NEW PERSPECTIVES ON ARTIFACTUAL AND BIOLOGICAL FUNCTIONS

Marc Artiga
Universitat de Barcelona & LOGOS
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Abstract

In this essay I introduce the question of artifactual functions in the context of the recent debate on the notion of function. I discuss some of the desiderata a satisfactory account should fulfill and compare them to the desiderata for a theory of biological functions. Finally, within this general framework, I briefly present the three papers included in this volume.

0. Introduction

The notion of function pervades our daily life. We claim that the function of the pancreas is to secrete insulin, that the function of traffic lights is to avoid car crashes and that a function of demonstrations is to express support or opposition to a particular policy. We also routinely employ a range of expressions closely tied to functions. For instance, when we claim that the pancreas is supposed to secrete insulin, that traffic lights are designed to avoid car crashes or that the purpose of a demonstration is to manifest a political view.

Nevertheless, despite the ubiquity of functional talk, functions are puzzling entities. For one thing, an entity can have a function and fail to perform it. Thus, we claim that a main cause of diabetes is a dysfunctional pancreas, that during a blackout traffic lights do not work properly or that too often demonstrations fail to achieve their purposes. These items have functions but, for some reason, sometimes fail to carry them out. For another thing, it is often unclear what process endows items with functions. Is it always the same process or are there different ways of acquiring them? What are their essential features? These are still hotly disputed issues in the philosophical arena.

For these and other reasons, providing a general theory of functions turns out to be a herculean task. The main goal of this introductory essay is to highlight some of the central issues a theory of function should address, with special emphasis on a topic that has been largely overlooked in the literature, but that some recent papers (including the excellent essays included in this volume) are drawing attention to: the nature of artifactual functions.

Accordingly, the paper has three main sections. I first introduce the question of artifactual functions in the context of the recent debate on the notion of function. Then, I will discuss some of the desiderata a satisfactory account should comply with and, finally, within this general framework, I will briefly present the three papers included in this volume.

1. Biological and Artifactual Functions

As some have already pointed out, functions are mostly attributed to three kinds of entities: biological traits, artifacts[1] and social entities (Krohs and Kroes, 2009). The function of the

1 I will not attempt to define 'artifact'. This a disputed question and a detalled analysis would lead us far away from our present concern. For a clear and accessible introduction, see Hilpinen (2011).

gallbladder is to store bile, the function of the fridge is to preserve food and the function of *fumata blanca* is to indicate the election of a new Pope. It is worth mentioning, however, that so far most philosophical research on the nature of functions and functional talk has focused on biological items. This is rather surprising, given the central role that technology plays in contemporary (Western) societies.[2] Many reasons might contribute to explain the little attention that has been payed to artifactual functions, but three of them seem to be specially important.

The first historical reason for this neglect is the lack of a philosophical literature on the ontology and epistemology of artifacts in general. Moreover, those branches that are mainly supposed to address artifacts (aesthetics and philosophy of technology) have historically focused on moral, aesthetic or social values, rather than ontological questions (Preston, 2009). This situation contrasts with the growth of philosophy of biology in the 70s and the 80s, precisely at the time in which the modern debate on the notion of function originated.

Secondly, the idea that artifactual functions were easier to account for has been a common idea for a long time (see Wright, 1973, p. 142). The motivation for that thought can be traced back to the origin of the discussion on functions. In the early days of philosophy, it was taken for granted that biological as well as the artifactual objects were goal-directed. Teleology was a central element in Aristotelian metaphysics and in the theistic tradition, and the classical way of explaining the origin of functions appealed to an intelligent designer. Since the Enlightenment, however, and once the mechanistic way of thinking replaced the Aristotelian tradition, the idea that natural entities have purposes or goals was regarded with suspicion (Perlman, 2004). In contrast, the idea of an intelligent designer seems to fit nicely with an account of artifactual functions. What an artifacts is supposed to do seems to depend on the intentional states of agents designing or using them. As a result, the 'hard problem of function' was thought to lie in biology.

Last but not least, the biological notion of function has played a fundamental role in naturalistic projects in philosophy of mind, especially in teleological theories of mental content (Millikan, 1984; Papineau, 1987; Neander, 1995; Perlman, 2004). The main goal of these theories is to naturalize intentionality, that is, to specify the conditions that must be met for an entity to represent another entity by appealing to non-intentional and scientifically respectable features such as causation, information or function. Crucially, the notion of function could be employed in a naturalistic project only if it does not presuppose intentionality. If functions depended on the intentions, beliefs or desires of agents, then it will not be possible to use them in order to naturalize intentionality without circularity. Thus, given the widespread idea that artifactual functions depend on the intentions of agents while biological functions do not, those interested in developing teleological theories of mental content developed some of the most sophisticated theories of functions (e.g. Millikan, 1984, Price, 1998).

But times are changing. The last decade has witnessed a significant increase in research on artifactual functions. The philosophy of technology is a growing field and traditional disciplines such as metaphysics, epistemology or philosophy of mind are turning their attention to artifacts (see Clark and Chalmers, 1998; Margolis and Laurence 2007; Hilpinen, 2011; Krohs and Kroes, 2009). Furthermore, artifactual functions are no longer thought to be unproblematic. A crucial landmark in establishing this idea was the paper by Vermaas and Houkes (2003), in which they showed that mainstream etiological accounts of function were not easily applicable to artifacts. Finally, the development of novel theories of function is also opening the door to new naturalistic approaches to intentionality (e.g. Abrams, 2005; Nanay, 2013, 2014). After a long period of neglect, artifacts are slowly but progressively moving to center of the stage.

2 I leave aside the question of whether social entities can legitimately be said to have functions and how best to conceptualize them, although I am convinced there are important lessons to be learned from them.

Nonetheless, shifting the attention from biological to artifactual functions raises a set of challenges that we are only starting to discover. There are of course remarkable similarities between artifacts and organisms. In the modern age, human-made machines served as models for understanding organisms and natural structures and processes are still used as models for machines (think, for instance, about bioarchitecture). Indeed, there are some cases that lie between the two, such as plants and animals that have been domesticated and cultivated for a long time (Longy, 2009). However, the disanalogies between the biological and artifactual domains are also striking. A careful analysis of these differences and the peculiarities of each of these ambits is required to avoid imposing an exogenous and inadequate model onto the artifactual world.

The first and most obvious dissimilarity between biological and artifactual functions concerns their relation to intentional agents. Whereas most people believe that biological functions are ontologically independent of human intentionality, artifactual functions seem to hang upon the propositional attitudes of the agents producing, designing or using them (cf. Fraansen, 2009; Searle, 1995). It seems that it does not make sense to talk about artifactual function if no agent has designed or manipulated the object (see the papers in this volume). Accordingly, a compelling theory of artifactual functions should accommodate this fact and anlayze what kinds of propositional attitudes are linked to functionality.

A related disanalogy concerns novel artifacts. In biology, functional traits are to a great extent reproductions of previous items of the same type. Obama's heart is an (imperfect) copy of his parents', the hearts of his parents are copies of the hearts of his grandparents, and so on. Relying on this idea, many hold that a trait acquires a function only after a long process of reproduction and selection (see below). This suggestion entails that new traits lack functions until a sufficient time has passed for selection to occur. However, while this idea might seem plausible for biological entities and even for some artifacts, it is clearly inadequate as a general account of artifactual functions. New (and unique) objects can surely be said to have functions: the first telephone already had the function of transmitting sounds and it was not a reproduction of previous telephones and the 25 de Abril Bridge has the function of connecting Lisboa and Almada without it being a copy of any bridge linking these two cities. This is one of the most important disanalogies that has provoked a revision of biologically-centered accounts of function.

A third difference is that biological functions are usually attributed to traits, and only rarely to whole organisms (Krohs and Kroes, 2009). Asking for the function of sparrows sounds somehow odd in a way in which asking for the function of the sparrow's beak does not. But note that whole artifacts are routinely said to have functions: the function of the hammer is to nail and the function of the thermostat is to keep room temperature within a certain range. There are of course some ways of going around this problem: one might suggest, for instance, that organisms can be said to have functions when considered as parts of larger systems (e.g. ecosystems). Nonetheless, this is a significant difference that artifactual theories of function need to take into account.

Other disanalogies are illustrated by means of examples. For instance, Kroes and Krohs (2009) argue that most accounts have focused on ordinary artifacts, such as hammers or heaters, but many contemporary functional objects, such as airbuses, atomic-force microscopes or modern computers require a much higher level of complexity and sophistication. It is not obvious that an account that works well for the former should straightforwardly accommodate the latter. At the other extreme lie 'naturefacts', which are natural objects which humans have not created but which we use for certain purposes (Oswalt, 1973; Hilpinen, 2011). A naturefact is, for instance, a piece of wood exhibited in a museum or a seashell that is used as a musical instrument; although they have not been created by humans, they seem to possess functions. Other problematic cases involve what Preston (2009) calls

'phantom functions': artifacts that are regularly reproduced for a certain function, but which never have been structurally capable of performing it. Some amulets, for instance, are supposed to protect their bearer against the 'evil eye'. Assuming that there is not such a thing, that would be a function that traits have never been able to perform. Note that it is dubious that phantom functions can be attributed to biological traits; ovaries can have the function to F only if some (past or current) ovaries actually perform (or performed) F. Any theory of functions that intends to be extensionally adequate will have to accommodate these and other examples.

Therefore, one should not uncritically assume that a theory that works well in one domain should also gives the right results in the other. Even more, one should not even take for granted that the desiderata for a theory of artifactual functions run parallel to the desiderata for a theory of biological functions. This is the question I will examine in the next section.

2. Desiderata

There are already various essays discussing the criteria that should be used in order to assess theories of functions (see, for instance, Wouters, 2005; Röhl and Jansen, 2014; Houkes and Vermaas, 2010; Preston, 2009). In Artiga (2011) I also provided a core set of desiderata, in the context of a discussion on organizational theories of function. Since all the papers in this volume discuss or mention them, I would like briefly review them in the context of the preceding discussion. Note that organizational theories have been mainly applied to biological traits (although they aim at providing a unifying theory of function; see Mossio et al, 2009; Saborido et al, 2011; Artiga and Martinez, forthcoming), so the desiderata I provided especially focused on biology. Accordingly, it might be interesting to see whether they also provide plausible criteria for a satisfactory theory of artifactual functions.

The first desideratum derives from one of the key properties of functions mentioned earlier:

> **(NORMATIVITY)** An item's function determines a criterion against which the activity of the item is normatively evaluated. (Wouters, 2005, pp. 133–134; Krohs & Kroes, 2009; Mossio et al., 2009, p. 814.)

The function of a device is an effect that it is *supposed to* have. Hearts are supposed to pump blood and calculators are supposed to perform mathematical operations. If they fail to have these effects, then we say that they *mal*function, are *dys*functional or fail to work properly. This is probably one of the most important criteria for functional attributions, and also the one that has received most attention (Davies, 2000; Fraansen, 2009).

Failing to perform a function should be clearly distinguished from not having it. This is a key distinction because an item can malfunction only if it possesses a function. Kidneys can be dysfunctional because they have functions, whereas whirlpools cannot because they lack them. Any theory unable to draw the distinction between malfunctioning and not having a function will fail to capture this essential aspect of purposes.

The second desideratum concerns the distinction between essential and accidental effects:

> **(ACCIDENTAL)** An item's function is appropriately distinguished from its accidental effects (Wright, 1973; Wouters, 2005, p. 134).

Some examples will help to clarify the point: an essential effect of fingers is to enable us to grasp objects with some precision, while one of its accidental effects is to carry rings. Similarly, an

essential effect of light bulbs is to produce light, while an accidental effect is to produce heat. As it is usually understood, what lies behind this criterion just is the distinction between functions and non-functional effects; essential effects are functions whereas accidental effects are not. Thus, in a sense, this desideratum simply suggests that a theory should be extensionally adequate: it has to a appropriately distinguish those effects that intuitively are functions from those that are not.

There is a related distinction that a fully satisfying proposal should also accommodate. It seems that, among functions, we also frequently distinguish those that are essential (or, at least, more central) from those that are not. Chairs are for sitting, but one can also stand on them to reach for something. Cups are for drinking, but they can also function as pencil cups. Among the various functions an item may have, some of them seem to be more important than others. One way of capturing this idea is in terms of the distinction between *having a function* and *functioning as.* And, again, even though this distinction is also likely to make sense in a biological context, artifacts provide much clearer examples.

The next desideratum, which might be called 'TELEOLOGY', provides an additional reason for adequately telling apart functions from other non-essential effects:

> **(TELEOLOGY)** An item's function plays an important role in explaining its existence (Nagel, 1977, p. 291; McLaughlin, 2001, p. 168; Mossio et al., 2009).

Many think that functions play a very important explanatory role: they are effects that contribute to explain the existence of an item. The fact that hearts pumped blood in the evolutionary past helps to explain why nowadays organisms tend to have hearts. Note that this is distinctive property that is not shared by non-functional effects: making thump-thump noises is an effect of hearts, but it is not one of their functions partly because it does not contribute to explain why they exist. This is also the property of function that has motivated the most popular approach: etiological accounts (see below). As a result, those who sympathize less with this approach have tended to reject this desideratum (e.g. Johansson et al. 2005, p.163). So it is status is also disputed.

Now, should TELEOLOGY count as a desideratum for artifacts? Interestingly, in most cases artifacts clearly satisfy this condition. Indeed, they often provide better examples than biological traits. The reason saws exist, for instance, is clearly tied to their function. We needed an object for cutting wood, so we invented one. Saws owe their existence and structure to the effects they were intended to produce.

However, the hardest cases are also among artifacts. Think about naturefacts, that is, natural objects that have not been created by humans but which might acquire functions. If a stone with a convex whole is used as a mortar, it seems it has a function, even if this effect does not explain why it exists: neither its presence nor its form can be explained by appealing to its function. Thus, although TELEOLOGY seems to be a property of function ascriptions for many artifacts, some difficult cases remain.

Finally, the fourth desideratum considered in Artiga (2011) is EPIPHENOMENALISM:

> **(EPIPHENOMENALISM)** The item's function is determined by an item's current performances (Cummins, 1975, p. 756; Christensen & Bickhard, 2002; Mossio et al., 2009).

This condition is trying to capture the intuition that whether a trait has a function seems to depend on its actual effects or dispositions. It is sometimes overlooked, however, that there are different ways of interpreting EPIPHENOMENALISM. First, it might be understood as referring to tokens, the idea

being that the function of Merkel's hypothalamus, for example, depends on what it does or is able to do in her brain. In contrast, it does not depend on the contribution that hypothalami generally make to brains, nor on whether it used to have any effect on our ancestors in the Pleistocene. Intepreted in this way, however, this is an overly restrictive requirement (Nanay, 2010; Artiga, 2014). Any theory that assumes a trait's function depends on the type it belongs to would fail to satisfy it.

Alternatively, one can also interpret this desideratum in terms of types. On this reading, the function of an item depends on what *items of the same type currently* do or are able to do. At least for biological traits, many understand the desideratum in that way. Neuroscience, for instance, might provide evidence for that claim; when scientists investigate the function of a certain brain structure, they seem to test what it does or can do in current brains of the same type. Other facts such as its evolutionary history are not obviously relevant (cf. Neander, forthcoming).

Now, should EPIPHENOMENALISM be also considered a desideratum for artifacts? Prima facie, it is not obvious why the answer to that question should differ from the answer given in the context of biological entities. Interestingly, however, in this debate many substitute EPIPHENOMENALISM. for a related condition, which is sometimes labeled 'SUPPORT'. This desideratum holds that 'a theory of artifacts should require that there exists a measure of support for ascribing a function to an artifact, even if the artifact is dysfunctional or if it has a function only transiently' (Houkes and Vermaas , 2010, p.5; Röhl and Jansen, 2014). In a nutshell, the idea is that we can only ascribe the function F to a device if its physical make-up could support such a function. Tea bags cannot have the function of digging holes and coffee machines cannot have the function of flying.

However, I doubt that SUPPORT should actually count as a desideratum for a theory of artifactual functions. The main difficulty concerns the notion of 'support', which is not only too unspecific, but also probably unspecifiable. For instance, the function of an amulet is to bring luck, but it is unclear what would be for an object to support this function. Likewise, in many cultures animal sacrifices have the function of pleasing gods, but we don't know what would be required for an object to support this effect. In general, it is mysterious what kinds of physical properties could support many of these functions and, even if we knew it, these items would probably lack them. Less extreme cases can also be pointed out. If one thinks about the function of the Bible, or the Communist Manifesto, the connection between the structural properties of the object (either an abstract entity or an object made out of ink and paper) and their function seems to be hard to spell out. That suggests there is probably no general way of specifying the relation between support and function, in a such way that it can deliver a substantive and plausible requirement.

Finally, whereas I doubt that SUPPORT should count as a desideratum for a theory of artifactual functions, Houkes and Vermaas (2003, p. 266) also add an extremely plausible criterion:

> **(NOVELTY)** A theory of functions should accept an ascription of proper functions to innovative or atypical artifacts.

As we saw, one of the distinctive properties of artifacts is that recently invented or unique objects can have functions. For this reason, NOVELTY seems to be a plausible desideratum for artifactual functions. In contrast, it is much less clear it should also work for biological entities (cf. Röhl and Jansen, 2014).

Summing up, these are some of the desiderata that a satisfactory theory of functions should comply with.[3] This short discussion also helps to illustrate that in the same way that it is an open question

3 Let me clarify that the acceptance or rejection of these desiderata should depend on the properties that functions actually possess (so they are supposed to rely on metaphysics, rather than epistemology-- cf. Spear et al., this volume).

whether an account that works for biological functions should also straightforwardly apply to artifactual functions, one should not take for granted that the desiderata for a theory of biological and artifactual functions must coincide. Some of these requirements are more plausible for biological traits (e.g. TELEOLOGY) while others apply more clearly to artifacts (e.g. NOVELTY). Additionally, there are others which might be interpreted differently depending on whether we are assessing biological traits or artifacts. That result supports the idea that we are addressing a phenomenon that is more complex than it is usualy assumed.

Is there any theory in position to satisfy all these desiderata? Extant approaches are usually classified into two broad families: etiological and systemic (or dispositional) theories.[4] According to the etiological approach, an item x has the function to F iff F explains why x exist (Ayala, 1970; Wright, 1973; Millikan, 1989). In biology, this explanatory relation is usually cashed out in terms of natural selection: the etiological function of a trait is to F iff past traits of the same type were selected for F. For instance, the function of the kidney is to filter wastes from blood because kidneys were selected for this task. As we saw, etiological theories are inspired by TELEOLOGY, so it is not surprising that that they can satisfy it. Similarly, they can also fulfill NORMATIVITY and ACCIDENTAL, but they have problems with EPIPHENOMANALISM (Artiga, 2011). According to etiological theories an item's function is not determined by what it (or items of the same type) are currently able to do, but by the history of selection. Thus, on this approach whether actual traits do or are able to F is irrelevant for attributing a function to them.

The alternative broad family is usually labeled 'systemic' or 'dispositional' accounts (Cummins, 1975). These theories stress the role that function ascriptions play in functional analysis, in which a system is decomposed into several parts. Roughly, the function of a particular element of the system (with respect to a certain functional analysis) is the contribution that it makes to this activity of the system it participates in. On this view the function of the kidney is to filter wastes from blood because it (or, on some theories, because current traits of the same type) contribute to the system by filtering wastes. Hence, these accounts seem to clearly satisfy EPIPHENOMENALISM, but have difficulties accommodating the other three desiderata (as argued in the essay by Spear and colleagues and Artiga, 2011).

The fact that neither of these approaches is in position to fulfill all requirements for a satisfactory theory of functions has generated a sort of stalemate. As a consequence, many endorse a pluralist view, according to which both etiological and systemic theories can give rise to functions. This is what Godfrey-Smith (1993) labeled a 'consensus without unity' (see also Preston, 1998). That does not mean, of course, that the quest for a unifying theory has been abandoned. There are indeed different ways this unification could be accomplished. Carrara et al. (2011) distinguish two strategies:[5] The *revisionary strategy* provides a new definition of function that seeks to replace some of the current notions. An *overarching strategy* does not reject any of the current proposals and tries instead to describe an umbrella concept that could encompass all of them. To these to models, we could add a third category: a *defiant strategy*, which seeks to argue that one of the extant accounts (perhaps with some slight modifications) is superior to the available alternatives. Interestingly, it seems that the papers included in this volume nicely illustrate each of these strategies. Let us now turn to them.

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4 The distinction between two broad families is of course a simplifcation of the debate. There are many approaches that are hard to accommodate within these two paradigms, such as the Propensity Theory (Bigelow and Pargatter, 1987), the Organizational Theory (Mossio et al. 2009) or the Modal Theory (Nanay, 2010). Indeed, even within these broad families, there are significant differences (e.g. Godfrey-Smith, 1994; Buller, 1998).

5 They distinguish these two unificationist projects from what they call a 'descriptive strategy', which merely seeks to formalize the main notions available.

3. Essays

This volume includes three papers that share important features. All of them seek to provide an unifying theory of function for biological traits and artifacts. That makes these projects much more interesting and ambitious, but also more difficult. As argued above, the desiderata for a theory of biological functions might not coincide with the desiderata for a theory of artifactual functions. Indeed, even if we focus on one of these domains, it might actually be impossible for a single theory to satisfy all of them at the same time. All three papers seek to challenge this pessimistic idea.

A second aspect that these three essays have in common is that they should be understood in the context of larger research projects that their authors have been developing over the years (see, for instance, Arp et al., 2015; Mizoguchi et al. 2012; Kitamura et al. 2006; Herre et al. 2006, Burek et al. 2015). These general frameworks are explained very clearly by the authors in the first sections of their papers, so I will not attempt to add anything substantial in that respect.

Finally, all of them are concerned with function modeling (Erden et al. 2008). Probably because of this focus on the formalization of functions, some of their most insightful ideas have to do with the precise definitions they provide and the way they are interwoven. Unfortunately, these interesting details cannot be discussed in detail in this introduction for obvious reasons, so I will simply present the papers and try to connect some of their main ideas to the current debate on functions.

The paper by Spear, Ceusters and Smith follows a revisionary strategy (in the sense outlined above), since it provides an original perspective which combines features of etiological and dispositional accounts. They work within the framework of the Basic Formal Ontology, which is a top-level ontology. The chief goal of top-level ontologies is to provide a taxonomy of the most general types of entities and relations in order to facilitate the integration of data from different scientific domains, so it is very important to use as few categories as possible. In that respect, the function category seems to be specially difficult to categorize for reasons that should be obvious by now. In versions up to 1.1.1. of the Basic Formal Ontology, *Disposition, Role* and *Function* were pairwise children of the category *Realizable* (Arp and Smith, 2008). In BFO 2.0, however, function appears as a specific kind of *Disposition*. One of the main purposes of their paper is precisely to argue that functions should be considered dispositions.

In this new version of the framework, F is a function iff (1) F is a disposition, (2) F exists in virtue of the physical make-up of the bearer and (3) this physical make-up is something the bearer possesses because of how it came into being, either through evolution or intentional design. In other words, an item has a function to F if it has a disposition to F, this disposition is grounded in its physical properties and this physical constitution and disposition are the result of a certain historical process (either evolution or intentional design).

Without doubt, one of the most interesting and original ideas of the paper is to try to combine a dispositional account with an etiological approach to functions. This is unusual because, prima facie, it is not obvious that etiological functions satisfy the properties of dispositions. According to the etiological approach, functions are defined historically. A trait has the function to F iff past traits of the same type were selected for F; thus, whether an item has a function seems to be independent of the physical make-up of current traits of that type (as we saw, this is why they are thought to fail to fulfill EPIPHENOMENALISM). In contrast, according to the proposal by Spear and colleagues functions are dispositions and in the BFO framework dispositions strongly depend on the physical make-up of the object. Hence, putting together dispositional and historical factors is a central and innovative aspect of this approach.

Unsurprisingly, it is also the most controversial. In particular, as Röhl and Jansen (2014) argue, this combination threatens to undermine one of the key motivations for etiological theories: the satisfaction of NORMATIVITY. By separating function possession from the dispositions of the actual trait, etiological theories can account for complete malfunction: an item can have a function because past members of the same type had this effect and, nonetheless, that particular instance or even all current traits of that type might be unable to perform that function. An extreme case would be a lung with a tumor, which has the function of providing oxygen to the body but is unable to perform it. Since, in contrast to mainstream etiological theories, Spear and colleagues require that current functional items need have the disposition to F in order to possess it as one of its functions, it seems they cannot account for cases where a trait has a function but it is unable to perform it.

Spear and colleagues provide two original ways of addressing this worry. Both of them seem to admit that if a trait lacks a disposition, then it does not have a function, but suggest two interesting arguments for making this idea more palatable. First, they argue that even if an item lacks a function, it might still be *supposed to* have a function in virtue of the kind of entity it is. So hearts, in virtue of being hearts, are supposed to have the function of pumping blood (which is very different from saying that they have the function of pumping blood). As a result, Spear and colleagues seem to admit that there is a sort of normativity that exclusively depends on history and which is possessed by any item irrespective of its actual physical make-up. Interestingly, that seems to be the kind of property attributed by classical etiological theories. Indeed, one might wonder whether the adoption of this proposal might eventually lead the addition of a non-dispositional category in the BFO for a property that gives rise to normativity and which is independent of the bearer's current physical make-up. The second strategy they suggest also accepts that a device that lacks the disposition to F cannot have the function to F, but they argue that this is an unproblematic consequence because in that case the device would not count as an instance of that kind. In short, the idea is that if an item is unable to provide oxygen to the body, then it cannot be a lung. This second proposal avoids introducing a second source of normativity, but might be more counterintuitive. For example, it is committed ot the idea that the line separating entities that are able and unable to carry out a function can be used to classify items into kinds. This is controversial for biological traits (it could be argued that lungs with tumors are still considered as lungs by biologists or doctors) and, for the reasons outlined above, also for artifacts: an amulet can have the function of protecting the bearer against the evil eye, even if it is probably unable to do it. In any event, the two suggestions are insightful and worth developing further.

Indeed, there is a third way of making an etiological and a dispositional accounts compatible, which might be worth considering: to define functions in terms of the disposition of past items. That is, one might suggest that a trait can have a function even if it does not have the disposition, as soon as past items did have it. This alternative way of combining an etiological and dispositional approach might be in position to satisfy TELEOLOGY and NORMATIVITY, although it would probably fail to comply with EPIPHENOMENALISM (a result that Spear and colleagues seem to accept anyway). That would confirm that this is indeed an etiological theory of function, and that there is an inevitable tension between the desiderata. Unfortunately, it would also probably fail to satisfy NOVELTY, so whether this idea can be extended to artifacts is far from obvious.

A second difficulty faced by the proposal of Spear and colleagues (which they briefly touch upon in section 3.1.) concerns condition 3 of their definition, which requires that the physical make-up of a functional artifact has to come into being in order to realize that process. As we saw, there seem to be certain objects that acquire or change their function without modifying their physical make-up. This is most clearly exemplified by naturefacts. i.e. natural objects used for a certain purpose. When a natural stone with a convex whole is used as a mortar, the stone seems to acquire a function, but its physical make-up does not depend on natural selection or the intention of the designer (Hilpinen,

2011). Interestingly, failing to account for naturefacts might be a consequence of satisfying TELEOLOGY: if the function has to explain the existence of the item, then it might not be possible to attribute functions to naturefacts. That might be another unavoidable consequence of fulfilling a particular desideratum.

Finally, it is worth stressing that while Spear and colleagues adopt the BFO to defend an etiological or history of selection account, others have used the very same framework in order to put forward a different approach (see Röhl and Jansen, 2014). Indeed, Spear and colleagues 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 (see, for instance, Arp and Smith, 2008). Thus, in principle BFO is fully compatible with a pluralist view on functions. For instance BFO could include a Function_1 category at the same level of *Disposition* and *Role* and a Function_2 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.

Whereas the paper by Spear and colleagues can be classified as revisionist, the essay by Mizoguchi, Kitamura and Borgo pursues what we called an 'overarching strategy'. They present an ambitious definition of function that it is supposed to encompass biological as well as artifactual uses and which relies on two key notions: behavior and function context. 'Behavior' is a semi-technical term that refers to a kind of process (that they classify as an 'ongoing instantaneous change'). A function context C for an entity O is a triple formed by a context for O, a behavior B and a goal G. Crucially, in a function context the goal G is a result that the behavior B causally contributes to achieve.

Besides this general definition of function context, Mizoguchi and colleagues also distinguish three kinds of them: Systemic, use and design contexts. Contexts can also be nested, in the sense that they can be included in larger contexts that have them as parts. Finally, the notion of context is used in the definition of 'appropriate goal'. Given a context C involving an item O, a behavior B and a goal G, a goal G is appropriate for a goal G' iff B contributes to the one of the processes leading to G'.

All these notions are used to define the notion of systemic function. In short, the idea is that, given a context C involving an item O, a behavior B and a goal G and a context C' involving a goal G', O performs a systemic function in system S with respect to context C if (1) O is a component of a larger system S' with goal G and (2) the goal G is appropriate for the goal G' of S' (via a sequence of contexts). The idea is that an item has a function to F if it contributes by F-ing to the goal of the larger system is participates in. This is indeed a sophisticated version of what is known as 'systemic' or 'dispositional' account (Cummins, 1975; see Mizoguchi et al, 2012, p. 114). As they point out, one of the chief purposes of their approach is precisely to clarify the notions of goal and context within the framework of a sophisticated systemic theory.

Mizoguchi and colleagues also distinguish two further kinds of functions. If the context goal of the larger system is provided by the user, O is said to have a *use function* and if it is provided by the designer it is said to have a *designer's function*. It should be stressed, however, that these two kinds are specific versions of systemic functions. The notion of of systemic functions is the umbrella concept that includes use and designer's functions as subtypes (this is why they pursue an overarching strategy).

The last work in this volume is Burek, Loebe and Herre's essay, which discusses different ways of modeling functions within the Unified Modeling Language (UML). Although their primary goal is to provide a formal model for bioinformatics, to carry out their project they need to make certain theoretical choices that are important for our understanding of this notion. The key idea is that a

function is a role that a device plays in achieving certain goal. More precisely, 'an entity x has a function y if it plays a role y and there is a goal achievement z such that x has a function of doing or contributing to z in virtue of y' (Burek et al., p. 31). So their approach is also a version of the systemic theory of function.

Within their framework, a goal is defined as a situation of utility. Burek et al recognize that goals can have a wide variety of origins; they can derive from the beliefs and desires of the designers or users (and, here, they appeal to the work of Mizoguchi and others), but also from the interests of those explaining a system. That is, goals can be internal to the system as well as imported by the observer. Accordingly, they hold that the inclusion of a agent in the definition of goal (and hence, of functions) entails that goals and functions are subjective entities (in that respect, see especially their footnote 10).

Their paper provides many compelling definitions of different notions related to function. An interesting contribution, for instance, is the notion of mode. They suggest that describing functions only in terms of output and input is insufficient and for this reason they introduce the notion of *mode*, which is supposed to capture the way an item performs its function. Although in many situations a notion of function that abstracts away from modes can be explanatory useful (indeed, it is not unreasonable to think that the notion of function is often valuable precisely because it does not take into account the various specific ways devices accomplish it), in other contexts appealing to the modes of achieving functions might also be illuminating.

Another appealing aspect of the paper concerns the distinction between different kinds of functions. Burek and colleagues distinguish *doer* functions from *contributor* functions. Whether a device plays the role of a doer or a contributor depends on what they call the 'execution': doers are participants that are responsible for the execution of the function, while contributors merely contribute to it (don't execute it). These notions are taken as primitive, so even though their intuitive interpretation is clear, it might be interesting to develop them in more detail in future work.

Now, since the papers by Mizoguchi and colleagues and Burek and colleagues are versions of the systemic approach to functions, it is not surprising that their proposals share some of the strengths and weaknesses of these theories. I would like to conclude by briefly considering three of them that are indeed addressed in their papers: the nature of goals, the distinction between essential and accidental effects and TELEOLOGY.

On the one hand, a central feature of their accounts is that an attribution of functions depends on the identification of goals. Spear and colleagues object that this feature might cause troubles in biological contexts, although they do not develop this point in depth. One way of spelling out this idea is that in the biological domain goals seem to be part of the *explanandum.* The fact that hearts have the goal of pumping blood seems to be the aspect that motivated the search for functions in the first place. Be as it may, it seems that in biology at least, goals cannot be simply taken for granted.

The two papers in this volume address this concern. Mizoguchi and colleagues deflate the notion of goal: in the case of biological systems, a goal just is a particular behavior of the system selected for a certain reason. Thus, in principle there are as many possible goals as behaviors. In turn, Burek and colleagues argue that goals are observer-dependent: the goals that account for the attribution of functions in biology are epistemic goals, which depend on the explanatory utility they have for some agent. These strategies might successfully explain how there could be goals in nature, but they have an important side-effect: deflating goals or making them observer-dependent tends to increase their number, so that too many effects might qualify as functions. The question, then, is whether this strategy is compatible with the satisfaction of ACCIDENTAL.

Mizoguchi and colleagues try to accommodate the distinction between essential and accidental effects in two different ways. On the one hand, they claim that once a context is determined (which assumes a specific goal), then those factors contributing to it are essential and those that are not are accidental. That is, whether an effect is essential or accidental depends on the selected context. The second suggestion (which differs from the first one) is that 'use functions' are accidental while the rest of systemic functions are essential[6]. This original proposal can indeed make interesting distinctions between functions: it can capture the intuition that the primary function of cups is to contain liquids and not holding pens by appealing to the distinction between design and use functions. However, note that this differs from the standard way of understanding ACCIDENTAL, which does not concern the difference between more or less central functions, but the distinction between functions and non-functional effects. Mizoguchi and colleagues, for instance, admit that on their account the heart's sound-making is an essential function with respect to certain contexts (and, consequently, in these contexts pumping blood would count as an accidental effect).

This issue also connects with the TELEOLOGY desideratum. Whereas Burek and colleagues do not address this question, Mizoguchi and colleagues claim that their account satisfies TELEOLOGY because 'the object which realizes the system function exists to contribute to the systemic goal specified by the systemic context'. However, while the definition of systemic function clearly establishes that functions need to be contributing effects, there is not any condition specifying that the functional object needs to exist *because of* that effect. This is clear from the example mentioned in the last paragraph: on the approach of Mizoguchi and colleagues, producing certain sounds can be a function of the heart (with respect to a certain context), but it does not seem that making sounds explains in any substantive sense why hearts exist. Nonetheless, on behalf of their account, it should be pointed out that whether this consequence should be regarded as a problem for the theory is not entirely obvious. As I suggested eariler, wheras in the biological case TELEOLOGY seems to be a plausible requirement, it is unclear whether this is also true in the artifactual case. Indeed, the proposals by Burek and colleagues and Mizoguchi and colleagues can account for the functional nature of naturefacts, while those satisfying TELEOLOGY can not. Thus, there seems to be a complex trade-off between some desiderata.

There are many other interesting issues raised by these papers that this brief introduction cannot address. For instance, various essays argue against modeling functions directly from natural language, or show a special interest in understanding the temporal features of function. There are also substantive disagreements: while some argue that functions are roles, others reject this view; whereas some define functions as behaviors, others hold that this is inadequate. In any case, all three papers are insightful, illuminating and thought-provoking. Furthermore, although they were written separately, they seem to engage in a fruitful dialogue. The reader will probably be astonished by the large amount of ideas that are shared and discussed in them. I am sure these essays will greatly contribute to a better understanding of the familiar but puzzling concept of function.

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6 That the two suggestions are not equivalent can be illustrated by considering a behavior B that never acquires a use function but that in a context C has a systemic function. If in a context C* (which differs from C) behavior B is not essential, it will count as accidental according to the first criterion but not according to the second.

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