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Guest Editorial

On the ontology of functions

Stefano Borgo [a,*], Riichiro Mizoguchi [b] and Barry Smith [c]
[a] *Institute for Cognitive Sciences and Technologies (CNR) and KRDB (FUB), Trento, Italy*
E-mail: borgo@loa-cnr.it
[b] *The Institute of Scientific and Industrial Research, Osaka University, Osaka, Japan*
E-mail: miz@ei.sanken.osaka-u.ac.jp
[c] *Center of Excellence in Bioinformatics and Life Sciences, Buffalo, NY, USA*
E-mail: phismith@buffalo.edu

1. Functionality: a cross-disciplinary research topic

Although the notions of function and functionality seem to be necessary tools – along with notions like object, event and property – for making sense of the outside world, our understanding of functions is still poor and fragmented. Serious theoretical work on functions and functionalities started in philosophy of science only about 40 years ago (see, for instance, Hempel, 1965). The issue was raised later in other communities, mainly because an appropriate definition of 'function' was seen as helping to explain issues relative to normality and to the design of artifacts. In other domains teleological theories of functionality were advanced as a means to find room for intentionality within causal contexts. Since the 1990s several approaches have been developed in application domains like biology and engineering design (Ariew et al., 2002; Erden et al., 2008; Krohs & Kroes, 2009), and in the last 10 years the notion of function has received attention also in the area of applied ontology, see, for instance, publications in Borgo et al. (2006) and the EuJoint[1] project. The present volume is one contribution to this series whose focus, broadly considered, is defined in the Call for Papers published in 2009: "Function and functionality play a central role not only in modern science but also in our extra-scientific understanding of the world. Unfortunately, the term 'function' is hereby used with a variety of meanings and is associated with a variety of views as to what functions are".

Roughly speaking, the philosophical literature on functions concentrates on two approaches. On the one hand we have causal theories (e.g., Wright, 1973; Cummins, 1975), which see *performing* as the basic criterion for functional assignment and the *disposition* to play a causal role as the property that an entity must enjoy if it is to be said to have a function. The attractiveness of such theories is that they take at face value the intuition that the function of an entity or trait is related to the way that entity or

*Corresponding author.
[1] www.loa-cnr.it/EuJoint/EuJoint.html.

trait contributes to the general system to which it belongs, an assumption particularly suitable for the engineering domain where, indeed, the causal approach is most appreciated.

So, why is this approach not acceptable as a general theory? We list here two important reasons. First, it makes it hard to distinguish essential from merely accidental functions. The standard example here is the nose: we take it for granted that the functionality of the nose is related to respiration; but the nose also supports glasses, and this is clearly a positive effect that noses serve. Causal approaches are unable to provide a general principle on which to distinguish these two sorts of cases. Second, performance does not seem to be the needed silver bullet, since of course not performing a function need not entail that an entity does not have it. The distinction between not having a function at all and not having it because of some malfunctioning is an issue that causality theories find it hard to deal with.

Etiological theories (e.g., Millikan, 1984; Griffiths, 2006) seek to explain function by appeal to the reasons why a given trait survives selection. Such theories have been deeply studied and have influenced in one way or another almost all research on functional approaches. The basic idea is that the function of an entity or device is the reason for its existence, and since existence is guaranteed not at the individual level but rather at the level of the species or kind, it is to kinds that functions are here associated. We then say that an entity has a function *because* it is member of a given kind. This approach is capable of giving an account of what happens in a variety of biological cases, but it seems not suitable as a general theory of function, since it points backwards – to an entity's origin – and its lack of considerations for how an entity actually behaves seems to us to be too much to swallow.

Causal and etiological approaches have certainly been developed in ways that seek to cope with these drawbacks. However, these attempts are not satisfactory, see, for instance, Ariew et al. (2002) and Wouters (2003).

A further problem with etiological approaches turns on the phenomenon of artifacts, entities whose functions reflect some designers' intention. For such entities functions are in a sense essential so that, given the entity there is no need to explain further why the function exists also. This reveals a big difference between artifact functions and biological functions, and explains why intentionality is a key issue in discussion of function in the domain of engineering.

In fact, two distinct kinds of intentional agents need to be addressed: designers and manufacturers on the one hand, and users on the other. The former give birth to the artifact and the latter has the desire or purpose to use it. These two notions are both characteristic of artifact functions, though there is some discussion as to which plays the dominant role. At the one extreme, some philosophers say that it is users who determine the function of artifacts, a view generally proposed by American philosophers (Ihde, 2008). Most engineers, however, believe that it is designers and manufacturers who play the critical role in determining the functions of artifacts. And while the intentionality of designers and manufacturers is strictly speaking irrelevant in the case of biological functions, even there we are presented with a certain analogue in what we can think of as the internal use (or component) function, see Mizoguchi and Kitamura (2009) and Kitamura and Mizoguchi (2010). This rests on viewing the organism as a system whose components contribute to the behavior of the system's parts and thus to that of the organism as a whole. Even though artifacts are marked by the fact that they are produced according to the intention of some designers, we can still see a beautiful correspondence between the two cases in the way in which functions of each component part contribute in each case to the functioning of the whole. This observation shows that it is *external use* that is the key factor in distinguishing artifactual from biological functions and this means however that context is another issue central to the notion of function, since to talk about artifact functions we have to take context into account. The context of a component part is provided in each case by its circumcluding components. Driving a nail with a hammer is the use context

of the hammer function. Organisms as a whole do not in this sense have a use context, and thus do not have a function. Thus we do not ascribe any function to lions eating zebras. However, when we consider behavior within an ecological system, we can ascribe a function to it.

In engineering we can distinguish different contexts relative to different stages in the artifact life-cycle such as requirement specification, designing, manufacturing, use, re-cycling, etc. (Kitamura & Mizoguchi, 2010). In each such context, Kitamura and Mizoguchi identify special kinds of functions which they refer to under headings such as: function as specification, function as disposition and so on. Three perspectives of artifact functions have emerged from this discussion, which see functions, respectively, as:

– behavior-oriented (what a device physically does);
– effect-oriented (the change brought about by an artifact's behavior) and
– purpose-oriented (the fact that a goal state is realized).

In addition to the domains of biology and engineering debates on the nature of functions are being pursued also in areas like cognitive science (Sober, 1990), social science (Castelfranchi, 2001) and philosophy of mind (Lycan, 2003). We believe that the ontological approach to the discussion of this matter, meaning a felicitous interaction between philosophy and information science, can lead to more complete and satisfactory theories. Indeed, there are already some proposals developed within the research area of applied ontology, for instance, Arp and Smith (2008), Burek et al. (2009), Kitamura and Mizoguchi (2010). Admittedly, these proposals need to be developed further to make an impact and serious comparative works are necessary to establish their real value. This line of research is undertaken in this volume by the paper by Carrara and colleagues.

2. The special issue

The above analysis led the editors of this special issue to seek for specific initiatives in which different views on the notion of function and functionality could be presented, analyzed, compared and even improved by ontological means. The goal was to provide opportunities to foster foundational studies and comparison works which might help to provide the basis for a unified theory of functionality. Applied Ontology was chosen as venue because of its interdisciplinary nature. The call for papers for the special issue states:

> function and functionality play a central role not only in modern science but also in our extra-scientific understanding of the world. Unfortunately, the term 'function' is hereby used with a variety of meanings and is associated with a variety of views as to what functions are.
> Some distinctions are explicitly motivated by ontological concerns (are functions types or tokens?, real or fictional?). Others can be traced back to historical sources (function as a special mode of behavior, function as a consequence of a certain sort of causal relation); or they turn on a restriction to some specific class of examples (for example to parts of organisms or to artifacts).
> In all these cases, there is one clear common feature: reference to functions or to functionalities seems to be the best way to describe or explain a given system's behavior, structure or purpose.

Researchers in both engineering and biology have developed sophisticated theories that rely on the notion of function. While these theories manifest certain common features, there is still lacking a systematic framework in terms of which the various existing approaches can be criticized and compared and in terms of which we can begin to understand the basis for their shared elements and to address the

reasons for the differences. A comparative analysis of the work produced by these communities, beside pushing forward the development of a unifying framework for functions, can lead to direct improvements in the existing systems and fruitful cross-fertilization.

This special issue is devoted to the foundation, the comparison and the application of functional theories in all areas, with particular attention to the biological and engineering domains. More practically, its goal is to publish state-of-the-art theoretical and technical contributions related to the description, characterization, and application of functions. We especially welcomed contributions in which the theories are presented and motivated with an eye to the underlying ontological aspects and their formalization.

3. Selection of the papers

We received 27 submissions in the form of extended abstracts, representing considerable diversity of perspectives and focusing on a wide variety of topics, including not only engineering design and ontology but also cybernetics, evolutionary theory, anatomy, agent societies, chemistry and qualitative spatial reasoning. The large number of submissions confirmed the high degree of interest in the topic, but the variety of approaches and their focus on local issues is a sign that the understanding of functions and functioning is still insufficiently mature to allow true cross-disciplinary studies.

The authors of 14 abstracts were asked to submit full papers, but in too many of the papers submitted either critical issues were left untouched or the treatment of the foundational aspects was superficial. Moreover, most of the papers advanced theories developed from a local perspective, so that even seemingly promising views were not developed in such a way that they could be applied to other domains. The review process ended with the selection of 3 papers which are published in this volume. We thank all of those who submitted their work. A number of papers submitted were of high value but the focus was insufficiently well aligned with the goals of this special issue to allow their inclusion.

Contrary to our initial expectations, the construction of a unified theory of functions seems still seen to be very problematic; one paper makes a concrete proposal in this sense while the other two papers concentrate on difficulties on developing such a theory. Another interesting observation is the coverage of the published papers. All the authors are philosophers, which might be the result of the longer tradition of foundational studies in this discipline. Surprisingly, other promising communities of applied ontology, of engineering design or of biomedicine, are not yet ready, as far as we could see from this experiment, to propose general and robust theories of function. It is, we believe, only a question of time before this problem is rectified.

4. The accepted papers

The papers in this volume take philosophical analysis as their common starting point but address quite different topics, as we shall see.

First, the paper "Re-organizing organizational accounts of function" by Marc Artiga presents a challenging study of the *Organizational Account* (OA) approach whose goal is to provide a single notion of function that combines the advantages of both the etiological and dispositional views. Although previous versions of the OA were not sufficiently developed to serve as the basis for a unified account of function, recently a more robust description of the theory has been provided and it is this which serves as Artiga's starting point in analyzing the basic notions on which OA relies, in particular: "self-maintaining system", "organizational closure" and " organizational differentiation". On this basis he formulates a list

of desiderata for a definition of function in terms of OA. As problems arise, Artiga attempts to correct the definition of function in order that it will satisfy the desiderata. However, his attempts to reach such a definition fail which lead him to conclude that the Organizational Accounts are unable to realize the project of unifying etiological and dispositional theories within a unique definition of function. In this way, Artiga sets a new challenge for the followers of OA.

The contribution of Ulrich Krohs, "Functions and fixed types: Biological and other functions in the post-adaptationist era", takes seriously the request for a unified theory of functions and presents a new proposal in this light. It begins with a discussion of etiological theories of biological functions, arguing that such theories cannot do justice to recent discoveries in biological research and in particular to the role of historical, developmental and geometrical constraints. The author then argues that the notion of function and that of adaptation in biology must be clearly separated, and proposes to understand the notion of function in terms of type fixation. A function, it claimed, is "a contribution of a type-fixed component to a capacity of the type-fixed system". The author proceeds by arguing extensively that this view does not require the usual metaphysical apparatus of types which, instead, can be understood in a nominalistic way. Finally, he shows how artifact functions are included under this approach and he describes how to conceive the intentionality dimension that is characteristic of artifacts.

The paper by Carrara et al., "If engineering function is a family resemblance concept: Assessing three formalization strategies" discusses the functions of artifacts, starting from the hypotheses that they are a case of "family resemblance" in Wittgenstein's sense. The authors propose a strategy for the formalization of the notion of function as used in engineering contexts starting out from the claim that "function" is analogous to "game" in the sense that there is no common core meaning covering all its uses in such contexts. The authors' claim is supported by a comprehensive survey of papers on engineering functions. Another good thing is that the authors discuss pros and cons of three possible ways to formalize functions as approaches to ontological analysis of functions:

(1) the revisionary strategy which tries to establish *the* definition of function;
(2) the overarching strategy which introduces a most general notion of function which serves as an umbrella;
(3) the descriptive strategy which aims at formalizing each existing notion of function.

They finally suggest the descriptive strategy as the one to be preferred.

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