized by multiple behaivors such as sending wind(moving air) to you, lower the room temperature (by an air conditioner), showering some water over you, etc. On the other hand, a behavior can realize multiple functions depending on the context where it is performed. For example, waving (behavior) your hand realizes functions such as to stop (call) a taxi and to say hello to your friend, and heat transferring behavior of a heat exchanger realizes heating or cooling functions depending on in what context it is put, etc. etc. Researchers working on artifact function have been struggling with how to differentiate function from behavior, while the proposed definition of function is nothing to do with such differentiation. In sum, as far as the authors claim that the proposed definition covers artifact functions, this paper can't be accepted as a J. AO paper.

AUTHORS:
Quoting Reviewer: “According to the proposed definition of function and explanations about it, any behavior X about which we can say "He lost his X-ing function" is a function.”
Authors: This claim is not made in the paper. The example of walking is meant as an intuitive example only and there is no suggestion at that point in the paper or anywhere else that the example is meant as a general recipe for the identification of functions. Indeed, our paper is not primarily about the identification of functions where this is understood epistemologically, but rather the ontology of functions, what they are.

Quoting Reviewer: “Researchers working on artifact function have been struggling with how to differentiate function from behavior, while the proposed definition of function is nothing to do with such differentiation.”
Authors: This is one thing that researchers working on artifact function have been struggling with, but surely not the only thing. Further, this objection seems to presuppose in its very formulation a certain way of thinking about the ontology of functions. Namely, that functions are essentially behaviors and that the challenge is then to differentiate the functional behaviors from others. We are clear in the essay that this is not our view. Indeed we emphasize the distinction between functions (continuants) and functionings (occurrents). Some instances of behavior – for instance the behavior of an engine when it is running – functionings, but most instances of behavior are not. We now discuss our reasons for viewing functions as a type of disposition in section 4.2.1 and consider the issue of processes and functionings again in 6.3. Our view begins with a consideration of the dispositions possessed by certain entities and of their histories, and it is on this basis that we attempt to answer questions about which dispositions (and attendant realizations in processes when these occur or manifest) are functions. In terms of the example above, that there are many ways “to cool the body” is something we acknowledge, but our view is that there will be no way to distinguish functional “cooling of the body” from non-functional (or afunctional) cooling of the body unless ontological categories other than behavior/process are appealed to. It is possible to cool the body by perspiring or by blowing a fan on it. It is also possible for the body to be cooled in undesired or unexpected ways, as in being buried by an avalanche or accidentally locking oneself inside a walk-in freezer. Roughly, our view handles the function in the first case in terms of the evolutionary history of physical structures of the body involved in perspiration and in the second in terms of the history of intentional design or use of fans. In the second two cases it is the fact that the avalanche that buries the person has neither an evolutionary history nor intentions, and the fact that the freezer was not intentionally designed to cool human bodies that explain why the processes they are (in part) realizing are not functional processes. This is a difference of ontological commitments and approach, but not, so far as the reviewer’s comment has argued, anything more than this.

REVIEWER 1:
Major comments:
(3) How to defend your definition
Once you set up your definition, you must defend it in terms of the definition in any case. I mean, you should not defend your definition without mentioning it, that is, a defense must address the question "How does your DEFINITION meet the desiderata". In spite of this simple truth, you defend it employing type-based theory without mentioning the content of your definition. In addition to this, you explain function in terms of a kind of contribution theory as if your definition explains so. I think either one is inappropriate.
An example of the former is:
".... to endorse option (2) for the simple reason that it seems possible for a lung that has just ceased functioning in the way under consideration here to still have enough structural and historical similarities with canonical lungs so as to count as an instance of the universal lung."
and that of the latter is:
"Intuitively, the function of a thing is what it is supposed to do. This typically involves both what is popularly called a goal or end of some sort and a way of achieving that end. A thing is functioning well when it does what it is supposed to do reliably or effectively and in the, for it, appropriate way. A thing is malfunctioning when it does what it is supposed to do poorly or not at all.
The function of the heart is to pump blood; when this function is realized ? when the heart is pumping ? blood

flows through the circulatory system. This is a consequence of the realization of the heart's function. A healthy or well functioning heart does this well. An unhealthy or malfunctioning heart does this poorly. The purpose of a pair of sunglasses is to shield the eyes from the sun or other source of bright light while still enabling vision. A good pair of sunglasses does this well. A defective or bad pair of sunglasses does it poorly (either by failing to shield the eyes from the light source or by obstructing the vision of the wearer). Our talk of functions is thus in some sense teleological (involves reference to goals or ends or purposes) and normative (reference to functions serves as the basis of judgments of good and bad, better and worse)."
In other words, once you have adopted etiological statements in the definition, then you have to stick to them, and hence your definition can't avoid its difficulty in dealing with innovative functions which have no precedents/antecedents. I'm afraid this is why you rejected Epicondition from the desiderata.

AUTHORS: There seem to be three distinct objections here. Concerning the first, about the definition, we do appeal to types in our defense of the BFO understanding of function against Röhl and Jansen. However, the entire essay is framed in part in terms of the distinction between universals and particulars (types and instances) discussed in section 2 and the development of the view makes reference to both kinds and their instances at various points throughout. Further, the response to Röhl and Jansen (section 7.2) does, so far as we can see, rely on our definition throughout, identifying the function of lungs (Röhl and Jansen's example) in terms of their etiology and then discussing the way in which this function, understood as a disposition (or collection of dispositions) must be conceptualized. We take it that the question of total or complete loss of function (due to complete loss of underlying dispositions) for functional kinds such as hearts or hammers does raise the question of the identity conditions for instances of those kinds for *any* account of function and outline various possibilities as to what to say about this before tentatively endorsing one of them. It may be that the objection here is just that we should explicitly include reference to types, kinds, or universals in the definition of function. This is something that we now discuss in section 7.2.2.
Concerning the second objection, we are less clear what it is supposed to be. The passage quoted occurs at a point in the essay when we are still sketching the intuitive notion of function and before our official elucidation. However, before the second objection has been fully explained, the reviewer introduces a third, which seems to focus on the issue of the introduction of novel uses for artifacts (repurposing an anvil as a doorstop) or of natural objects that become artifacts (the chopsticks of section 7.1) and on Artiga's criterion concerning epiphenomenalism. The objection here is not entirely clear. We acknowledge in the paper that our account does not satisfy the epiphenomenalism criterion. Given this, it is not clear why we should appeal to it in responding to issues concerning artifacts in the way the reviewer seems to suggest. In his introductory remarks to the special issue Artiga raises some concerns about novel uses of artifacts and repurposing of natural entities as artifacts, so we address this issue in more detail in our response to his introduction and also in 5.2.1 and 7.1.

REVIEWER 1:
(4) Malfunction
The difficulty of your definition as to explanation of malfunction is caused by your understanding function as a kind of "capacity" as indicated in (2). What Rohl and Jansen and many others want to claim as to malfunction is that even when an object has lost its capacity to perform its function, it is supposed to do it. Your definition can't meet such malfunction desiderata because your definition is dependent only on its internal matters, so you suddenly employ type-based theory which is already refuted by Artiga [Artiga 2011].
I'm afraid you might want to accept "externally grounded"-ness shown in Table 3 in [Rohl and Jansen 2014] in order to explain malfunction.

AUTHORS:
Concerning "suddenly", we addressed the role of types (or universals) in our account in response to (3) above. Concerning the refutation of the appeal to types in Artiga 2011, his argument there is directed specifically at organizational accounts and his argument is that such views cannot satisfy his criteria of teleology, accidental properties, and normativity unless they appeal to something like the type/token distinction, but that doing this

means they will run into problems with epiphenomenalism. We have already accepted that our account does not satisfy epiphenomenalism so, by the arguments of Artiga 2011, we take ourselves to be in the clear in our appeal to types. Artiga himself, in his introduction to the special issue, does not make any complaint about our appeal to types in 7.2.

REVIEWER 1:
(5) EPIPHENOMENALISM (Epi) condition
You should not reject the Epi condition which is critical to artifactual function as already discussed in the literature, say, [Vemaas2013]. [Vermaas2013] Vermaas PE, Carrara M, Borgo S, Garbacz P: The design stance and its artefacts. Synthese 2013, 190(6):1131-1152.
"We consider EPIPHENOMENALISM as the weakest of the three desiderata however, since it clearly cannot deal with a host of cases where entities - both artifacts and biological continuants - have functions but are not at any given time functioning"
No. This is incorrect for artifact functions in which case Epi is one of the most critical desiderata, since the value of artifact lies in the current performance of its function. An electric fan IS recognized as an electric fan mainly because the fins turn and it sends wind to users. In biology, it can't explain functions created by mutation, which is a non-negligible drawback.

AUTHORS:
So far it is not clear from the Reviewer's comments exactly why Epi is such an important condition. We acknowledge its intuitive attractiveness, but in light of the tradeoff identified by Artiga 2011 and other considerations choose to not satisfy it in favor of having an account that can handle many other cases and satisfy the majority of extant criteria. The considerations in, e.g. Vermaas et al. 2013 seem to be epistemological in nature, focusing not on the question of what functions *are* but rather on the standpoint from which we ascribe, identify, or know objects as possessing functions of various types. The Reviewer writes "an electric fan IS recognized as an electric fan mainly because the fins turn and it sends wind to users". This is no doubt a significant way of *identifying* something as an electric fan, but it hardly decides the question of what an electric fan itself *is* or of what features or facts about it determine, ontologically, what its function or functions are. Epiphenomenalism and the issue of novel or repurposed artifact functions are raised by Artiga in his introduction to the special issue, so we do now say more about these things in our response to him.

REVIEWER 1:
(6) The definition is vague.
"f is a function means:
f is a disposition
& f exists in virtue of its bearer's physical make-up
& this physical make-up is something that this bearer possesses because it came into being, either through evolution (in the case of natural biological entities) or through intentional design (in the case of artifacts), in order to realize processes of a certain sort. (Smith et al. 2015)"
All biological objects (parts) of any organism are there because of evolution. How to differentiate essential functions from accidental ones is not specified in the definition. How you identify "in-order-to" relation between structure and a realized process is not specified in the definition either. So, this definition would include the sound making function of a heart because such behavior/function has existed since nature found the mechanism of a heart through evolution. For example, the following can't be reduced from the definition:
"The heart is supposed to pump blood because this is what was selected for in the history of organisms possessing hearts"
There is no evidence why only to pump blood was selected. All other "side effects" existing in the current hearts WERE also selected.

AUTHORS:
Quoting Reviewer: "There is no evidence why only to pump blood was selected. All other "side effects"

existing in the current hearts WERE also selected."
Authors: This claim seems false to us. In the actual evolutionary history of organisms possessing hearts, the fact that their hearts pumped blood plays a causal role in explaining why they survived and reproduced. The fact that their hearts made thumping sounds does not play such a causal role in explaining why they survived and reproduced. The first is then a function while the second is an accidental side-effect of that function. In this respect we do not take our view to depart at all from standard etiological accounts of function. We have given this and related issues their own section in 3.4.

REVIEWER 1:
(7) Not a unified definition
The definition is composed of two definitions: one for biological function and the other for artifactual function. Therefore, let us confirm that it (the definition proposed in this paper) is not a unified definition of function. From all the above comments, the conclusion stated in the Conclusion section is not supported.

AUTHORS: We take our definition to be unified by the fact that we define a function as a disposition with a history. This is true of both biological and artifactual functions. This is why we make reference to them both in the definition. There are some important differences between artifactual and biological functions and it is our view that no unified account of function will be able to ignore these differences entirely without glossing over them (pretending they are not there). However, we have a single definition of function that assigns both biological and artifactual functions to the same independently developed ontological categories and are not sure what more could be asked. Artiga, in his introduction to the special edition, raises a question about this issue concerning his criteria of "novelty" for a definition of artifactual function, which we address in our response to him.

REVIEWER 1:
Minor comments:
(8) Redundancy
You should not duplicate how existing proposals don't meet Artiga's desiderata. After a brief explanation of what they are, you simply evaluate your definition against each of them.

AUTHORS: The expanded discussion here was part of our response to previous reviewer comments (from Reviewer 1 or another, we are not sure) on the essay, which read as follows:
"(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.
(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."
While we still are not discussing "all" criticisms or related work, the point of the discussion now labelled as redundant is precisely to put our work in the context of contemporary discussions and to provide some additional reasons for the decisions that we make in developing our account of function. Given that BFO is now so widely used (http://ifomis.uni-saarland.de/bfo/users) we believe that it comports well with the goals of *Applied Ontology* to elucidate in this fashion an important BFO category.

REVIEWER 1:
(9) Artifact functions
I'm afraid your understanding about artifacts are somewhat limited to so-called tools. Besides hammer, chair, knife, etc. there are other kinds such as pump, pipe, valve, cylinder, motor, etc. which are embedded in a system exactly like all the biological organisms.

AUTHORS: The example of a watch spring is used in section 5.3. We understand it to be embedded in a watch at some times, but also removable, transferable, and replaceable. What is said about the watch spring here should apply, with little additional explanation, to the examples mentioned.

REVIEWER 1:
(10) context-dependency
"However, as the glycogen synthesis example once again shows, it is possible for a given disposition of a given bearer to become or to cease to be a function of that bearer solely as a result of certain changes in what we can think of the spatial and temporal context in which the bearer is located. This holds at the level of types ? when the new synthesis mechanism takes over from the old across an entire species. But it can hold also at the level of instances: Suppose that John is possessed of two glycogen synthesis systems along the lines described above. And suppose that some mutation brings it about that John's old-style glycogen synthesis mechanism loses its function to synthesize glycogen because as he grows older the newer, better mechanism takes over its duties."
The authors seem to have missed a good chance to learn the truth. The above fact is a very good example to learn what a function is. It nicely suggests that a function is something externally dependent, usually dependent on a context in which the function bearer is.

AUTHORS:
The main point of this example and of the surrounding discussion is to illustrate and acknowledge the ways in which changes in the history of an organism or species can, with time, lead to changes in the function of a particular physical structure of that organism or species. Insofar as (for example) an evolutionary history includes considerations of environment and selection pressures and these things are to be considered a kind of context, our definition happily recognizes the partial dependence of functions on contexts of this sort. However, what these contexts do on an etiological view is causally mold an individual (or members of a species) of a specific sort with specific physical structures and dispositions, and it is in terms of these things that the function of particular entity is to be understood. Nothing in the above example or comment provides us with reason to think otherwise. There are some views of function according to which a context has to do, not with a causal, historical, or environmental context per se, but with a context of function ascription or attribution by an intentional agent. 'Context' used in this sense raises issues of epistemology (how do we know/decide what the function of something is) rather than ontology (what is a function) and we are clear throughout that the epistemological questions are not our concern in this essay. Sections 5.2 through 5.2.1 have been significantly revised to make clearer the role of history in our account.

REVIEWER 1:
(11) A misinterpretation of literature
The description about the paper (Mizoguchi et al. 2012) seems to include incorrect interpretations. At least "A" in "the systemic context A "should be "C".

AUTHORS:
We have corrected the typo but were unable to find any other incorrect interpretations. Our comments concerning Mizoguchi et al. 2012 are very similar to those made by Artiga in his introduction to the special issue in relation to the essay by Mizigochi et al. If there are incorrect interpretations, they seem, then, to be repeated by Artiga as well.

REVIEWER 1:
(12) As to "a process has a function"
I don't know who said it, but it is incorrect, since any function is REALIZED by a behavior. A function bearer performs a behavior which realizes a function depending on a context. So, you don't have to be worried about the seemingly new topic of functional talk.

AUTHORS: The issue here seems to be similar to that of (2) above. According to some views of function what the reviewer says here is correct. According to others, including our own, it is incorrect or at least not the entire story. We take ourselves to be comparatively conciliatory on this point in the essay and are not sure why the discussion in 4.1 should be deleted or rejected. Reasons in support of the view of functions as dispositions are also further discussed in 4.1.2.

AUTHORS: Thank you once again for the comments, criticism, and suggestions.

## REVIEWER TWO

SUMMARY
I read the revised version of "Functions in Basic Formal Ontology: An Elucidation and Defense". The authors have significantly revised the paper and added quite a bit of new material. I organize my review into two parts: (1) Authors response to my first review, (2) New issues raised by the current draft.
From the structural point of view, the paper has three main pieces: BFO definition of functions, how functions relate to dispositions, and how BFO definition relates to other literature. In the revised version the authors consider work by Artiga as well as work by R&J in different parts of the paper. I suggest that they consider merging these into one section. They should also consider discussing other related work in the same section. Addressing the criticism of R&J no longer makes sense as a high level goal of the paper. The presentation in the paper can substantially condensed by eliminating presentation of so many different versions of the definition of function.

AUTHORS (1):
Concerning the first point, we have substantially reorganized the paper in order to make its broader focus clear. We now consider BFO, recent desiderata for accounts of function, the BFO elucidation itself, implications of the elucidation, and then objections to the BFO elucidation among which R&J's objections still have a central but not the sole place. As it turns out, Artiga's critical remarks on the paper as well as our response to him does focus largely on the discussion of R&J. Nevertheless, it is no longer framed as the central project of the paper.

Concerning the second point, we have reorganized the paper as a whole quite a bit and have condensed the discussion of the different versions of BFO function. However, part of the point of the essay is to acknowledge the revision from 1.1.1 to 2.0 and to defend it. We view this as important both in explaining the current BFO view of function itself and also in responding to criticisms such as those of R&J.

REVIEWER 2: The author's explanation of relationship between disposition and functions do not come across as very convincing. I wonder if it is possible to define functions by making no reference to dispositions as is done in AI literature on functions. If one does that, that leaves a separable task of explaining how functions are related to dispositions, while the functions are explained and defined as a stand alone notion. It may be difficult to accomplish this within BFO in which functions are entangled with dispositions, but many ontologies do not represent dispositions, and can much more simply define functions without having to deal with BFO's problematic relationship between functions and dispositions.

AUTHORS (2):
Part 1: We have added a section in which we explicitly present and discuss five reasons why we think functions and roles should be identified. These are now section 4.1.2. Some of these were already present in the essay, but they are now all located in one place.

Part 2: The AI literature. We did respond to the previous comment about the AI literature. Our original response was:
"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."
We explain in sections 3.4, 4.1.2, and to some extent 4.1.3 our reasons for preferring an etiological account over other accounts of the ontology of function, including the systems account. Insofar as the AI literature mentioned presents variations on the systems view, there is nothing new in it from this standpoint. The reviewer writes: "I wonder if it is possible to define functions by making no reference to dispositions". It is possible to attempt to

do so. We consider some alternatives in section 3.1 through 3.3 and present some of the extent problems that they face. In addition, we have now expanded the discussion of our reasons for thinking that functions are dispositions (in section 4.1.2).

REVIEWER 2:
How do authors propose to explain their definition to users with different levels of sophistication? Even grade 8 biology students need to understand functions as well as bio-curators. What are the central notions of functions that need to be communicated for a range of users? The current definition is very complex and confusing even for ontology researchers.

AUTHORS (3):
We are sympathetic to the concern about understandability and complexity, but we hope that, at least for purposes of the current essay, explaining our definition in a way that is understandable to readers of *Applied Ontology* will be sufficient. In terms of complexity, we offer the views discussed by either of the two other papers in this special issue on functions as approaches to the notion of function that will be more difficult to explain to grade 8 students and/or bio-curators than our own might be.

REVIEWER 2:
In summary, the revised version of this paper has improved in some ways, but in other ways, some new problems have been introduced. The paper also perpetrates the arbitrariness in ontology design instead of using objective and/or empirical methods. The current version will benefit if the authors were to take a step back and really rethink what they wish to communicate, and what are their strongest arguments.

AUTHORS (4): We have responded to the other points here above. Concerning empirical methods/verification, we will be incorporating the following information in a footnote in section 4.1:
"To see how influential the BFO treatment of function is in the world of scientific ontologies go to http://bioportal.bioontology.org/search?utf8=%E2%9C%93&query=function&commit=Search and scroll down to BFO:Function; all the 70 or so scientific ontologies listed in the indented list immediately following are reusing the BFO term -- 'function'."
We share the desire for empirical verification where possible and are aware of some efforts on this front that are currently underway. On the other hand, ontology design does also involve conceptual-logical issues and these are the main focus both of our own essay and of the other essays being included in the special edition on function.

REVIEWER 2:
AUTHORS RESPONSE TO MY PREVIOUS REVIEW
- Recognize the primitive nature of functions. In section 2.2 of the revised version of the paper, the authors do an adequate job of acknowledging this issue.

- Relate your work to work on representing functions in AI research. The authors have chosen to ignore this point from my previous review. Even if they choose to not address it in the main body of the paper, it will be helpful for me to understand why they do not feel the need to relate their work to work on functions in AI literature.

AUTHORS (5): We respond to this comment earlier in "AUTHORS (2)".

REVIEWER 2:
- Function vs Functioning: In the BFO approach to representing functions, one is forced to introduce a continuant and an occurrant version of each function leading to unnecessary duplication in the ontology. The authors failed to address this important prgagmatic concern in their revision. If they view this issue to

be unimporant, they need to explain their rationale.

AUTHORS (6): We now address this issue in section 4.1.2 (on why we think functions are dispositions) and again in section 6.3. In short, shortcomings of the systemic accounts (discussed in 3.2 and in much more detail in Artiga 2011) make it very difficult if not impossible to define functions entirely in terms of their realizations without any references to the entities that the functions are functions of, we thus contend that both a continuant and occurrent element must be involved in a complete account of functions/functioning.

REVIEWER 2:

- Function vs disposition in natural language: The authors acknowledge this issue on page 18, and to some degree address it. It is debatable whether their explanation is sufficiently convincing.

AUTHORS: We have kept the original discussion of this issue in section 6.2, and have worked throughout the essay to further address it. Here too we take the expanding discussion of why functions are dispositions to in part mitigate the natural language concern.

REVIEWER 2:

SOME NEW COMMENTS/CRITIQUES FOR THE CURRENT DRAFT
- page 4: It is unclear if "roundness" should be a particular or a property. This issue is orthogonal to the main point of the paper, but has a potential to cause distraction.

AUTHORS: this is the result of background assumptions explained in 2 (though property in BFO would correspond most closely to either dependent continuant or quality, depending on just what is meant). These do form part of the framework of BFO, so we use them as (explained) background assumptions here.

REVIEWER 2:

- page 7: The authors claim that "BFO's primary goal is always to assist scientists and others in the development of practically useful, accurate, coherent, and interoperable domain ontologies ...". The paper is surprisingly silent on any feedback from the domain scientists in making use of the definition of functions from BFO.

AUTHORS: We have responded to the other points here above. Concerning empirical methods/verification, as noted above we will be incorporating the following information as a footnote along with the main discussion of BFO function:
"To see how influential the BFO treatment of function is in the world of scientific ontologies go to http://bioportal.bioontology.org/search?utf8=%E2%9C%93&query=function&commit=Search and scroll down to BFO:Function; all the 70 or so scientific ontologies listed in the indented list immediately following are reusing the BFO term -- 'function'."
We share the desire for empirical verification where possible and are aware of some efforts on this front that are currently underway.

REVIEWER 2:
- page 8: It is unclear why footnote 6 could not be simply a citation

AUTHORS: We have changed this.

REVIEWER 2:

- page 10:Footnote 8 does not seem to match the text it is cited in

AUTHORS: The footnote points the reader to further discussions of the issues mentioned in the sentence after which it occurs. We take these to be different ways in which it could turn out that BFO is expanded or revised in the future.

REVIEWER 2:

- page 10: Why shouldnt footnote 9 be an inline reference?

AUTHORS: We have changed this.

REVIEWER 2:

- page 11: Why should there be a fundamental difference between the functions of a biological entity and the functions of an artifact? If there is no difference, why not provide a uniform treatment for the two? If there is a difference, please explain.

AUTHORS:
The discussion on page 11 (section 4.1 now) is providing only an overview of the BFO notion of function, with the main elucidation and discussion coming in (now) 4.1.1 and after. Here we are stating what we take to be the primary range of application of the notion, not arguing that these are the only things that could possibly have a function or making any special point about our elucidation being a unified account of artefactual and biological function. We have rewritten parts of the relevant sections to make this clearer. Sections 4.1 and 4.1.1 do amount to a unified account of function (for both artefactual and biological functions), or so we argue. In his introduction to the special edition Artiga makes some points about this, so we will discuss the issue in our response to him as well.

REVIEWER 2:

- page 11: Footnote 10 is bothersome. I do not understand why we have to take a position on evolution for defining functions. I'd be inclined to come up with a definition that is agnostic of this issue. i.e., Why not offer an evolution / existence neutral account of functions?

AUTHORS:
We are not sure what an existence neutral account of function would be. The general ingredients of our elucidation of function are dispositions and histories of those dispositions. This does not yet make reference to evolution. However, as an etiological account evolution is the obvious historical mechanism in the biological case and this is what we endorse. See AUTHORS (2) above and sections 3.1-3.4 in the essay for additional clarification of our reasons for elucidating function as we do. We have added some additional explanation as well.

REVIEWER 2:

- page 12: The authors consider four desiderata for the definitions of a function by Artiga. Later on page 29, they present somewhat overlapping desiderata by R&J. Presenting these desiderata separately an so far apart makes them difficult to understand.

AUTHORS: We have now relocated the majority of this discussion to section 3 at the beginning of the essay.

REVIEWER 2:

- page 19: I find the review of different versions of the definitions of functions not very helfpul. The authors claim that BFO has hundreds of users. Why couldnt they have done a survey of their users on how

practically useful have they found the current definition in information modeling applications giving them an empirical basis for what is neededed than purely theoretical consierations used so far?

AUTHORS: See AUTHORS (2) and AUTHORS (4).

REVIEWER 2:

- page 22: In sections 2.5.1, the authors give examples of evolutionary changes of functions. I was troubled by the fact that these examples are hypothetical. If the users in biologists and bio-medicine users indeed use the term function in reference to evolution, then the authors ought to be able to come up with some real examples instead of inventing contrived ones as they had to do with this paper. (i.e., some collaboration with domain users is called for.)

AUTHORS:

The purpose of the example in 2.5.1 is primarily to acknowledge a possibility that our definition allows for. Most biomedical ontologies do not focus on the evolutionary history of the entities they represent in detail and so do not need to represent all of the information that the hypothetical possibility described includes. We now include a footnote discussion concerning the appendix and its evolutionary history, which current research suggests is similar though perhaps less complicated than our glycogen example: Laurin, M., Everett, M. L., Parker, W. (2011). The cecal appendix: One more immune component with a function disturbed by post-industrial culture. *The Anatomical Record*, 294(4), 567-579.

REVIEWER 2:

- page 26: Section 2.6 has only one subsection suggesting a structural problem. The objections raised in section 2.6 are valid, and the defense offered in Section 2.6.1 is not particularly convincing.

AUTHORS:
The dilemma is now more explicitly discussed and addressed in 5.2 and 5.2.1, as well as in 7.1. A similar concern is raised by Artiga in his editor's introduction to the special issue, so we now also address the issue in our response to his second concern there.

REVIEWER 2:

- page 28: It is not clear what is the purpose of Section 2.7

AUTHORS:
We take it that an account of functions as dispositions, like any other, owes an account of the identity and persistence conditions of instances of function. Section 5 and subsections (where 3.7 was located) are now clearer that this is what they are about.

REVIEWER 2:

- page 31: I agree with R&J that the functions are context dependent. For example, a function of endoplasmic reticulum is to detoxify in liver cell. This is not a general function of endoplasmic reticulum. Such context-sensitivity is unique to functions and is not seen in dispositions.

AUTHORS:
It is not clear that context sensitivity is unique to functions. An unused match sitting on the table has the disposition to ignite, whereas the same match submerged in water may not. We are not sure what hinges on this point though. Concerning artifactual functions, our response to R&J is that the element of context can be accounted for in terms of the history of intentional selection of the chopsticks. The example of the endoplasmic

reticulum is a good one. There is nothing in our view that precludes a given biological structure from having multiple functions, including different functions in different contexts, if the evolutionary story works out that way, as it does in this case.

REVIEWER 2:

- page 34: The author's defense in Section 3.2.1 is plausible, but unnecessary complex, and coincides with R&J, if one defines functions with no reference to disposition.

AUTHOR:

It would be helpful to understand the source of the complexity. We consider (3) options for responding to the situation when we might get by with 2, but other reviewers have insisted we acknowledge all three options and we do now think that this makes our position dialectically stronger. Concerning the second point, yes, that is right, if no reference is made to dispositions or physical structure in the definition of function then our view might correspond with R&J's, but it is precisely the question of whether or not total malfunction is a counter-example to our elucidation that is at issue in this section, so it is a relevant difference.

- page 37: It is very difficult to evaluate the supremacy of BFO choices based on the arguments in this section. Perhaps, if the authors did an empirical validation with their large user base, it might provide a better basis.

AUTHORS: See AUTHORS (4)

AUTHORS: Thank you once again for the comments, criticism, and suggestions.