

# Investigating Functions in BFO from the Viewpoint of Extrinsic Dispositions

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## Abstract

We take initial steps towards a meticulous analysis of functions (including the so-called “use function”) within a recently proposed, unifying dispositional framework for realizable entities in Basic Formal Ontology (BFO). Our approach to function is strikingly characterized by an ontology of “extrinsic dispositions”, which are realizable entities outside the BFO category of disposition. This work helps to articulate multiple possible senses of the term “function” within BFO and to deepen the understanding of the present BFO dispositional theory of function.

## Keywords

function, Basic Formal Ontology (BFO), disposition, role, realizable entity, extrinsic disposition, use function

## 1. Introduction

Function (in its non-mathematical sense) is an entity that is central to a wide range of domains such as biology, engineering, and sociology. Paradigmatic examples of functions include the function of the heart to pump blood and the function of this screwdriver to turn screws. The nature of function nonetheless remains nebulous from an ontological perspective [1][2].

In this short paper we will explore the notion of function in the upper ontology Basic Formal Ontology (BFO) [3][4]. There are some thorny questions concerning the current BFO view that function is a special kind of disposition [5]. A first question is whether, according to BFO’s dispositional account, the function of Mary’s heart is a function to pump blood in *her body* (but not in anybody’s else, even if it is transplanted into another body), or a function to pump blood in any body to which it would be connected? Which BFO category (*inter alia* of realizable entity) do these different senses of “function” correspond to? A second question is the ontological status of the so-called “use function” in BFO, such as the use function of this chair to help to reach for something? We will briefly address such issues by leveraging a recently proposed, unifying dispositional framework for realizable entities in BFO that involves so-called “extrinsic dispositions” [6].

The paper is organized as follows. Section 2 provides preliminaries. Section 3 examines the status of function within this unifying dispositional framework for realizable entities in BFO. Section 4 investigates the notion of the so-called “use function”. Section 5 offers discussion *vis-à-vis* related work. Section 6 concludes the paper with a brief remark on future work.

## 2. Preliminaries

### 2.1. BFO and its dispositional account of function

The BFO upper ontology [3][4] includes the top-level distinction between continuants (which persist over time) and occurrents (which extend through time), the former being further divided into

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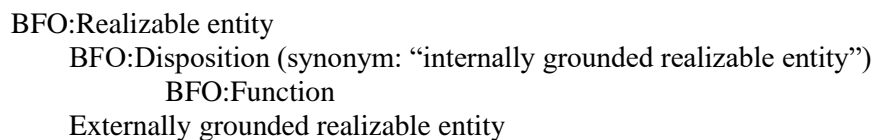
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independent continuants and dependent continuants. As for continuants, a specifically dependent continuant is a dependent continuant that depends (existentially) on at least one independent continuant. A quality is a specifically dependent continuant that does not require any further process in order to be realized (e.g. color, shape, and mass). A realizable entity is a specifically dependent continuant that inheres in some independent continuant and is of a type such that some instances thereof are realized (or activated) in processes of a correlated type. Note that this process of activation or realization is not the same as the process of being brought into existence: for example, the fragility of some mineral can be brought into existence by this mineral being heated and cooled; but it will be realized by this mineral breaking when hit. As for occurrents, a process is an occurrent that exists in time by occurring, has temporal parts, and depends on at least one independent continuant as participant (e.g. the process of blood pumping).

A disposition is: “A realizable entity (...) that exists because of certain features of the physical makeup of the independent continuant that is its bearer” ([3], p. 178). It is also characterized as an “internally grounded realizable entity”: if a disposition ceases to exist, then we can conclude that the physical makeup of the bearer has changed. Exemplars of dispositions include fragility (the disposition to break when pressed with force) and solubility (the disposition to dissolve when put in a solvent).

A function is a disposition of a bearer with a specific kind of historical development [5]. In more detail: “a function is a disposition that exists in virtue of the bearer’s physical make-up, and this physical make-up is something the bearer possesses because of how it came into being — either through natural selection (in the case of biological entities) or through intentional design (in the case of artifacts)” ([3], pp. 102-103). This hierarchy of realizable entities is visualized in Figure 1 (note that a realizable entity is “externally grounded” if and only if it is not internally grounded).



**Figure 1:** A hierarchy of realizable entities in BFO

## 2.2. A unifying dispositional framework for realizable entities in BFO

We will deploy Toyoshima et al.’s [6] unifying dispositional framework for realizable entities in BFO. It is built upon McKittrick’s [7] pragmatic and very broad conception of dispositions (which she calls “dispositional pluralism”) and an enriched theory of dispositions in BFO that has been elaborated in compliance with Röhl & Jansen’s [8] and Barton et al.’s [9] works. The pivotal idea is that multifarious realizable entities (including dispositions in BFO) can be understood as dispositions in McKittrick’s pluralist sense of the term.

Construed as a disposition in this pluralist sense, a realizable entity can be realized in some process and to be realized in a process, a realizable entity needs to be triggered by another process. A realizable entity has some “categorical basis”: roughly, a quality or sum of qualities of the bearer that render(s) the realizable entity causally relevant to its realization. For instance, the fragility of this glass can be realized in a process of glass-breaking, it can be triggered by a process of pressing the glass with sufficient force, and it has as categorical basis some specific molecular structure of the glass: the glass is fragile and can be broken because of the causal import of this molecular structure (for details, see Toyoshima et al.’s [6] discussion on the causal import of realizable entities).

To clarify dispositions in BFO, we will postulate — somewhat, if not perfectly, in Toyoshima et al.’s [6] spirit — that a realizable entity being internally (respectively: externally) grounded amounts to that realizable entity being intrinsic (respectively: extrinsic) (refer to Röhl & Jansen [1] for an alternative interpretation of realizable entities being internally/externally grounded). To be more specific, we will introduce the distinction between “intrinsic dispositions” and “extrinsic dispositions” (where the term “disposition” is used in McKittrick’s pluralist sense) and assume that an intrinsic (respectively: extrinsic) disposition in McKittrick’s terms is synonymous with an internally

(respectively: externally) grounded realizable entity in BFO's terms. Consequently, BFO:dispositions are identical to intrinsic dispositions in our McKittrick-style terminology.

The distinction between intrinsic and extrinsic dispositions is based on the distinction between intrinsic and extrinsic properties. The latter distinction is notoriously difficult to define explicitly, but the basic idea is that a property instance is intrinsic if it inheres in its bearer purely in virtue of the way its bearer is and it is extrinsic if it inheres in its bearer (at least partially) in virtue of the way the world that is external to the bearer is [10]. Paradigmatic examples of intrinsic and extrinsic dispositions include, respectively, the intrinsic disposition  $\mathbf{d}_{in}$  of this key (say  $\mathbf{key}_1$ ) to open any instance of the type  $Lock_2$  and the extrinsic disposition  $\mathbf{d}_{ex}$  of  $\mathbf{key}_1$  to open this particular lock (say  $\mathbf{lock}_2$ ), where  $\mathbf{lock}_2$  is an instance of  $Lock_2$ . From a pluralist point of view,  $\mathbf{d}_{in}$  is intrinsic because  $\mathbf{key}_1$  can open any instance of the type  $Lock_2$  as long as  $\mathbf{key}_1$  does not change intrinsically, while  $\mathbf{d}_{ex}$  is an extrinsic disposition because it is borne in virtue of the existence of  $\mathbf{lock}_2$ , which is external to  $\mathbf{key}_1$  and whose structure might change (in which case  $\mathbf{key}_1$  would not be able to open  $\mathbf{lock}_2$  anymore, and  $\mathbf{d}_{ex}$  would cease to exist). We can also say that  $\mathbf{d}_{in}$  is an "intrinsic dependee" [6] of  $\mathbf{d}_{ex}$ , where an intrinsic dependee is an intrinsic disposition which some extrinsic disposition depends on (technically: "relies on" [6]). Note that any extrinsic disposition has at least one intrinsic dependee.

Finally, we will provide a list of subtypes of categorical basis of realizable entities (see Figure 2). There are two kinds of categorical bases of a realizable entity: the "internal basis" and the "external basis" of this realizable entity. An internal basis inheres in the bearer of the realizable entity, whereas an external basis inheres in some entity that is external to (mereologically speaking: that does not overlap with) the bearer. To illustrate them with an example taken from Barton et al. [11], consider a match that would get burnt if scratched in the presence of oxygen. We can distinguish two closely related, but different realizable entities. First: the realizable entity (say  $\mathbf{rm}_{int}$ ) of this flammable match to get burnt when scratched and surrounded by oxygen. This realizable entity  $\mathbf{rm}_{int}$  would *continue* to exist absent oxygen:  $\mathbf{rm}_{int}$  has as internal basis some quality of the match but it does not have as external basis the concentration of oxygen molecules surrounding the match (more generally, it has no external basis). The presence of oxygen molecules around the match, instead, is part of the *background condition* [8]: roughly, a necessary condition for the realization of the disposition. Second: the realizable entity (say  $\mathbf{rm}_{ext}$ ) of the same match to get burnt when scratched *simpliciter*. This realizable entity  $\mathbf{rm}_{ext}$  would *cease* to exist absent oxygen: indeed, the match cannot get burnt if there is no oxygen, so in such a situation,  $\mathbf{rm}_{ext}$  would not exist. The entity  $\mathbf{rm}_{ext}$  has as internal basis some quality of the match and as external basis the concentration of oxygen molecules surrounding the match. To summarize: when the match is placed in an environment without oxygen,  $\mathbf{rm}_{int}$  exists, but  $\mathbf{rm}_{ext}$  does not exist; and when the match is placed in an environment with oxygen, both  $\mathbf{rm}_{int}$  and  $\mathbf{rm}_{ext}$  exist.

- Categorical basis (which renders the realizable entity causally relevant to its realization)
- Internal basis (which inheres in the bearer)
- External basis (which inheres in something that is external to the bearer)

**Figure 2:** A list of subtypes of categorical basis

### 3. Function in BFO

We begin by considering the realizable entity  $\mathbf{r}_1$  of Mary's heart to pump blood in the human body in general, to wit, in any instance (such as Mary's body) of the type *Human body*. Quite importantly,  $\mathbf{r}_1$  is an intrinsic disposition, as it still exists when Mary's heart is transplanted into another person's body, for example. In addition,  $\mathbf{r}_1$  can be triggered by a process of Mary's heart being physically connected to a human body, it has as internal basis some quality of Mary's heart, and it has no external basis. We can plausibly take  $\mathbf{r}_1$  to be a function in BFO: it is the function of Mary's heart to pump blood *in the human body* (whether in Mary's body or in another person's).

One can identify two realizable entities that are different from but closely related with  $\mathbf{r}_1$ , and that are both realized by the heart pumping blood in *Mary's* body (but not in anyone's body). The first one,  $\mathbf{r}_2$ , is analogous with  $\mathbf{rm}_{int}$ . It is the realizable entity of the heart pumping blood in Mary's body when it is connected to Mary's body. This realizable entity always exists when the heart exists — even when,

for example, the heart is placed outside Mary’s body during some cardiac surgery. The second one,  $r_3$ , is analogous with  $rm_{ext}$ . It is the realizable entity of the heart pumping blood in Mary’s body *simpliciter* (that is, it does not need any special trigger to be realized — or said differently, it is constantly triggered). This realizable entity would cease to exist absent the physical connection of Mary’s heart with her body. As distinct from  $r_1$  and  $r_2$ ,  $r_3$  is an extrinsic disposition because it is borne in virtue of the existence of this particular human body (namely Mary’s body — to be precise, parts of her body) which is external to Mary’s heart. For that matter,  $r_3$  has as external basis the connection between Mary’s body and her heart (by which we mean a quality that is external to Mary’s heart and ensures that it is connected to Mary’s body). When Mary’s heart is physically connected to another person’s, then it is  $r_1$ , but neither  $r_2$  nor  $r_3$ , that can be realized in a process of Mary’s heart pumping blood in that person’s body. We can think of  $r_2$  and  $r_3$  as functions of Mary’s heart to pump blood in Mary’s body only. The entity  $r_2$  is an intrinsic disposition and can thus be considered as a BFO:function. But  $r_3$  is not a BFO:disposition, as it is not an intrinsic disposition, and thus *a fortiori* it is not a function in BFO, where BFO:function is a subtype of BFO:disposition (see Section 5 for discussion about whether  $r_3$  — as well as another similar realizable entity to appear below — constitutes a counterexample to the current BFO dispositional account of function).<sup>2</sup> Differences among three realizable entities  $r_1$ ,  $r_2$  and  $r_3$  are shown in Table 1.

**Table 1**  
Differences among realizable entities  $r_1$ ,  $r_2$ , and  $r_3$

	intrinsic or extrinsic disposition	external basis	trigger / background condition	realization
$r_1$	intrinsic disposition	none	the heart being connected to a person’s body	pumping blood in this person’s body
$r_2$	intrinsic disposition	none	the heart being connected to Mary’s body	pumping blood in Mary’s body
$r_3$	extrinsic disposition	the connection between Mary’s body and her heart	any process	pumping blood for Mary’s body

#### 4. What is “use function”?

We move onto the notion of use function, as it remains largely unexplored in the BFO context (which we will touch on in Section 5). The basic idea is that a use function is a function that is ascribed to something in virtue of an intentional agent’s usage of that thing for her use purpose. Use functions are usually reckoned to be borne by (technical) artifacts [12]: e.g. the use function of this chair to help to reach for something. But non-artifacts can also have use functions: e.g. the use function of my nose to hold glasses and the use function of this pair of sticks in the woods to help eating. (We remark as an aside that non-artifacts with use functions may be sometimes called “naturefacts” [13].)

To investigate use function, we will employ the following driving scenario. At time  $t_0$ , Sam sees a pair of sticks in the woods. At time  $t_1$ , she forms the intention to use this pair of sticks (say  $ps_1$ ) to help her eating. At time  $t_2$ , she actually uses  $ps_1$  to help her eating. We take it for granted that Sam is an intentional agent, that she did not know about the existence of  $ps_1$  before  $t_0$ , that nobody else finds  $ps_1$  in the woods or intends to use  $ps_1$  to help eating.

First of all, consider  $ps_1$  at time  $t_0$ . Since use function is in nature allied with an agent’s intentional usage,  $ps_1$  has no use function at this time because there is no intention to use  $ps_1$  to help eating. However, we can think of at least one realizable entity that is borne by  $ps_1$  at time  $t_0$  (as well as later) and that is related to the use function of  $ps_1$  to help Sam’s eating, as this use function comes into being later than time  $t_0$ . It is the realizable entity  $rs_1$  of  $ps_1$  to move objects when manipulated in a certain way

<sup>2</sup> We can consider the relationship between the two functions  $r_1$  and  $r_2$  from the perspective of their etiological element, although the etiological aspect of BFO:functions goes beyond the scope of our investigation. We are assuming that both  $r_1$  and  $r_2$  are functions because their bearer (namely the heart) come into being through natural selection, based on the idea that a heart is “built” (for lack of a better term) to help an organism to maintain homeostasis and controlled exchanges with the outside world for this organism. Under this assumption,  $r_1$  and  $r_2$  may emerge at the same time. But suppose, for the sake of argument, that we could “grow” a heart out of stem cells without planning that it would pump blood in a given individual. In this thought-experimental scenario, this “growing heart” comes into being through intentional design and thus the disposition  $r_1$  would be indeed a function (namely a function to pump blood in any human’s body); whereas the disposition to pump blood in Mary’s body  $r_2$ , which comes into existence at the same time as  $r_1$ , becomes a function to pump blood in Mary’s body at a later time, when the heart is redesigned to be transplanted into Mary’s body.

(namely, the way we usually use a pair of sticks). Notably, **rs<sub>1</sub>** is an intrinsic disposition, as it exists even before Sam sees **ps<sub>1</sub>** in the woods. Additionally, **rs<sub>1</sub>** can be triggered by a process of **ps<sub>1</sub>** being moved in a certain way, it has as internal basis some quality of **ps<sub>1</sub>**, and it has no external basis.

Consider next **ps<sub>1</sub>** at time  $t_1$ , where Sam intends to use **ps<sub>1</sub>** to help her eating without actually using it for that use purpose. According to a first, broad understanding of use function, merely intending to use something for the user’s use purpose (even without actually using it) suffices to attribute to that thing the associated use function. Thus, at time  $t_1$  (and later), **ps<sub>1</sub>** has the broad use function to help Sam’s eating. We can characterize this use function as the realizable entity **rs<sub>2</sub>** of **ps<sub>1</sub>** to help Sam’s eating such that **rs<sub>2</sub>** can be realized in a process of **ps<sub>1</sub>** bringing food into Sam’s mouth and it can be triggered by a process of **ps<sub>1</sub>** being moved in a certain way.

Unlike **rs<sub>1</sub>**, **rs<sub>2</sub>** is an extrinsic disposition because it is borne in virtue of the existence of Sam’s intention, which is external to **ps<sub>1</sub>**, such that **rs<sub>1</sub>** is an intrinsic dependee of **rs<sub>2</sub>**: intuitively, **ps<sub>1</sub>** can bring food into Sam’s mouth because of its capability to move something. In addition, **rs<sub>2</sub>** has some external basis because it owes its existence partly to Sam’s intention to use **ps<sub>1</sub>** to help her eating. One way of analyzing this external basis of **rs<sub>2</sub>** is to assume, following Toyoshima et al. [14], that intention is roughly a disposition (in the pluralist sense) to actions that emerges from the complex interactions among various beliefs and desires. Given this dispositional account of intention, we can think that the external basis of **rs<sub>2</sub>** is the internal basis of Sam’s intention to use something to help her eating. Differences between **rs<sub>1</sub>** and **rs<sub>2</sub>** are shown in Table 2.

We will finally consider **ps<sub>1</sub>** at time  $t_2$ , where Sam actually uses **ps<sub>1</sub>** to help her eating. According to a second, narrow understanding of use function, it is not enough to merely intend to use something for a use function to come into being: a thing has a use function (in the narrow sense) only when the user *actually* uses that thing for her use purpose. Thus, at time  $t_2$  (but not earlier), **ps<sub>1</sub>** has the narrow use function to help Sam’s eating. One simple way to formalize this use function is to think of it as “**rs<sub>2</sub>** when Sam actually uses **ps<sub>1</sub>** to help her eating”, based on the idea that a broad use function becomes also a narrow use function when the user actually uses the thing for her use purpose. That is to say, **rs<sub>2</sub>** is an instance of the type *Broad use function* between  $t_1$  and  $t_2$ , and becomes also an instance of the type *Narrow use function* at time  $t_2$ .<sup>3</sup>

**Table 2**  
Differences between realizable entities **rs<sub>1</sub>** and **rs<sub>2</sub>**

	intrinsic or extrinsic disposition	external basis	trigger/background condition	realization
<b>rs<sub>1</sub></b>	intrinsic disposition	none	<b>ps<sub>1</sub></b> being manipulated in a certain way	<b>ps<sub>1</sub></b> moving a thing
<b>rs<sub>2</sub></b>	extrinsic disposition	the categorical basis of Sam’s intention to use <b>ps<sub>1</sub></b> to help her eating	<b>ps<sub>1</sub></b> being manipulated in a certain way	<b>ps<sub>1</sub></b> bringing food into Sam’s mouth

## 5. Discussion and related work

We will provide discussion by focusing on realizable entities **r<sub>3</sub>** and **rs<sub>2</sub>**, as they are not BFO:functions but may be seen as functions in their substantive sense. To consider their status in BFO more carefully, we introduce the BFO category of role: “a realizable entity that (1) exists because the bearer is in some special physical, social, or institutional set of circumstances in which the bearer does not have to be (optionality), and (2) is not such that, if this realizable entity ceases to exist, then the physical make-up of the bearer is thereby changed (external grounding)” ([3], pp. 99-100). Therefore, a role amounts to an optional and externally grounded realizable entity. Examples of roles include the role of being a student and the role of this heart to being a plastinated prop in a museum display.

<sup>3</sup> Note that this raises the issue of when a realizable entity gets and stops having a broad use function. If Sam uses the stick to bring some food in her mouth, and then stops using them for a few seconds in order to chew her food, do the sticks stop having a broad use function during that time? That is, during that time, **rs<sub>2</sub>** would still be an instance of *Narrow use function*, but would not be an instance of *Broad use function*? (we thank an anonymous reviewer for this remark). This conclusion might be avoided by endorsing a definition of “use” that has a large enough temporal window (Sam “uses” the sticks during her whole meal, even when she is only chewing her food). Alternatively, if one is uncomfortable with this back and forth into instantiating *Broad use function*, this might be an argument in favor of sticking to narrow use functions only, as **rs<sub>2</sub>** remains an instance of *Narrow use function* even when Sam stops temporarily using the sticks to chew her food (since she intends to use them to bring food to her mouth again).

Since we equate the type *Externally grounded realizable entity* with the type *Extrinsic disposition*, if  $r_3$  is optional, then it is a role in BFO (and similarly so for  $rs_2$ ). Although the BFO notion of optionality remains to be defined precisely, we can think that use functions are roles in BFO: for instance,  $ps_1$  has  $rs_2$  merely because it finds itself in the situation in which Sam intends to use it to help her eating (and thus  $rs_2$  is optional). As a matter of fact, Spear et al. [5] and Röhl & Jansen [1] submit that use function is a role in BFO. Besides, “the role of a stone in marking a boundary” is cited as an example of a role in BFO ([3], p. 100) and this role can be taken as a use function.

Let us now turn to  $r_3$ : is  $r_3$  optional (and thus a role in BFO) or non-optional? To tackle this question, it will be useful to examine the optionality of  $rs_2$ . Given the BFO sense of optionality (refer to Röhl & Jansen [1] for an alternative interpretation of optionality), it means that  $rs_2$  exists in virtue of the circumstances in which  $ps_1$  does not have to be: those in which Sam intends to use  $ps_1$  to help her eating. In other words,  $rs_2$  owes its existence partly to the *external* fact that Sam intends to use  $ps_1$  to help her eating. This may turn out to be equivalent to the statement that  $rs_2$  has as *external* basis the internal basis of Sam’s intention to use something to help her eating. This line of reasoning can yield the general hypothesis that a realizable entity is optional if (or perhaps more strongly: if and only if) it has some external basis. Given this hypothesis,  $r_3$  is optional (and is a role in BFO).

As for  $r_2$ , it is a BFO:disposition and thus might be seen as a function (as it arguably satisfies the etiological requirement of a BFO:function). It is thus important, when introducing a BFO:function, to clarify whether one has in mind an entity like  $r_1$  or  $r_2$ .

## 6. Conclusion

We analyzed the notion of function within a recently proposed, unifying dispositional framework for realizable entities in the BFO upper ontology. We distinguished different closely related entities falling into BFO:function ( $r_1$  and  $r_2$ ) and argued that when introducing a BFO:function, one needs to clarify which of those is referred to. We also argued that there can be some realizable entities ( $r_3$  and  $rs_2$ ) that we may think of as functions but that fall outside the purview of the current BFO dispositional account of function because they can be characterized as extrinsic dispositions. We also contended that use functions can be generally formalized as extrinsic dispositions.

In the future we will further this line of inquiry into a BFO-based ontology of function. Examples of the tasks to be grappled with include a meticulous analysis of the etiological element of the BFO notion of function and a more sophisticated clarification of the BFO notion of optionality (especially in connection with the external basis of a realizable entity, as we briefly discussed in Section 5). It is also worthwhile to formulate and compare possible views with different implications for the present BFO theory of function. One prominent view is the “revisionary view”, which would both expand the extent of *Function* in BFO to cover such realizable entities as  $r_3$  and/or  $rs_2$  (for thoughts, see Artiga’s [15] remark on “a pluralist view on functions” that is compatible with BFO<sup>4</sup> and his claim that a satisfactory theory of function should capture “the distinction between *having a function* and *functioning as*” — chairs for sitting and chairs for helping to reach for something, to borrow one of his illustrative examples — the latter being intimately related to use function). Another major view is the “conservative view”, which would keep the same extent for *Function* in BFO by explaining why some entities are commonly called “functions”, although they are not BFO:functions (for this line of reasoning, see Spear et al.’s [5] and Röhl & Jansen’s [1] opinion that the BFO theory of function does not need to cover use function). Finally, by advancing our approach to function, we plan to examine a long-standing controversy over whether the current BFO dispositional account of function can account for malfunctioning [1][2][5].<sup>5</sup>

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<sup>4</sup> Artiga [15] (p.98) states: “Spear and colleagues [by which he means Spear et al. [5]] admit that their proposal is not supposed to exhaust all possible categories that should be included in the taxonomy, so if different accounts turn out to capture different senses of function, further branches could be added to it (...). Thus, in principle BFO is fully compatible with a pluralist view on functions. For instance BFO could include a *Function*<sub>1</sub> category at the same level of *Disposition* and *Role* and a *Function*<sub>2</sub> category as a subtype of *Disposition*. Obviously, that option would be less parsimonious, but it might be in position to accommodate more cases. In any case, it seems to be an alternative worth considering.”

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