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Teleology, Normativity and Functionality

According to the autonomous perspective, the constitutive organisation of biological systems realises an emergent regime of causation, which we labelled *closure of constraints*. One of the crucial implications of the realisation of closure is that, as we will argue in this chapter, it provides an adequate grounding for a distinctive feature of biological systems, namely their *functionalities*.

The concept of function is widespread in the language of all life sciences. At the scale of individual organisms, functions are usually ascribed to a variety of structures, traits, or processes that constitute the whole, such as, for instance, systems, organs, cells, and molecules. Similarly, functions are invoked when considering larger scales, so that organisms themselves, as well as populations and species, may be the object of functional ascriptions. Moreover, as Gayon points out (Gayon 2006: 480), functional ascriptions mostly tend to have a nested structure: parts of a functional entity can also perform functions and, reciprocally, systems containing functional entities may also be described as functional.

What is the status of the concept of biological function? At first glance there seems to be a broad consensus regarding the idea that functions play a genuine explanatory role in biology and the other life sciences: functional ascriptions are by no means simple descriptions of a trait, but rather provide an understanding of some of its essential properties and activities. To be sure, the explanatory role of functions seems to be so fundamental in life sciences that one could argue that biological explanations are *essentially* functional: in contrast to those at work in, for instance, physics or chemistry, biological explanations would be specific in this, i.e. in that they appeal to functions.

Many of the ideas developed in this chapter, as well as several portions of the text, come from Mossio et al. (2009b), and Saborido et al. (2011). Section 3.3.2 is partially based on Saborido's account of malfunction, exposed in his PhD dissertation (Saborido 2012) and in Saborido et al. (2014).

Even though it is not our aim to adopt a final position in relation to this last issue, it cannot be denied that the concept of function is at the very heart of scientific discourse in life sciences. Yet it generates a major epistemological problem, since it seems to be, at least at first sight, at odds with the ordinary structure of scientific explanation, because of its characteristic dimensions, i.e. its *teleology* and *normativity*. But what does this actually mean?

On the one hand, functions have an explanatory role in accounting for the existence of function bearers. Affirming that (to cite a classic example) “the function of the heart is to pump blood” does not correspond to a simple description of what the heart does; rather, in addition, it means that this effect has specific relevance in explaining the existence, structure and morphology of hearts (see also Buller 1999: 1–7). Hearts exist to some extent because they pump blood. Functional attributions thus introduce a teleological dimension into the structure of explanation, in the sense that the existence of a trait could be explained by appealing to some specific effects or consequences of its own activity, which reverses the conventional order between causes and effects.

On the other hand, the concept of function possesses a normative dimension, to the extent that it refers to some effect that the trait is *supposed* to produce (Hardcastle 2002: 144). Attributing functions to a trait implies a reference to some specific norm, against which the activity of the trait can be evaluated. The claim that “the function of the heart is to pump blood” implies also that the heart must pump blood. Whereas, usually, causal effects simply occur, functional causal effects must occur.

Because of its teleological and normative dimensions, the concept of function seems then to be in conflict with the accepted structure of scientific explanation. The central question is then: is the concept of function a legitimate and admissible scientific concept?

To answer this question, two alternative strategies are possible. The first is an eliminativist one, and consists of denying that functions do in fact play an explanatory role. All functional claims can be reformulated in terms of an ordinary causal claim, without losing information or meaning. In this case functions would constitute, at best, a linguistic shortcut. The second strategy, in contrast, claims that while functional statements cannot be reduced to ordinary causal ones, they are compatible with the structure of scientific discourse. In this case, a naturalisation of teleological and normative dimensions is required, i.e. a justification of the idea that these dimensions are grounded in some objective features and properties of biological systems and, consequently, can be analysed in adequate scientific terms.

In this chapter, we will suggest that the autonomous perspective adopts the second strategy, and puts forward a naturalised “organisational” account¹ of functionality, based on the emergent properties of closure.

¹For terminological clarity, note that we will dub “organisational account” (OA) the account of functions stemming from the view of living beings as organisationally closed systems, and, in particular, from the autonomous perspective.

3.1 The Philosophical Debate

Broadly speaking, the philosophical analysis of the concept of function is very old, to the extent that it has always developed hand in hand with scientific research into biological phenomena. However, the debate on functions, in its contemporary form, has been framed during the last four decades, during which an increasing number of studies have been conducted in philosophy of science and philosophy of biology (several collections have published that survey the recent philosophical debate: see Ariew et al. 2002; Buller 1999; Allen et al. 1998; Gayon and de Ricqlès 2010).

The contributions that gave rise to the contemporary debate were formulated during the sixties by Nagel (1961, 1977) and Hempel (1965) who, by adopting an eliminativist stance, tried to reduce functional statements to the nomological-deductive model (Hempel and Oppenheim 1948). Because of the difficulties inherent in their approach (Saborido 2012: 51–59), the vast majority of subsequent literature has focused on justifying functional discourse through naturalisation.

Current philosophical accounts of functions are usually grouped into two main traditions, called “dispositional” (or “systemic”) and “aetiological”. As we will argue, the autonomous perspective advocates a third one, the “organisational” view, which aims to combine the previous accounts into an integrated framework. Before expounding our own view, we shall first provide a brief overview of the other two accounts, and describe their respective strengths and weaknesses.

3.1.1 Dispositional Approaches

In the philosophical debate on functions, several authors have, against the eliminativist stance, advocated the idea that functional attributions do indeed refer to current features of the system under examination. By explicitly discarding teleology as a constitutive dimension of the concept of function, these authors hold that functions do not refer to a causal process that would explain the existence of the function bearer by appealing to its effects. Rather, functional relations are interpreted as a particular class of causal effects or dispositions of a trait – means-end relationships contributing to some distinctive capacity of the system to which they belong.²

The philosophical agenda of dispositional approaches focuses on providing naturalised and appropriate criteria for identifying what counts as a target capacity of a functional relationship, from which the relevant norms can be deduced, and the different dispositional approaches have proposed various criteria to identify these target capacities.

²On the basis of this common theoretical stance, these approaches have been labelled “causal role”, “dispositional” or “forward-looking”, as opposed to “backward-looking” etiological ones. Here we will use the general label “dispositional” to refer to this class of theories.

The more classical dispositional approach is the “systemic approach” (SA), which defines a function F as the contribution of a process P to a distinctive higher-level capacity C of the system S to which it belongs (Craver 2001; Cummins 1975; Davies 2001). In the SA, explaining functions means analysing a given higher-level capacity of the system in terms of the capacities of the system’s components, which jointly concur in the emergence of the higher-level capacity. The SA dissolves the problem of teleology of functions by reducing them to any causal contribution to a higher-level capacity. In turn, the normative dimension of functions is reduced to the fact that the causal effect must contribute to a higher-level capacity, with no reference to a “benefit” for the system.

The explanatory strategy adopted by the SA is subject to one major criticism, namely that it seriously *under-specifies* functional ascriptions, which in turn generates several problems (see also Wouters 2005). Firstly, the SA fails to draw a principled demarcation between systems whose parts appear to have functions and systems whose parts do not (Bigelow and Pargetter 1987; Millikan 1989). Secondly, the SA lacks a principled criterion for identifying the relevant set of contributions for which functional analysis makes sense. And thirdly, the SA is unable to draw an appropriate distinction between “proper” functions and accidental, useful contributions (Millikan 1993, 2002).

Because of these fundamental weaknesses of the SA, the “goal contribution approach” (GCA) has attempted to introduce more specific constraints on what makes causal relations properly functional, by linking the concept of function to the cybernetic idea of *goal-directedness*. In particular, the GCA restricts functional attributions to causal contributions to those (higher-level) capacities that constitute the “goal states” of the system (Adams 1979; Boorse 1976, 2002; Rosenblueth et al. 1943). In particular, biological systems can be described as having the essential goal of surviving (and reproducing). Hence, biological functions are dispositions that contribute to these goals.

The main virtue of the GCA is that it provides an interpretation of functions that, in contrast to the SA, recognises and substantiates their specificity as means-end causal relationships. Nevertheless, the characterisation of a goal-directed system introduces norms whose application is not restricted to the relevant kinds of systems and capacities. As Bedau (1992) points out, the cybernetic characterisation of the goal state is unable to adequately capture the frontier between “genuinely” goal-directed systems (supposedly biological systems and artefacts) and physical equilibrium systems, which tend to some steady state or state of equilibrium (see also Nissen 1980).

Moreover, as Bedau (1992) and Melander (1997) argue, cybernetic criteria may interpret the dysfunctional behaviours of goal-directed systems as functional and, also, the GCA account lacks the theoretical resources to distinguish between functions and accidental contributions to a goal state. In sum, the GCA still seems to under-specify functional attributions, and in some cases it appears even to be a less satisfactory account than the SA.

The third main dispositional perspective proposes the identification of functions with causal contributions of components to the life chances (or fitness) of the system

(Bigelow and Pargetter 1987; Canfield 1964; Ruse 1971). Bigelow and Pargetter, in particular, have proposed the “propensity view”, according to which “something has a (biological) function just when it confers a survival-enhancing propensity on the creature that possesses it” (Bigelow and Pargetter 1987: 108).

By appealing to survival in terms of enhancing propensities as the goal of a functional relation, the propensity view succeeds in restricting functions to components of biological entities. Moreover, Bigelow and Pargetter’s reference to survival-enhancing *propensity* is intended to avoid functional attributions to contingent and/or accidental contributions to survival, which would be contrary to intuition and common use. Yet, as McLaughlin perceptively argues (McLaughlin 2001: 125–8), the appeal to propensities does not fully succeed in restricting functional attributions to the relevant cases. Even by restricting propensity to the current environment (the “natural habitat”, in Bigelow and Pargetter’s terms), it is possible to imagine, for each specific effect produced by a trait, a situation in which that specific effect would confer a (possibly low) propensity that enhances survival, and thus have a function.

The problem is that propensities to enhance survival in virtual (but not impossible) situations correspond, in a forward-looking approach, to *actual* functions of the existing trait. Moreover, to the extent that the specific contribution of the trait would presumably change in accordance with the particular condition in question, each trait in fact possesses an indefinite list of actual functions. Again, the propensity view fails to provide an adequately restricted definition of what counts as a functional relation. All (biological) functions are survival-enhancing contributions, but not all survival-enhancing contributions are functions. Appealing to propensities does not solve the problem.

To summarise, the main virtue of the dispositional approaches is their capacity to capture the fact that the concept of function points to something more than mere causal relations: functions refer to current means-end relationships, and more specifically to current contributions of components to the emergence of a target capacity of the containing system. Yet, dispositional approaches in the end fail to provide a satisfactory grounding for the normativity of functional attributions, and dispositional definitions turn out to be systematically under-specified, allowing functional ascriptions to irrelevant systems and/or capacities. In a word, the price paid for excluding the teleological dimension as a proper *explanandum* is not compensated for by a satisfactory foundation of the normative dimension.

In fact, most of the existing literature has favoured a different approach, according to which an adequate understanding of functional attributions has to deal with the problem of teleology. In particular, both the teleological and normative dimensions are conceived as being inherently related to the *aetiology* of the functional trait.

3.1.2 Aetiological Theories

The mainstream philosophical theory of functions is the aetiological approach (Wright 1973, 1976; Millikan 1984, 1989; Neander 1980, 1991; Godfrey-Smith

1994). The aetiological approach defines a trait's function in terms of its aetiology (i.e. its causal history): the functions of a trait are past effects of that trait that causally explain its current presence. In sharp contrast with dispositional accounts, the aetiological approach explicitly takes the issue of teleology as the central problem of a theory of functions.

The first aetiological approach was proposed by Wright, who defined functions as follows:

The function X is Z means:

1. X is there because it does Z.
2. Z is a consequence (or result) of X's being there (Wright 1976: 48).

Wright's definition explicitly appeals to a form of causal loop, in which the effect of a trait helps to explain – teleologically – its existence. The scientific validity of Wright's definition has been questioned and, moreover, several obvious counterexamples have been formulated (see, for instance, Boorse 1976).

In order to ground the teleological dimension of functions without adopting an unacceptable interpretation of the causal loop described by Wright, mainstream aetiological accounts, usually called “selected effect (SE) theories”, have appealed to the Darwinian concept of Natural Selection as the causal process, which would adequately explain the existence (or, more precisely, the maintenance over time) of the function bearer by referring to its effects. The gist of SE theories is that functional processes are not produced by the same tokens whose existence they are supposed to explain. Instead, the function of a trait is to produce the effects for which past occurrences of that trait were selected by Natural Selection (Godfrey-Smith 1994; Millikan 1989; Neander 1991). Selection explains the existence of the *current* functional trait because the effect of the activity of *previous* occurrences of the trait gave the bearer a selective advantage. The main consequence of this explanatory line is its historical stance: what makes a process functional is not the fact that it contributes in some way to a present capacity of the system, but rather that it has the right sort of selective history.

By interpreting functions as selected effects, SE theories are able not only to deal with the problem of teleology, but also to ground the normativity of functions. By defining functions as effects subject to an evolutionary causal loop, SE theories identify the norms of functions with their *evolutionary conditions of existence*: the function of a trait is to produce a given effect because *otherwise*, the trait would not have been selected, and would not therefore exist.

Several virtues of SE theories are often emphasised, including their capacity to exclude functional attributions to traits of physical systems, and their ability to unambiguously identify functions from among the whole set of all processes occurring in a system and to draw a boundary between functions and accidental useful effects. Nevertheless, SE theories have their own weaknesses, which have been extensively discussed in the literature (see, for instance, Boorse 1976; Cummins 2002; Davies 1994, 2000). We will focus here on one specific weakness of the theories, which Christensen and Bickhard (2002) have labelled their *epiphenomenalism*. The crucial drawback of SE theories' explanatory line is the implication that

functional attributions bear no relation to the *current* contribution of the trait to the system, since they point solely to the selective history of the trait. This is at odds with the fact that functional attributions to biological structures do seem to bear some relation to what they currently do, and not only to what explains their current existence.

To solve some difficulties inherent to previous formulations of aetiological theories (mainly that they attribute proper functions to effects that are, in fact, no longer functional in the current system), Godfrey-Smith (1994) has proposed a “modern history theory” of function. In his approach, functions are “dispositions or effects a trait has which explain the recent maintenance of the trait under natural selection” (Godfrey-Smith 1994: 199; See also Griffiths 1993). While it successfully counters several objections raised against previous versions of the theory, Godfrey-Smith’s account is no better placed to deal with the problem of epiphenomenalism. More precisely, as McLaughlin (2001: 116) points out, by reducing the cases in which it attributes functions to currently non-functional traits, Godfrey-Smith’s account (which is explicitly an historical one) possibly reduces “uncooperative cases”, but does not provide a principled solution to the problem.

Accordingly, SE theories provide an account that is problematically epiphenomenal, in the sense that it maintains that the attribution of a function does not provide information about the current system being observed. From the perspective of SE theories, a function does not tell us anything about the current organisation of the system being analysed.

3.2 The Organisational Account of Functions

The outcome of this brief critical survey is that current theories of functions seem to face a dilemma, arising from the way in which they deal with the two main issues related to the concept of function, i.e. its teleology and its normativity. Dispositional theories try to account for functions in terms of current contributions to some target capacity of a system, and discard the teleological dimension, but seem unable to provide fully adequate normative criteria for functional attributions. Aetiological theories, on the other hand, try to account for both the teleological and normative dimensions of functions, but appear inevitably historical and are unable to justify how functional attributions may refer to features and properties of the current system.

According to some authors, the solution to the dilemma consists of concluding that there is no unified account of functions, and that aetiological and dispositional approaches provide two different yet complementary concepts of function (Allen and Bekoff 1995; Godfrey-Smith 1994; Millikan 1989). Other authors, such as Kitcher (1993), Walsh (1996), and Walsh and Ariew (1996), have claimed that there is, in fact, a single concept of function, in which the aetiological and dispositional formulations can be subsumed as special cases. In this section, we argue that, from the autonomous perspective, there is indeed room for a unified account of functionality, based on the properties of self-determination of biological organisation.

The core of the organisational account (OA) is the idea that functional ascriptions do account *at the same time* for both the existence of functional traits and their current contribution to a system capacity, since functions make sense only in relation to the specific kind of organisation which is characteristically at work in biological organisms. In particular, as we shall argue, functions correspond to those causal effects exerted by the constraints subject to closure that contribute to maintaining the organisation.

Before expounding our own version of the OA, it should be mentioned that, very recently, a considerable amount of work has been done in this direction by Bickhard (2000, 2004), Schlosser (1998), Collier (2000), McLaughlin (2001), Christensen and Bickhard (2002), Delancey (2006), Edin (2008), and more recently by ourselves (Mossio et al. 2009b; Saborido et al. 2011; Saborido and Moreno 2015). In spite of some differences between the various formulations, there seems to be substantial convergence³ regarding the fundamental tenets of the OA, which makes it a credible philosophical alternative to both aetiological (mainly in its “selected-effects” version) and systemic-dispositional accounts.

3.2.1 *Teleology, Normativity and Self-Determination*

The OA relies on an understanding of biological systems as sophisticated and highly complex examples of natural self-maintaining systems. In particular, the first claim of the OA is that self-determination, as characterised in Chaps. 1 and 2, constitutes the relevant emergent causal regime in which the teleological and normative dimensions of functions can be adequately naturalised.

On the one hand, the causal regime of a self-maintaining system provides a naturalised grounding for the teleological dimension. Since the activity of the system S contributes, by exerting a constraint on its surroundings, to the maintenance of some of the conditions required for its own existence, the question “Why does S exist?” can be legitimately answered by “Because it does Y”. This justifies explaining the existence (again, in the specific sense of its *maintenance* over time) of a system in “teleological” terms by referring to its causal effects.

On the other hand, self-maintenance grounds normativity. The activity of a self-maintaining system has an intrinsic relevance for itself, to the extent that its very existence depends on the constraints exerted through its own activity. Such intrinsic

³Christensen and Bickhard (2002) have suggested, relying on their own work on the notion of biological autonomy, that the organisation of autonomous systems provides an adequate grounding for the normativity of functional ascriptions. In a similar vein, McLaughlin (2001) has developed an account in which both the teleology and normativity of functions can be naturalised in the organisation of self-reproducing systems. Despite some terminological differences, the central idea of these approaches (i.e. that the organisational closure instantiated by living systems provides an adequate basis for naturalising functions) fundamentally coincides with that defended here, and we explicitly recognise this theoretical relationship.

relevance generates a naturalised criterion for determining what norms the system is supposed to follow: the system must behave in a specific way, otherwise it would cease to exist. Accordingly, the activity of the system becomes its own norm or, more precisely, its conditions of existence are the intrinsic and naturalised norms of its own activity.

Note that, so far, we have been generally referring to self-maintenance, and not closure. Hence, we acknowledge that the grounding of the teleological and normative dimensions goes beyond the biological domain, and includes some kinds of physical and chemical self-maintaining systems. Let us take the simple example of a candle flame. As Bickhard (2000: 114) points out, by constraining its own surroundings, the flame makes several contributions to the maintenance of the conditions required for its own existence. Indeed, the flame keeps the temperature above the combustion threshold, vaporises wax and induces convection (which pulls in oxygen and removes combustion products). Accordingly, to the question “Why does the flame exist?” it is legitimate to answer “Because it does X”: the existence of the combustion reactions (the flame itself) is explained (at least in part) by taking into account the effects of its constraining action. Moreover, what the flame does is relevant and makes a difference for itself, since its very existence depends on the specific effects of its activity. The conditions of existence of the flame are the norms of its own activity: the flame must behave in a specific way, otherwise it would disappear.

One may object that, if self-maintenance as such provides the relevant grounding for teleology and normativity, then the OA should allow functions to be ascribed to physical dissipative systems. But of course, this implication seems unsatisfactory since, usually, no one ascribes functions to physical systems. Hence – the objection could continue – the OA clearly fails to restrict functions to the relevant kind of systems, just as dispositional approaches do. To this objection, we reply by formulating the second claim of the OA, according to which self-maintenance is a necessary but not sufficient condition for grounding functions in a naturalised way. Functions emerge when the self-maintenance is realised in the specific form of closure.

3.2.2 *Closure, Organisation and Functions*

The second claim of the OA is that when self-maintenance is realised as closure, then the causal effects of the constraints subject to closure are functional. Accordingly, as we claimed in Chap. 2, functionality is an emergent property of closure. Closure of constraints is therefore closure of functions.

Before providing a more precise definition and exploring some implications, let us clarify what is behind the conception of functionality advocated by the autonomous perspective.

The central idea is that functionality, in addition to teleology and normativity, includes a third dimension, that of *organisation*. Functions, we submit, involve the fact that self-determination is achieved through the interplay of a network of

mutually dependent entities, each of them making *different yet complementary* (and also *hierarchical*, as in the cases of regulation and control, discussed in Chap. 1, Sect. 1.8) contributions to the maintenance of the boundary conditions under which the whole system can exist. In other words, to ascribe functions we must distinguish between different causal roles in the system, a division of labour among the parts. And, of course, this is precisely what happens when closure of constraints is realised. As clarified above, closure is realised as the mutual dependence of the whole set of constraints which collectively achieve self-determination. But the very idea of mutual dependence presupposes that the various constraints produce different yet complementary causal effects: if all constraints produced the same effect, they would not depend on each other, and each constraint would be able to self-maintain individually. That is why, in our view, functions are not ascribed to dissipative structures. As discussed earlier, in this case there is only a single entity (the macroscopic structure itself) that acts as a constraint on the surroundings, and contributes to maintaining the conditions of its own existence. Since there is no need to distinguish between different contributions to self-determination generated by different constraints, functional ascriptions are meaningless.

At this point, it is important to set out one general implication of the autonomous perspective. The concepts “closure” and “organisation” are inherently linked. In the technical sense defined in Chap. 1, an organisation appears precisely when a set of constraints realise closure. Here, we add a third dimension. To the extent that closure is taken as the naturalised ground of functions, it follows that the concept of functionality itself is theoretically linked to that of closure and organisation. “Functionality”, “closure”, and “organisation” are then *mutually related concepts*, which refer to the very same causal regime; in other words, in the autonomous perspective an organisation is by definition closed and functional.⁴

Functional ascriptions and explanations are relevant as soon as the kind of organisational complexity realised by closure comes into being. Accordingly, it might be useful to focus on the distinction between the organisational and what could be labelled the “material” complexity of a system, i.e. the variety of its internal components. Minimal self-maintaining systems may indeed differ considerably with respect to their material complexity. Whereas many physical dissipative systems possess a rather homogeneous nature in terms of the variety of molecules of which they are made up (e.g. whirlwinds and Bénard cells), other systems, including chemical dissipative systems such as candle flames, have many different molecular components. Certain types of dissipative chemical systems (the Belousov-Zhabotinsky reaction, for instance) may even possess a high degree of material complexity.

Even high material complexity, however, has nothing to do with organisational closure, and therefore does not imply functions. In the case of the flame, for instance, the different chemical components all “converge” to generate a single macroscopic

⁴Of course, the reciprocal equivalences hold equally: closure refers to a functional organisation, and functionality indicates a closed organisation.

pattern (the flame), which in turn constrains the surrounding dynamics. Accordingly, it is not possible in this case to distinguish between the different ways in which the various components contribute to the self-maintenance of the system. The flame, although materially quite complex, is organisationally simple: in fact it has no organisation at all. Hence, functional attributions to components of the flame, as well as to all physico-chemical dissipative structures, are not meaningful. The realisation of closure requires not only that different material components be recruited and constrained to differentially contribute to self-maintenance but, in addition, that the constraints which contribute to self-determination be generated, and maintained, within and by the organisation of the system.

Let us now give an explicit and formal definition of function. According to the organisational account, a trait T has a function if, and only if, it exerts a constraint subject to closure in an organisation O of a given system. This definition implies the fulfilment of three different conditions (Saborido et al. 2011):

- C₁. T exerts a constraint that contributes to the maintenance of the organisation O;
- C₂. T is maintained under some constraints of O;
- C₃. O realises closure.

Let us apply this definition to the classic example of the heart. The heart has the function of pumping blood since (C₁) pumping blood contributes to the maintenance of the organism by allowing blood to circulate, which in turn enables the transport of nutrients to and waste away from cells, the stabilisation of body temperature and pH, and so on. At the same time, (C₂) the heart is maintained under various constraints exerted by the organism, whose overall integrity is required for the ongoing existence of the heart itself. Lastly (C₃), the organism realises closure, since it is constituted by a set of mutually dependent structures acting as constraints, which, by contributing in different ways to the maintenance of the organisation, collectively realise self-maintenance.

It should be underscored that this characterisation of functions is consistent with the one proposed by Wright. In this example, the heart is there because it pumps blood (otherwise the organism, and thus the heart, would disappear), and pumping blood is a consequence of the heart's being there. This consistency stems from the fact that the organisational account, by appealing to a causal loop at work in the organisation of the system, provides an argument for naturalising both the teleology and normativity of functions, which, at an organisational level, mirrors the explanatory strategy adopted by the aetiological approaches. The resulting account represents an integration of the aetiological and dispositional perspectives, since it may at the same time explain the existence of the trait and its current contribution to the maintenance of the system.⁵

⁵In a recent contribution, Artiga (2011) offered a detailed critical analysis of the organisational account. Some of his remarks have been taken into account in the present formulation of the OA, while others (with which we do not agree) would require a full reply; but we will leave this for a future analysis.

The organisational definition given above is very general, and aims at encompassing all particular cases. Yet, actual functional ascriptions would take into account the complexity of autonomous organisation. This means, first of all, that functional ascription could vary according to the specific instance of closure that the system is realising at a given moment (what we called a “regime of self-maintenance”). Also, for each specific constitutive regime, as discussed in Chap. 1, Sect. 1.8 above, autonomous systems can realise different *orders* of closure, in particular insofar as regulation is involved. Moreover, in Chap. 6 we will discuss how different *levels* of closure (and then of organisation) can be described in certain classes of biological organisms, in particular multicellular ones.

Each specific regime, orders and levels of closure generate, as argued in this chapter, a distinct set of norms and functions. For instance, a given function could be related either to an individual cell (first-level) or to the whole multicellular organism (second-level) to which that cell belongs; in each of these cases, that very function could be either constitutive (first-order) or regulative (higher-order). And that function could be at work only within a specific regime of maintenance of the considered system, realised, for instance, only in some particular conditions or at a given moment. As a consequence, adequate functional ascriptions should make explicit, in each specific case, which are the regime, order, and level of the closure involved in C₃.

Lastly, it should be noted that, in principle, for each constraint subject to closure, functional ascriptions may concern either the *structure* itself (the trait) or the *effects* produced by that structure. Although the second option would possibly be more precise, here we mainly refer to the functions of traits and structures, which is consistent with the typical use of functional ascriptions in the relevant literature, as well as in ordinary language (see also Wimsatt 2002: 179).

3.3 Implications

The organisational account of functions has several relevant implications for the philosophical debate. Some of them⁶ have already been spelled out in a previous study (Mossio et al. 2009b), and shall not be discussed here. In this section, we will focus on two main issues that are of crucial importance for assessing the scope and prospects of the OA: the ascription of cross-generation functions and the characterisation of malfunctions.

⁶For example, the distinction between functionality and usefulness; or the relationship between the concept of primary functions and the aetiological concept of proper functions.

3.3.1 *Cross-Generation Functions*

A major theoretical challenge facing the organisational account concerns, as Delancey (2006) has argued, the capacity to ground “cross-individual functions”, i.e. those functions which go beyond the boundaries of individual biological systems. Let us explain what exactly this challenge consists of.

In the OA, functions are characterised as contributions of parts to closed organisations, and since closed organisations are typically realised by individual organisms, the OA appears to have trouble grounding those functions involving several individuals and their interactions. In particular, it is unclear whether and how the organisational approach would account for what Schlosser (1998) calls “cross-generation functions”, for instance, the function of reproductive traits (e.g. the function of semen to inseminate the ovum). In these cases, in fact, the trait seems to contribute to maintaining the organisation of a system that is different from the system of which it is a component. Hence, the trait does not contribute either to the maintenance of an organisation or to its own self-maintenance. Still, we do ascribe cross-generation functions, just as we do, for instance, in the case of the reproductive function of semen. At first sight, then, cross-generation functions constitute a major group of counterexamples within the organisational approach.

As we explained in a previous work (Saborido et al. 2011), some of the authors who advocated the organisational account were of course aware of this issue, and proposed (following very different paths) solutions, which were designed to enable the account to embrace both intra- and cross-generation biological functions. Broadly speaking, the existing formulations can be regrouped into two main versions. The first version, advocated by Schlosser (1998) and McLaughlin (2001), tends to characterise reproductive functions as states or processes, which are causally required for the reproduction of the trait that causes them. The emphasis is therefore on the self-reproduction of the trait, rather than specifically on the whole system that, nevertheless, must possess the adequate properties to enable trait self-re-production. The second version, proposed by Collier (2000), Christensen and Bickhard (2002), shifts the focus onto the organisation of the system, and interprets reproductive functions as contributions to a higher-level self-maintaining organisation.

Delancey’s analysis criticises all these “unified accounts” by pointing out their weaknesses and drawbacks. As an alternative, he proposes a “splitting account”, according to which intra- and cross-generation functions are in fact two different kinds of biological functions, requiring different conceptual treatment within an organisational account.⁷

⁷We do not describe Delancey’s account here. For details, see Saborido et al. 2011.

It is our contention, however, that the OA may provide a unified definition applying to both intra- and cross-generation functions. The essence of our argument will be that cross-generation functions contribute to the maintenance of systems, which realise a closed self-maintaining organisation in the very same sense as that of systems whose parts are ascribed intra-generational functions. To the extent that the two kinds of systems do not differ in terms of organisational self-maintenance, there is no need to invoke two kinds of functions, and the ontological problem is therefore overcome.

Before developing our own formulation, let us briefly discuss another proposal, put forth by Christensen and Bickhard (2002), which also tries to provide a unified account of intra- and cross-generation functions within the autonomous perspective. Their central move consists of appealing to higher-level organised self-maintaining systems, composed of individual organised self-maintaining organisms, in which reproductive traits could be subject to closure. In particular, Christensen and Bickhard explicitly grant systems like populations or species the status of autonomous⁸ systems, making them relevant supports for functional ascriptions, just like individual organisms:

Living organisms in general are autonomous systems, as are reproductive lineages, species, and some kinds of biological communities (Christensen and Bickhard 2002: 3).

As a consequence, intra- and cross-generation functions are simply contributions to the maintenance of different specific systems, sharing the same kind of organisation at different scales. Whereas intra-generation functions would contribute to the autonomous organisation of individual organisms, cross-generation functions would contribute to the autonomous organisation of the lineage, the species or the biological community in question.

Christensen and Bickhard offer an elegant alternative to the splitting account by admitting the idea of higher-level autonomous systems, namely, systems that would include individual organisms as parts, and that would ground the ascription of cross-generation functions. Accordingly, the heart is functional because it contributes to the autonomy of each individual vertebrate organism, while semen is functional because it contributes to the autonomy of the species.

Yet, this solution is problematic, as Delancey's lucid criticism (Delancey 2006) shows. As he points out, considering those higher-level systems that are relevant for grounding cross-generation functions as autonomous systems does not come without a price. Whereas an individual organism is a paradigmatic case of an autonomous system, "the sense in which the species or some population is a complex system of the appropriate kind is much more difficult to discern" (Delancey 2006: 90). For instance (and the list could be longer), such higher-level systems

⁸Christensen and Bickhard use the term "autonomy" in a somewhat weaker sense than the one developed in this book. Note that, in our account, closure is a *sufficient* requirement for grounding functions: in other words, functional systems are not necessarily autonomous systems.

have no clear boundaries, no stable form and, above all, it is very hard to see how their own “internal” organisation would realise closure, as is the case for individual autonomous systems.

According to Delancey, the organisational account has not explored these radical differences with sufficient accuracy, which means that the interpretation of higher-level systems as autonomous (or at least closed) systems appears, to say the least, to be an ad hoc hypothesis to cover reluctant cases.⁹ In particular, to the extent that Christensen and Bickhard appeal to the idea of autonomy in a fairly general sense, we assume that Delancey’s criticism applies equally to an interpretation of higher-level systems as organised self-maintaining systems, which could be put forward within our own conceptual framework.

A possible reply would consist of arguing that other biological supra-organismal systems do possess the properties required to be considered self-maintaining organisations. Let us briefly explore another possibility, not mentioned by Delancey’s analysis: the ecosystem. Compared with species, lineages or populations, there do indeed seem to be better reasons for considering ecosystems higher-level closed systems, relevant for functional ascriptions, especially if one adopts our characterisation in terms of self-maintaining organisations realising closure, rather than the more demanding terms of autonomy. Although there are clear differences (just to mention one: the ecosystem has no physical boundaries), ecosystems share several organisational properties with individual organisms. For instance, the various components (be they individual organisms or groups of organisms) contribute to maintaining a global organisation (the ecosystem itself), which in turn is a general condition for their own continuous existence. Similarly, the various components seem to be mutually dependent, so that the disappearance, death, or anomalous behaviour of one may provoke the collapse of the whole ecosystem.

For these and other reasons, the ecosystem has some features in common with an organism, and in fact it does not seem unreasonable, despite being somewhat uncommon, to use a functional discourse to describe it. So, for instance, we could describe and explain the organisation of an ecosystem by attributing to its various components functions such as the regulation of air, climate, water, water supply, disturbance prevention, soil formation and erosion, nutrient cycling, waste treatment, pollination, biological control of pests and diseases, and so on (De Groot et al. 2002; Nunes et al. 2014). Specifically, cross-generation traits would have the function of regenerating the various components of the ecosystem, which would tend to decay because of their dissipative nature.

In our view, the idea that the ecosystem is, at least, a closed self-maintaining system is an attractive one, and deserves further investigation. Indeed, we discuss

⁹Delancey’s remark is fundamentally correct. As a matter of fact, we try to make some preliminary steps towards an account of higher-level closed organisations at the end of Chap. 4, and then of higher-level autonomous systems in Chap. 6.

this issue in more detail in Chap. 4, Sect. 4.5.¹⁰ Yet, the search for higher-level closed organisations would be largely irrelevant for solving the problem of cross-generation functions within the organisational account since, we submit, *the reason why we ascribe functions to cross-generation traits is not related to their contribution to the maintenance of some higher-level system*. Cross-generation functions, we argue, do not require an account of higher-level closed systems in order to be adequately naturalised within an organisational account. Let us then turn to our proposal.

The gist of our account consists of arguing that the apparent difficulty in integrating cross-generation functions into the definition does not stem from an ontological difference between intra- and cross-generation functions but rather from an inadequate understanding of what a closed self-maintaining organisation actually is. Cross-generation functions constitute a “recalcitrant” class of functions only if the boundaries of the self-maintaining organisation are confused with the boundaries of the individual organisms themselves, whereas, in fact, they are conceptually distinguishable. Once this confusion has been cleared up, the ontological problem disappears.

In our account, functional traits are those traits that, by being subject to closure, contribute to the maintenance of an organisation, which in turn exerts some causal influence on the production and maintenance of the traits. The whole system, as discussed in Chap. 1, realises a self-maintaining organisation through closure. The first remark is that a self-maintaining organisation occurs in time, and can be observed only in time. Now, as we have mentioned in Chap. 1, Sect. 1.6, biological organisms undergo various material, structural and morphological changes and modifications over time. If, due to these changes, one were to consider the various temporal instances O_1, O_2, \dots, O_n , as different organisations, then functions could not exist. A trait would be produced by a given organisation O_1 , and would contribute to maintaining another organisation O_2 . No organisation would actually self-maintain, no trait could be subject to closure, and functions could not be ascribed.

The crucial point is that, in the organisational account, these changes are irrelevant with regards to functional ascriptions, because what matters is the *continuity of organisational closure*.

¹⁰Besides, the claim that certain supra-organismal organisations could harbour functional relations does not undermine our previous proposal of grounding functions in the causal regime of organisms. Since obviously any supra-organismal organisation requires the existence of organisms, it implicitly supposes the (intra)organismic organisation in order to ground the existence of functions. For example, the constraints that ensure the maintenance of an ecosystem are generated by the specific metabolic organisations of different types of species in a given ecosystem. In this sense, the requirement that the constraints be generated within the system – if by the system we understand the supra-organismal organisation – is only satisfied partially (Nunes et al. 2014).

As discussed in Chap. 1, Sect. 1.6, the realisation of closure requires considering a *minimal* temporal interval (say, τ_n), wide enough to include the specific time scales¹¹ at which all constitutive constraints and their mutual dependencies can be described. As a consequence, the various temporal instances (at time scales τ_1 , $\tau_2 \dots < \tau_n$) of a system can be considered – in spite of any changes that may occur – instances of the *same* encompassing self-maintaining organisation, to the extent that their constitutive organisation realises closure at τ_n . In particular, this implies that the system in which a trait x performs an enabling function at time τ_1 is the *same* system in which, at τ_2 , that function of x is dependent, if both τ_1 and τ_2 are included in τ_n (at which closure is realised).¹²

In other terms, for the purposes of ascribing functions, the continuity of closure (and thus the maintenance of the system) takes precedence as a criterion of individuation over other criteria on the basis of which the various instances of the organisation would possibly *not* be taken as instances of the same system. If there is a causal dependence between two temporal instances of a system, such that their conjunction realises closure, then it could be claimed that, in this respect (and possibly *only* in this respect) the two instances are temporal instances of the same encompassing organisation.

Our central thesis is that self-maintaining organisations, which ground the ascription of cross-generation functions, and specifically reproductive functions, comply with the very same characterisation as those organisations, which ground intra-generation functions. While they may (and actually do) differ in important ways, the two classes of self-maintaining organisations do not differ with respect to the relevant properties that ground functional ascriptions.

Cross-generation functions are subject to closure within those self-maintaining organisations whose extension in time goes beyond the lifespan of individual organisms. For instance, by inseminating the ovum, mammalian semen contributes to the maintenance of the organisation by contributing to the production of a new individual organism to replace the previous one. In turn, the organisation (which consists in the conjunction of both the reproducer and the reproduced system) exerts several constraints under which the semen is produced and maintained. The crucial point is that the organisation of the system constituted by the conjunction of the reproducing and reproduced organisms (in this specific case, a minimal lineage with two elements) has exactly the same status, in terms of self-maintenance, as that of the individual organisms themselves. The fact of considering the organisation

¹¹Of course, time scales may greatly vary according to the specific function: the function of the lung is subject to closure in a very short period of time (one cannot stop breathing for more than a few minutes) whereas, for instance, the function of the stomach is subject to closure over a longer period of time (one can stop eating for days).

¹²See Chap. 1, Sect. 1.5, for the definition of dependence among constraints (functions), as well as the distinction between enabling and dependent.

of individual organisms (at τ_n) or their conjunction (at τ_{2n}) as the relevant self-maintaining organisation depends on the explanatory exigencies for functional ascriptions.

Since what matters in the case of organisational self-maintaining systems is the fact that they use their own constitutive organisation to exert a causal influence on the maintenance of (at least part of) their own conditions of existence, then the organisation of the “encompassing system” made up by a reproducer and a reproduced system itself fits the characterisation of a closed self-maintaining organisation. Reproduction, in this sense, simply constitutes one of the functions through which the organisation succeeds in maintaining itself beyond the lifespan of individual organisms. Since the encompassing system made up by the reproducer and the reproduced organism possesses a temporally wider self-maintaining organisation, reproductive traits are subject to organisational closure, and their functions are correctly grounded in the organisational account.

Why do cross-generation functions appear problematic? Intuitively, the point seems to be that reproduction involves a dramatic transition from the reproducer to the reproduced organism, so much so, in fact, that it cannot be maintained that they constitute the same organised system. Given that reproduction may involve phenomena like embryogenesis and development, such causal and phenomenological discontinuities prevent us from considering these systems as temporal instances of the same self-maintaining system. Only individual organisms are genuine self-maintaining organised systems.

In our view, this objection is not compelling, since it is based on an insufficient understanding of what matters for considering that an organisation is self-maintaining. The crucial requirement, as discussed above, is the functional dependence of the temporal instances of an organisation. Two systems which realise closure at a time scale τ_n , may be said to constitute, at a longer time scale τ_{2n} , two temporal instances of an encompassing self-maintaining organisation if it can be shown that the conjunction of the two instances realises itself closure (which includes more functions, in particular cross-generation functions). The relevant question is: is there a causal dependence between the two instances, such that the encompassing organisation can be said to realise closure? Or, to put it another way, is there continuity in the realisation of closure across the successive instances of the self-maintaining organisation? Since the answer to these questions is, in a fundamental sense, affirmative for the case of the relationship between the reproducer and the reproduced system, we claim that the encompassing organisation including them is itself a closed self-maintaining organisation that maintains itself also through reproduction.

As Griesemer has pointed out, the reproduction process does indeed involve the material connection between the reproducer and the reproduced system:

Reproduction, ... is the multiplication of entities with a material overlap of parts between parents and offspring. Material overlap means that parts of the parents (at some time) become parts of the offspring (at some other time). Thus reproduction is no mere transmission or copying of form— it is a flow of matter (Griesemer 2002: 105).

Rather than a flow of matter as such, the autonomous perspective emphasises the continuity of the functional organisation, which maintains itself over time, also because of reproduction. As it has been argued (Zepik et al. 2001) the occurrence of reproduction may be explained in terms of the time relation between the production and decay of the constitutive components in a far-from-equilibrium organisation. If the rate of replacement of the constitutive components is faster than their decay, the self-maintaining cycles of the system will prompt it to establish reproductive cycles: the system will grow and reproduce; otherwise, it will disintegrate. Only in the very unlikely case of coincidence between the rates of replacement and decay will the self-production cycles of the system realise self-maintenance without reproduction.

The macroscopic transition produced by the reproductive process can then be seen as the way in which the organisation actually manages to self-maintain beyond the temporal boundaries of individual organisms. Just as the various temporal instances of an individual organism are considered, despite changes and modifications, a single self-maintaining organisation to the extent that the organisational properties are causally linked throughout the various instances, so too are the various instances of the inter-generational organisation considered a single self-maintaining organisation due to causal dependence between the instances. The conceptual operation is exactly the same, the difference lies only in the level of temporal “zoom” through which self-maintenance is observed.¹³

This is why development is an essential feature of the self-maintaining organisation of living organisms. Once we see reproduction as a process that causally connects the reproducer and the reproduced organisations, development appears as a necessary step in this continuous process of complex self-maintenance. Indeed, self-maintenance of biological individuals can only be ensured through a continuous unfolding of changes, including reproduction and development. Chapter 6 will further elaborate on the place of development within the theory of autonomy.

Since the only relevant ground for functional ascriptions is organisational closure, all other criteria of distinction between biological systems may be considered as irrelevant for this specific purpose. This is why reproductive traits can be said to be subject to organisational closure and why, then, we ascribe functions to them.

3.3.2 *Malfunctions*

A second major implication of the organisational account is the characterisation of malfunctions. It is often claimed (see for instance Neander 1995; McLaughlin 2009; Krohs 2010, 2011; Christensen 2012) that a satisfactory theory of functions

¹³The fact that self-maintenance, in the form of closure, spans beyond the lifetime of individual organisms is an important aspect related to the historical dimension of autonomy. See Chap. 5 for a detailed discussion.

should be able to ground both functions and malfunctions,¹⁴ since a function can be performed well, or defectively, or even not at all. Yet, in spite of the fact that the concept of malfunction is widely used both in everyday language and in scientific disciplines such as physiology or medicine,¹⁵ the theoretical grounding of malfunctions has received little attention in the philosophical debate, which has mainly focused on the concept of function.

What is the gist of a philosophical account of malfunction? Claiming that a trait can function “well” or “poorly” implies a reference to a norm, which may or may not be fulfilled. Malfunctions, then, have a normative dimension, just as functions do. But, and here comes the central philosophical issue, the norms grounding functions and malfunctions are not the same, and an independent justification must be provided for each.

The closure of biological organisation provides the relevant grounding in which the concept of function can be adequately naturalised. In particular, it generates the norms that the traits subject to closure must fulfil in order to be functional: as we claimed, the organisational approach identifies these norms as the conditions under which the whole organisation (or, more precisely, each specific regime of organised self-maintenance, see Chap. 1, Sect. 1.8.1), and consequently each of its constituents, can exist. Thus, functional traits are all those whose causal effects contribute to the maintenance of the whole organisation.

Now, of the whole set of traits that fulfil the norms of functionality, some do so well and others poorly. Yet the norms generated by closure are blind with respect to the distinction between these two types of effects, because both of them contribute to the maintenance of the organisation (albeit in some cases poorly), and both are therefore *functional*. Hence, the distinction between (well-)functions and malfunctions requires an additional set of norms, on the basis of which it might be possible to discriminate between different ways of contributing to the maintenance of a closed organisation.

One important implication of this line of thought is that functions and malfunctions are by no means alternative kinds of entities; rather, malfunctions are a subset of functions that, while fulfilling the norms generated by closure, fail to comply with the norms of *well-functions*. This enables, among other things, a straightforward conceptual distinction to be made between *malfunctions* and *nonfunctions* (often confused both in ordinary use and specialised literature): while the former are indeed a class of functions, the latter do not. Nonfunctions refer to the effects of traits which do not comply with the norms generated by closure, and do not therefore contribute at all to maintaining the organisation. A kidney that does not filter blood, for instance, is nonfunctional rather than dysfunctional. The distinction between

¹⁴We prefer to use the term *malfunction*, because *dysfunction* is usually used to refer both to dysfunctional and nonfunctional behaviours.

¹⁵The concept of malfunction has often been used to justify the conceptual distinction between health and disease: some of the most influential groundings of the concept of disease have specifically interpreted diseases as malfunctions (Boorse 1977, 2002; Schramme 2007).

nonfunctions and malfunctions also serves to highlight the fact that malfunctionality is a *matter of degree* (Krohs 2010: 342). While functions are all-or-nothing concepts (a trait is either functional or nonfunctional), malfunctions admit degrees and a given trait can contribute more or less well (or poorly) to the maintenance of the organisation.

How does the organisational account deal with the concept of malfunction? Although no fully-fledged organisational definition of malfunction has been proposed so far, several authors whose approach could be considered within, or at least close to, the organisational account have pointed to a link between malfunction and adaptivity. For instance, Edin (2008) refers to malfunctions in terms of deviations from the “optimal self-maintenance” of a living system:

Organisms are typically endowed with multiple, extensive and complex feedback systems, many of which have a set point that, when considered from the standpoint of the maintenance of the organism, is close to optimal. For this reason, physiologists talk about events or circumstances that cause the variable magnitude of such a system to deviate from the set point as disturbances or challenges. (Edin 2008: 206)

Christensen and Bickhard (2002) also consider malfunctionality to be related to the adaptive properties of organisms:

There are a number of reasons why understanding the relative significance of dysfunction is an important adaptive issue. It is important to understand the wider systemic implications of failure in order to understand whether and how the system can compensate. It is also important to know how the system can recognise failure as part of its compensatory abilities. These are surely important issues for understanding functional organisation (Christensen and Bickhard 2002: 18).

In what follows, we will elaborate on this very idea, by relying on our characterisation of regulation exposed in Chap. 1, Sect. 1.8.2 above. As we discussed, biological organisms have to modulate their organisation to cope with the changes that they continuously undergo, be they internally or externally generated (for instance, in this second case, by a variation of the environmental conditions). Regulation is a specific form of modulation, such that a functional subsystem (a dedicated mechanism) of the organisation induces the establishment of a different and more adequate constitutive regime of self-maintenance, among a set of possible ones. Regulatory functions are, then, second-order functions (subject to second-order closure and norms) that modulate the constitutive set of functional traits and their interrelations.

In a nutshell, our account of malfunction is the following. The whole dynamic repertoire of the constitutive organisation on which regulation is exerted is limited by its physical and material structure, which implies, in particular, that each trait can only operate within a given potential range of activity. For each specific regime of self-maintenance that the system may adopt, a specific *admissible* range of activity, included in the potential one, can be determined.

If, because of some structural defect, a particular trait (1) does not modulate its activity in spite of the triggering of a regulatory mechanism and (2) as consequence, it is unable to operate within the admissible range determined by some of the

regimes of self-maintenance among which regulation governs the shifts, then the trait malfunctions in organisational terms. Let us explain this idea in more detail.

Within each specific realisation of a closed organisation (i.e. each regime of self-maintenance), functional traits *presuppose*¹⁶ each other, which means that the whole set of mutual interactions among them determines the range of admissible functional effects, defined as a subset of all potential effects that the trait may possibly produce, given its own structure. For example, a human heart can pump blood within a certain range of potential frequencies, among which a range of admissible frequencies are determined by each ongoing realisation of the organisation. Similar ranges apply of course to the lungs, kidneys . . . and to all other organs and functional traits.

Suppose that, in some circumstances, a regulatory mechanism is triggered to shift an organism from a given regime of self-maintenance to a different one. For instance, the autonomic nervous system (the regulatory subsystem, in this case), in a situation of danger, can send signals to move from a regime “at rest” to another one “under stress” in which the organism runs. Suppose also that, for some structural reason, one functional part of the organism does not modulate its activity and, as a consequence, it is unable to match the functional presuppositions of the regime induced by the regulatory functions. For instance, the coronary artery might not be able to increase its diameter sufficiently to match the higher rate of blood flow pumped by the heart: as a consequence, its range of activity is not in accordance with the functional presuppositions of the other functional traits and organs in this specific circumstances. Regulatory functions might therefore fail in modulating the defective trait’s activity, so to match the new functional presuppositions (fall within the admissible ranges). For that specific trait, in a word, regulation had no effect.

In these specific situations, in which an unresponsive trait does not modulate its activity as required by the intervention of regulatory functions and therefore prevents adaptive regulation to shift to a different first-order organisational regime, so that the whole system can only remain in a specific organisational regime in which the trait match the functional presuppositions, that trait is dysfunctional.

¹⁶The idea of functional presupposition was originally put forward by Bickhard (see for instance Bickhard 2000; Christensen and Bickhard 2002). We can understand the idea through the following example: “As everybody knows, the function of the heart is to pump blood, or more accurately to pump blood as a contribution to an ensemble of activities that result in blood circulation. The function that this serves, however, is to provide fluid transport for delivering nutrients to cells and removing metabolic end products. In this respect heart activity and cellular metabolism are interdependent processes. Without heart activity, fluid transport stops, and with it cellular metabolism. And if cellular metabolism ceases then heart activity also ceases, and subsequently fluid transport. In addition to heartbeat, cellular activity also produces other motor action that contributes to interaction processes such as breathing, food acquisition, eating and excreting. In turn these processes provide the resources required for cellular metabolism and expel waste products, thus contributing to the cellular processes that subserve them., . . . , These patterns of process interdependence in biological systems are (...) what determine the nature of organisms as viable (cohesive) systems” (Christensen and Bickhard 2002: 16–17).

The organisational account, therefore, interprets malfunction as any functional activity with respect to which there has been a *failure*¹⁷ of regulation. In other terms, malfunctions are a subset of functions that fit first-order norms (of the first-order ongoing organisation in which they match functional presuppositions), but *not* second-order ones (since they do not obey to second-order regulatory functions, and prevent the shift to another first-order organisation). In this respect, the degree of malfunction of a trait could be assessed in terms of the set of first-order organisations of which it prevents the realisation. The degree of malfunction is, therefore, inversely proportional to the degree of adaptivity of the organism (see also chap. 4).

Malfunction occurs when the autonomous system fails in regulating the activity of a trait, including the specific case in which regulation aims at compensating for a “defective” activity of the trait in a given organisational regime. This is a crucial implication, because were a given first-order regime of self-maintenance capable of compensating for the apparently dysfunctional activity of a trait, it would be impossible, from an autonomous perspective, to contend that the trait is malfunctioning. In such a case, its contribution to the system would, in principle, be indistinguishable from another contribution within the presupposed range of functioning. Indeed, if there were no higher-order regime with respect to which the behaviour of the trait is unfit, we would simply be faced, from the autonomous perspective, with a *different* organism (i.e. an organism that would function in a different, equally viable, way), and not with a malfunctioning one. For example, certain organs of the mole (i.e. those involved in sensory-motor activities) presuppose that its eyes provide very limited visual capacity, and that is why this animal is perfectly viable despite being almost blind (in fact some moles, like the star-nosed mole, display a remarkable foraging ability thanks to the star-shaped set of appendages that ring their nose). If there were no (failed) regulatory intervention, there would not be organisational criteria to interpret the behaviour of the trait as dysfunctional. On the other hand, if regulation were able to compensate for the operations of a defective trait – by shifting to a regime of self-maintenance in which the trait would match the functional presuppositions – there would not be organisational reasons either to contend that the trait is malfunctioning. In such a case, its contribution to the system would match both first-order and second-order norms, and therefore it would be theoretically indistinguishable from any other contribution within the presupposed range of functioning.

A trait that malfunctions is, first of all, a functional trait, in the sense that it contributes to the maintenance of a self-maintaining organisation. What happens is that this contribution is not made *according to certain second-order norm* and that is why we say that it is a “bad” or “poor” contribution. Malfunctional traits show

¹⁷In technical terms, the very possibility to detect a failure of regulation supposes that the admissible ranges of the ongoing organisation and the alternative ones (to which regulation should move the system) are, at least *partly, non* overlapping. This means that the regulatory intervention must result in an observable *change* of the defective trait’s activity.

a degree of malfunction rather than an “all-or-nothing”, “function-no function” dichotomy. And the effects of a functional trait are deemed “good” or “bad” according to the norm that lies in the action of a regulatory subsystem (Saborido et al. 2014; Saborido and Moreno 2015).

It could be argued (Artiga 2011) that, ultimately, the norms to which any organism is subject have been set through evolution by natural selection, which shapes the species it belongs to. In particular, each given set of second-order norms could be defined at the populational level, because it has been selected in relation to the conditions of a stable existence (over a long period of time, covering many generations) in a given niche. Thus, it is because of its contribution to the self-maintenance of a class of organisms that this particular normative mechanism exists. And this happens too with the shaping of the structure and organisation of functional traits.

Yet, there are two aspects in which the current organisation of individual organisms matters. First, though the mechanism of adaptive regulation of a given organism is set through an historical-collective selective process – because only those forms of modulation that ensure viable organisations (in specific environments) can be selected – ultimately the regulatory mechanism would not exist if it did not make a contribution to the self-maintenance of each individual system in which it operates. The second, and even more important aspect is that although the *origin* of the norm according to which something is deemed dysfunctional is ultimately an evolutionary matter, this does not mean that we cannot define, in the current organisation of each individual organism, whether or not a given trait is well-functioning or not. As Christensen has recently pointed out:

The aetiologist may point out that, living systems have infrastructure for self-perpetuation largely as a result of an evolutionary history., . . . nevertheless, . . . the key perspective for normative evaluation of function is the current system rather than past selection. Regulation does not succeed by making parts function as they did in the past, it succeeds by making the system work well in present conditions. (Christensen 2012: 107)

In this respect, we consider that the organisational account of malfunctions can include evolutionary considerations without falling into epiphenomenalism, i.e., an understanding of functional attributions appealing to something other than the traits’ current performance (see Sect. 3.1.2 above).

To conclude, we wish to emphasise that the organisational account to malfunctions does not rely on the subjective criteria of an external observer. What matters is what happens operationally within the system itself, and whether or not there is failure in adaptive regulation. Moreover, the normativity to which obeys the adaptive subsystem of a given organism is not defined with respect to a *type* of organisms but, rather, in relation to the current organisation of this organism and, more precisely, to the second-order closure to which regulatory functional traits are subject. This way of understanding the concept of malfunction is quite different from the most predominant notion of malfunction used in the philosophy of medicine, namely the bio-statistical conception, expounded by authors such as Boorse (1977, 1997), which claims that a malfunction is a deviation from

“normal” (i.e., the statistically more common) functional behaviour. The biostatistical conception has been fiercely criticised (Amundson 2000), and numerous problems and counterexamples have been put forward, so that its influence within the philosophy of medicine is declining (Khushf 2007).

The implications of an organisational account of malfunction are still to be explored and critically assessed. Yet, this account might open new directions in the search for a theoretical grounding of the notion of physiological disease, within an alternative naturalistic perspective.

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