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ORIGINAL RESEARCH

Teleology and mechanism: a dialectical approach

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Abstract
The paper proposes a dialectical approach to our understanding of the relation between teleology and mechanism. This approach is dialectical both in form and content. In *form*, it proposes a contemporary interpretation of Hegel's metaphysical account of teleology. This account is grounded in a dialectical methodology, which consists in scrutinizing the inherent limitations of a theoretical position that lead it to suppress itself and evolve into a better one. I apply the same methodology to the function debate. For Hegel, teleology can be understood in three main variants, which can be fruitfully mapped onto the three main positions in the function debate, the key conceptual distinction being whether teleological principles are understood as extrinsic or intrinsic. When it comes to autonomous systems, i.e. systems that embody the regime of *Geist*, extrinsic functionality must be grounded in intrinsic functionality. My approach is dialectical also in *content*, insofar as it concludes that intrinsic functional ascriptions rely on the relation of co-determination between the parts and the whole of a system, as well as between the system and its environment.

Keywords Teleology · Mechanism · Function · Dialectics · Perspectivism · Autonomy

1 Introduction

This paper addresses the relation between teleology and mechanism. This formulation might sound outdated, as teleology has been subsumed under the rubric of functional explanation for the most part of the twentieth century. The function debate, on the other hand, has been a constant in philosophy of science for more than fifty years, showing off a longevity with few peers but also an immobility that has justifiably generated the

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impression of a 'fruitless' and 'boring' exercise (Cooper, 2018; Lewens, 2004). Yet with the dominance of the neo-Darwinian synthesis being called into question (Laland et al., 2015; Pigliucci & Müller, 2010) and discussions of organismal agency beginning to make their mark in theoretical biology (Aaby & Desmond, 2021; Desmond & Huneman, 2020; Jaeger, 2023; Walsh, 2015), teleology might be making a comeback.

For the most part of its history, the function debate has seen two candidates fight for prominence over the explanatory import of functional statements. A first contender has been the dispositional account (Cummins, 1975) taken as a model by the new mechanist tradition, which over the past twenty years has come to play a central role in philosophical accounts of scientific explanation (Bechtel & Abrahamsen, 2005; Bechtel & Richardson, 1993; Glennan, 1996; Glennan, 2002; Illari & Williamson, 2012; Machamer et al., 2000; Wimsatt, 1994). The historical and to this day main contender of neo-mechanism is the evolutionary approach, which contrasts the dispositional account of functions embraced by new mechanists with an etiological account that qualifies functions as evolved adaptations produced by the feedback mechanism of natural selection (Godfrey-Smith, 1994; Kitcher, 1993; Millikan, 1989; Neander, 1991; Wright, 1973).

The new mechanist framework appeared as a response to the deductive-nomological approach, with its emphasis on laws and the subject domain of physics, to a focus on mechanisms as epistemological tools apt to deal with the complexity of biological and cognitive systems. When dealing with complex systems, we are not in the business of discovering general laws, but rather accounting for the specific role played by parts in the functioning of an organized whole. Attempting to do so, the new mechanist abides by a dispositional account where function is understood as the perspectival ascription on the researcher's part of a certain causal role to a particular item of a system, which explains the production of a certain effect. This implies a rather broad understanding of functionality, since anything that contributes to a determinate effect can be qualified as a function, invoking a disjunction of function and teleology.

For most new mechanists, who inherit Cummins' account, a function is individuated when the researcher singles out a particular phenomenon that requires mechanistic explanation, and is thus always relative to such explanatory interest. Instead, the etiologist takes teleology seriously as an objective feature of the system. This objectivity is grounded by the fact that functions are not just effects, but *selected* effects. In this perspective, function is a historical and stochastic result that can be attributed to the individual organism insofar as it belongs to a determinate lineage, i.e. as the token of a certain type. In this respect, while objective and endowed with teleology, function is still attributed to the system extrinsically, by a process that extends beyond its own boundaries.

In recent years, a third contender has joined the fray, coming from the multifaceted background of complexity science and currently articulated around the theory of biological autonomy. The autonomy tradition is built upon the pioneering work of Kauffman (2000), Maturana and Varela (1980), Pattee (1973/2012), Piaget (1967), Rosen (1972), and has been recently developed into a unified framework (Moreno & Mossio, 2015; Mossio & Bich, 2017; Mossio & Montévil, 2015; Mossio et al., 2009). This framework attempts to combine the teleological and objective conception of function, put forth by evolutionary approaches, with the focus on the system in

its current state, emphasized by the new mechanism. Such a combination is achieved through an account of functions that focuses on system organization and relies on a characterization of teleology as intrinsic purposiveness. In this perspective, function is the feature proper to an item of an organizationally closed system which contributes to its dynamical process of self-maintenance. Functions are thus objective features of the system, yet their objectivity is grounded in the contribution that the functional item makes to the whole system in its present state, not in the lineage-focused feedback mechanism of natural selection.[1]

In this paper, I approach this debate from a Hegelian angle, which proves fruitful to make sense of the metaphysical implications inherent to the positions at play. As is well known, Hegel operates according to a dialectical methodology that consists in analyzing the strengths and weaknesses of a particular philosophical position, emphasizing how its own internal limitations push it towards a better and more refined account. I apply a similar methodology to the function debate. This operation should hopefully appeal both to Hegel scholars and philosophers of science.

With regard to Hegel scholarship, several authors have stressed the proximity between Hegel and the autonomy framework (Gambarotto & Illetterati, 2020; Gambarotto & Mossio, 2022; Marques, 2016; Michelini, 2012; Michelini et al., 2018), in some cases portraying Hegel as an early endorser of an organizational account of functions (Cooper, 2020; Corti, 2022; Maraguat, 2020). These studies focus mainly on the sections of the *Philosophy of Nature* dedicated to the animal organism, mostly leaving aside the *Teleology* chapter in the *Science of Logic*. My analysis draws almost exclusively on the latter. This chapter comes at the end of a section ("Objectivity") where teleology is addressed after an in-depth assessment of the notion of mechanism. The relation between mechanism and teleology is seldom addressed in this literature, despite being of pivotal importance to understand Hegel's views on the matter (with the exception of Kreines, 2015, and Yeomans, 2012 discussed below).

With regard to contemporary philosophy of science, the paper adopts a Hegel-inspired dialectical methodology to address our understanding of the relation between mechanism and teleology. Among his readers, Hegel is well-known for his provocative claim that teleology is the truth of mechanism. This expression is here interpreted as arguing that organisms, as 'realized purposes,' are systems that exercise functional control over both their parts and their relation to the environment. They should thus be understood not only as passive objects of selective pressures, acted upon by a genetic program, but as autonomous agents. While neo-mechanism has been around for more than twenty years, philosophers have recently begun to question the limitations of this approach when it comes to accounting for features such as *regulation* and *control* or to address the phenomenon of organismal *agency*. This has led some to press the issue of a

[1] It is worth emphasizing that the tripartite distinction between dispositional (perspectival), etiological and organizational theories is not quite as neat and clear-cut as portrayed here, and shows a series of borderline cases. For example, while being a dispositional theory, Bigelow and Pargetter's propensity view (1987) offers a more objective take on functions. Similarly, the approach advocated by Winning & Bechtel (2018) and Winning (2020a, 2020b) entails both perspectival and organizational elements. On the other hand, past evolutionary history is not irrelevant to organizational approaches: evolution is just not considered as the objective foundation for teleology, but rather as the historical dimension in which the autonomous regime of biological organization is maintained across generations (see Mossio & Pontarotti, 2022; Pontarotti et al., 2022). For purposes of discussion we will still maintain this tripartition as heuristically valid.

potential integration between neo-mechanism and the autonomy framework (Bechtel, 2007; Bechtel & Bich, 2021; Bich & Bechtel, 2021, 2022a, 2022b; Winning & Bechtel, 2018), while others argue that this should lead us to call into question the primacy of mechanism and reevaluate teleology as a legitimate explanatory principle (Fulda, 2017; Sultan et al., 2022; Walsh, 2015, 2018). Hegel is certainly not a reference for any of these developments, yet his account establishes a fitting metaphysical foundation for them.

The argument goes as follows: Sect. 2 deals with Hegel's understanding of mechanism, emphasizing how, for Hegel, an adequate account of mechanism implies the reference to the complex network of causal powers that endow a mechanism with its functional determination: as often repeated in the literature, there are no mechanisms per se, only mechanisms for a certain phenomenon. Provided that an account of mechanisms requires functional determination and that teleology is, in this sense, the truth of mechanism, the point is how such functional determination is to be achieved. For Hegel, there are three main variants of functional determination: the subjective purpose, the means and the realized purpose. Section 3 employs the notion of a 'subjective purpose' to make sense of the approach to functional analysis proposed by Cummins and embraced by most neo-mechanists, with Craver as a pivotal instance. Section 4 employs the notion of 'means' to make sense of the artifact model of the organism embraced by etiological accounts, according to which natural selection explains the design features of organisms in terms of machine mechanisms. Section 5 employs the notion of a 'realized purpose' to make sense of the organizational account proposed by systemic approaches, which ground teleology in the autonomous nature of biological systems.

2 From categorical properties to networks of intrinsic powers

To evoke Hegel's name in a discourse concerning scientific explanation may appear as an iconoclastic gesture and it is impossible to take a step in this direction without some justification. A compelling ground for this operation is the particular account of causation assumed by the new mechanists, who understand causality as essentially instantiated by interaction (Bechtel & Richardson, 1993; Glennan, 1996; Machamer et al., 2000; Wimsatt, 1976 speak of an "interactionist tradition"). A criticism of the idea of causality as the 'property' of individual objects was a distinguishing feature of Hegel's metaphysics since his early Jena writings (1801–1802).[2] This idea remains a cornerstone of Hegel's mature metaphysics, as presented in *The Science of Logic* (1812–1816), where Hegel argues that the reference to single, supposedly isolated

[2] The reference to a number of interacting entities for causal explanation might be considered essential merely in the standard scenario — while admitting unique causes in particular circumstances. However, such 'particular circumstances' might be considered as well causally relevant. Some philosophers have advocated a restrictive use of 'cause' to mean salient factors that 'make a difference,' and not anything that contributes in some way to a certain phenomenon. Yet, even they generally recognise that the entities and events that 'make a difference' do so against a backdrop of 'enabling conditions' which from the point of view of other new mechanisms and Hegel's are, in fact, causally relevant (cf. Lewis, 1986, for whom a metaphysical distinction between conditions and causes cannot be drawn; but see the discussion of his view in Broadbent, 2008 and Bird, 2020; see also Hegel, 2010b §§148f.).

causes is always insufficient, arbitrary, and often empty. In this respect, for both Hegel and the new mechanist, the components of a mechanical system become functionally determined on account of the context in which they can manifest their causal powers.

This implies a criticism of the neo-Humean principle according to which "there are no metaphysically necessary connections between distinct, intrinsically typed entities" (Williams, 2019, p. 26). In a neo-Humean view, objects are essentially passive: they "can only act if pushed around by something outside them, like a law" (Ibid, 29). To the contrary, in Hegel's metaphysics, laws are understood as the product of relations among powers. In a similar way, contemporary powers theorists understand power as "a property that provides its possessor with the ability to bring about some states of affairs—the *manifestations* of the power—when the power finds itself in the appropriate circumstances" (Ibid, 49). In this sense, while powers are inherent to objects, their manifestation requires that they are placed in the right network of enabling conditions. Thus, "powers are not just the producers but also the produced" (Ibid, 51), because their causal determination is brought about by the particular place they occupy within the relevant enabling network.[3]

An illustration of these traits is nicely provided by the parts of simple machines. Simple machines such as a lever or an inclined plane can be broken down into a few rather simple components (such machines are hereby called "simple" for this very reason). And when isolated from a given arrangement, these components can be used to build other (simple or complex) machines: they just need to be rearranged in a proper manner. Once rearranged, they become parts of a different machine. For instance, the parts of a lever can be rearranged to build an inclined plane.

The disparate determination of mechanical objects in different enabling networks (credit: Edgar Maraguat)

As a consequence of such a functional rearrangement, components receive new names, which denote different manifestations of the causal powers inherent to them. In the context of a different arrangement, component-parts contribute in new ways to new effects, producing different phenomena, and thus acquire new functions. Function, however, is made possible only on account of a certain arrangement, i.e. a certain interaction among parts. Powers are thus essentially multi-track, as their manifestation depends on the relevant enabling network. Hence, a component becomes a determinate part of a particular machine by means of the causal influence of other parts, the

[3] Alan Love (private correspondence) emphasizes how "looking at scientific practice, we can see that molecular biologists identify entities (e.g., a protein, like a transcription factor) that have an activity (e.g., DNA binding) and are organized with other entities into a mechanism that activates gene expression to specify an axis in the embryo (i.e., a particular role). The same entity and activity at a different time and place in the embryo could play a different role. In this case, the entities do not seem properly characterized as indeterminate (a transcription factor still binds DNA), but rather their activity is consistent with playing many different roles depending on a mechanism's organization (and where it is in space and time during an organism's life history) and also other functional domains of the protein (cf. Golson & Kaestner, 2016)."

totality of parts, or the overall arrangement of parts. Abstracted from this arrangement, a component cannot contribute anything in particular to the causal production of the phenomenon. Yet, at the same time, it can be considered able to contribute to an indeterminate number of phenomena. As soon as the interaction with those other objects is interrupted, function reverts to pure potentiality. Thus, this account presupposes a subtle balance between intrinsicality and relationality: causality is the product of intrinsic powers which, on the other hand, require specific enabling conditions for their manifestation.

The Hegelian account of mechanism starts from the notion of a 'mechanical object,' which can be understood as representing a conception of causal powers as purely extrinsic. In such a conception, mechanical objects are fundamentally *indeterminate* causes, insofar as they can participate in the causal production of an indefinite number of effects with qualities of all kinds. As a consequence, the causal determination of the mechanical object is always conferred from without. As such, the object is in itself nothing more than pure indeterminacy, which does not take a specific form until it finds itself in a specific causal context. Its causal power is not inherent to it per se, but bestowed upon it by its relations with other objects. Even so, mechanical objects remain ultimately indifferent to the particular determination they acquire on account of their context. In principle, they are indefinitely reusable, and can always lend themselves to new uses, contributing to produce different effects in new contexts. As such, mechanical objects have no determinate causal roles. Their causal roles are determined solely within the transient 'Humean mosaic' they presently belong to.

Kreines (2015) has portrayed Hegel's account of mechanism as a shift from 'conceptless' to 'reasonable' mechanism. Conceptless mechanism implies a conception of causal roles as extrinsic to their bearers, while reasonable mechanism acknowledges that mechanical objects have inherent causal powers. Hegel aims to show "that mechanism is really testament to the need to take immanent concepts as a primitive case of explanatory import […] in virtue of which things are *directed* at characteristic effects" (Kreines, 2015, pp. 35–36). The fulfillment of this transition towards intrinsicality is found in the category of a 'realized purpose,' which defines the autonomous nature of living organisms. Once we get there, however, the object category is not enough anymore and needs to be overcome in favor of an agent theory.

In the introductory remarks to the Teleology chapter, Hegel emphasizes that "*teleology* is above all contrasted with *mechanism*" because while the latter defines a regime of causation in which there is "no sign of *self-determination*," teleology implies a form of spontaneity and autonomy that is usually associated with conscious intentional action. This is why, in general, "where there is the perception of a *purposiveness*, an *intelligence* is assumed as its author" (Hegel, 2010a, p. 651). Now, when it comes to questioning the foundations of each of these forms of causation, this kind of "*purposive connection* has proved to be the truth of *mechanism*" insofar as it can be said to be self-grounding; whereas in mechanical relations, "the *externally* determining object is itself *again just another such object*, externally determined and indifferent to its being determined" (Ibid, 652).

This point is not dissimilar to many early-modern arguments, assessed in Kant's third *Critique*, according to which blind mechanism is per se incapable of grounding the 'origins of order' in nature. In those arguments, teleology takes the form of "an

intelligence that *externally* determines the manifoldness of objects *through a unity that exists in and for itself*." And yet, the fundamental shortcoming of this understanding of teleology is that "it only goes as far as *external purposiveness*" (Ibid, 653).[4] It is in this respect that, according to Hegel, "one of Kant's greatest services to philosophy was in drawing the distinction between relative or *external* purposiveness and *internal* purposiveness" (Ibid, 654). This distinction has been largely disregarded by twentieth century biology, dominated by the framework of the Modern Synthesis, and in this respect the long-standing function debate is not an exception.

McLaughlin (2001) has pointed out that the two main theoretical options in the decades-long function debate can be traced back to the positions of Nagel and Hempel. While the former provided a framework for functional ascription that is essentially 'forward-looking', focused on the causal role of entities within a system, the latter developed a 'backward-looking' approach, focused on the selective history of traits as the ground for functional ascription.[5] These frameworks have generated the two main contenders in the function debate: the dispositional (or causal-role) account and the etiological (or evolutionary) account. McLaughlin's core argument is that a focus on 'self-reproducing systems' has the potential to evade the decades-long theoretical challenges that have plagued both accounts. In continuity with McLaughlin, I contend that dispositional and etiological accounts rely on an understanding of teleology as *extrinsic* purposiveness and that this creates a series of shortcomings when it comes to account for the teleological character of biological systems. A conception of teleology as 'realized purpose', i.e. as *intrinsic* purposiveness, has the potential to overcome such shortcomings.

3 Subjective purpose and perspectivism

Dispositional accounts of functions can be traced back to Cummins' functional analysis (1975).The goal of functional analysis is not to explain why a particular entity is where it is, but rather what its contribution is to a particular activity of the system of which it is a part. For this reason, however, the attribution of functions turns out to be rather broad in scope. Functions, in this interpretation, are just *effects*, and depending on the phenomenon that one is currently trying to explain, almost any entity and any activity which has a determinate effect within a system can ultimately be ascribed a function. Cummins accommodates the indeterminacy of causal roles by ascribing the determining role to the observer: his "basic idea is that an item has a function if it contributes to the performance of some particular capacity of a larger system, which

[4] The same point is made in the *Encyclopedia*, where Hegel argues that "the teleological relation in its immediacy is initially the external purposiveness, and the concept is opposite the object which is something presupposed" (Hegel, 2010b, §205). In the Addition, Hegel further specifies that "when speaking of purpose, one usually has one's eye only on external purposiveness. In this manner of considering things, they do not count as bearing their determination in themselves. Instead they count merely as means that are used and used up to realize some purpose lying outside them."

[5] It should be noted that while McLaughlin portrays Nagel's 'general-goal contribution' (1979) the antecedent of Cummins' causal-role account (1975), at a closer look Nagel's account reveals cybernetic features that position it closer to organizational approaches (see Boorse, 2002).

capacity engages our interest" but in doing so he "interprets almost any instrumental relation within any system as a function" (McLaughlin, 2001, p. 120). On this account, functional indeterminacy is connected to the idea that a collection of entities can make the object of different research interests, and the causal role (or 'capacity') of a mechanical object is determined as the function that is extrinsically attributed to it by the perspective of the external observer. What you get is thus just the semblance of teleology: function is parted from teleology and becomes just causal contribution (see also Cummins, 2002).

As such, this determination does not amount to a, or *the*, proper function of the object, but only to a perspectival ascription. Causal roles are thus always relative to the observer's perspective. Functional ascription is dispositional only in a subjective sense, as it concerns the causal role that is ascribed to the object in light of a particular perspective: "to ascribe a function to something is to ascribe a capacity to it which is singled out by its role in an analysis of some capacity of a containing system" (Cummins, 1975, p. 765). This implies the shift from a subsumption strategy, typical of the deductive-nomological approach, to an analytical strategy (Ibid, 759): instead of subsuming regularities under general laws, one should analyze the dispositions inherent to specific objects that allow them to manifest specific causal powers (at a particular level of description).

Neo-mechanistic approaches abide by this dispositional account of functions. This is evident in the landmark paper by Machamer, Darden and Craver, for whom "functions are the roles played by entities and activities in a mechanism. To see an activity as a function is to see it as a component in some mechanism, that is, to see it in a context that is taken to be important, vital, or otherwise significant" (Machamer et al., 2000, p. 6). The point concerns the capacities of the parts of a system, but since the explanatory context is always relative to the level of description, this approach is essentially dependent on the perspective taken by the scientist towards the system.

Most neo-mechanists do not consider functions to be inherent features of objects, entities or traits, but only ascriptions made on the basis of a particular explanatory goal. From this perspective, talk of proper-function is fundamentally inappropriate, because it gives in to 'substantivalist tendencies.' To the contrary, a dispositional approach sees function as a marker for the causal contribution that a particular entity, or mechanical object, makes to the system at the level of the organizational hierarchy that is currently under description. For Craver (2013, p. 134), the "causal structure of the world" is "disenchanted and purposeless" because functions are a mere projection. Mechanistic and functional descriptions "presuppose a vantage point on the causal structure of the world, a stance taken by intentional creatures when they single out certain preferred behaviors as worthy of explanation" (see also Craver, 2001).

This approach is fundamentally Kantian in nature. The relation between Kant's transcendental idealism and scientific perspectivism has been already emphasized in the literature (Cooper, 2018; Massimi, 2008). In claiming that function is perspectival, Craver makes a move analogous to the one made in the third *Critique*, where Kant argues that teleology should be understood as a regulative principle that arises only within the epistemic field of human cognition, not as real things in the world. To proper-function theorists, who believe that natural selection provides the objective ground Kant lacked in order to give teleology a naturalistic foundation (Gambarotto

& Nahas, 2022), perspectivists like Craver (2013, p. 135) respond that etiological histories are not enough to ground naturalism about function: functions are always perspectival, "imposed from without by creatures seeking to understand how a given phenomenon of interest is situated in the causal structure of the world."

This kind of Kantian, perspectival reading of teleology is not foreign to Hegel studies. Yeomans (2012, p. 190), for instance, has interpreted Hegel's 'priority thesis' in terms of functional analysis, as a case for the perspectival nature of mechanistic explanation. In order to produce an analysis of the causal roles of a relevant entity, we need first to establish a certain level of description, and in this sense "the identity of the objects in even mechanical systems is always specified teleologically." The individuation of relevant explanatory items is always dependent on the perspective of a rational agent (the researcher) who defines particular entities and activities as explananda or explanantia. In such a picture, "the identity conditions of objects are always teleological" (Ibid, 236) because they are dependent on a goal-directed perspective, which determines mechanical objects within a specific explanatory attempt.

In this reading, however, function attribution is fundamentally arbitrary. The first section of Hegel's treatment of teleology (the subjective purpose) is dedicated to the examination of such arbitrariness. Function is never an objective feature of mechanical objects, but only an extrinsic ascription. On this account, the mechanical object offers itself to arbitrary functional ascription, through which only it obtains (extrinsic) determination. Function is thereby the product of a "subjective concept" characterized by "*objective indifference*," "*externality* of determinateness" and "the shape of a *presupposition*." Function attribution is arbitrary with respect to the objects to be explained, extrinsic to them, and simply assumed as a starting point for explanation. Purpose, that is, is not something objectively inherent to the mechanical object itself, but only an extrinsic function attribution.

And yet, as emphasized in the literature, the extrinsic-instrumental nature of functional ascription necessarily leads to a form of infinite regress. As Cummins (1975, pp. 753–754) himself acknowledges, in this kind of functional analysis we are either "launched on a regress, or the analysis breaks down at some level for lack of functions, or perhaps for lack of a plausible candidate for containing systems." McLaughlin (2001, p. 122) elaborates on this point in compelling terms:

> If we abstract from our analytical interests, an item has a function only relative to the activity of some other entity, that is, only insofar as it contributes (say) to some function of the containing system; and this activity of the containing system only counts as having a function if it, in turn, contributes to a function of its containing system, etc. This does, in fact, take us on a regress with no natural end. It ends only when we say: this is the level whose activity we are interested in.

Abiding by a dispositional account of function, the new mechanism falls prey to precisely this kind of regress, implied by its approach to mechanisms 'all the way down', where the particular effect of a mechanism is explained by another mechanism at a lower level of the hierarchy (see Winning & Bechtel, 2018 for a discussion). The key feature of the etiological account is precisely the attempt to avoid such infinite regress by finding a stopping point in the feedback mechanism operated by natural

selection, but in doing so it falls under what Hegel would dub as another inadequate understanding of purposiveness, namely that of teleology as 'means,' which we explore in the following section.

4 Machine mechanism and the artifact model

According to Nicholson (2012) new mechanists inadvertently conflate the heuristic understanding of mechanisms as 'causal mechanisms' with the ontic conception of mechanisms as 'machine mechanisms.' Yet, as emphasized by Illari (2013), Bechtel (2008, p. 18) is rather explicitly committed to the idea that "explanation is fundamentally an epistemic activity performed by scientists." On the other hand, while Craver (2012) is in fact committed to an ontic conception of mechanisms, he is also committed to a form of perspectivism where functions are essentially understood as projective ascriptions (Craver, 2013). On this account, it is fair to say that the new mechanism rather inclines towards an epistemic understanding of mechanisms and an instrumental-projective conception of teleology.

In this section I qualify the claim that it is rather the evolution-driven etiological approach, and not the physiology-driven new mechanism, to rely on a conception of mechanism as machine mechanism. A machine mechanism implies an analogy between organisms and artifacts, which in turn raises the question of how such an analogy is to be understood. This conception is fundamentally related to a different conception of teleology, which is based on the original formulation by Christian Wolff, who understood teleology as a form of experimental theology, the part of physics deputed to provide insight into God's intentional action by taking into account the purposive nature of organisms (van den Berg 2013). This is the same sense of teleology embraced by William Paley in his famous watchmaker analogy, which constituted the fundamental critical target of Darwin's scientific endeavor (Ospovat, 1981). As widely emphasized in the literature, while modern biology was born in opposition to this intentional understanding of teleology, the shadow of the artifact model still lurks behind mainstream biological jargon (Gould & Lewontin, 1979; Lewens, 2004; Nicholson, 2013, 2019; Reiss, 2009).

J.B.S. Haldane famously used to say that teleology is like a mistress to the biologist, who cannot live without her but is unwilling to be seen with her in public. Mayr's (1961, 1974) notion of *teleonomy*, defined as a goal-directed process directed by a *program*, was the theoretical device used by the Modern Evolutionary Synthesis, in allegiance with the emerging molecular biology, to overcome this predicament. As argued by Jacob (1970, p. 17), the notion of program was in fact supposed to give legal status to the hidden affair between biology and teleology: evolution writes the program as a blind watchmaker (Dawkins, 1986), or a software engineer (Dennett, 1995), which is then carried out by genetic information. In this respect, Monod was very explicit in arguing that "through its properties, by the microscopic clockwork function that establishes between DNA and protein, as between organism and medium, an entirely one-way relationship, this system obviously defies any 'dialectical' description. It is not Hegelian at all, but thoroughly Cartesian: the cell is indeed a machine" (Monod, 1971, pp. 110–111).

This machine metaphor plays a central role in the account of function that owes most to the dominance of the Modern Synthesis: the *etiological* account, whose main point is to explain design features of organisms via the feedback mechanism of natural selection. The key idea is the similarity between the work of natural selection and intentional design. As argued by Kitcher (1993, p. 383), e.g., "the simplest way of developing a post-Darwinian account of functions is to insist on a direct link between the design of biological entities and the operation of natural selection," because in fact "each functional attribution rests on some presupposition about design and a pertinent source of design" (Ibid, 391). The result of this "is a general account of functions that covers both artifacts and organisms" (Ibid, 396). Just like Kitcher, "when Wright seeks a general analysis, he means, however, an analysis general enough to cover what is common to the functions in artifacts and organisms" (McLaughlin, 2001, p. 94; see also Lewens, 2004).

The origin of the etiological account can be traced back to Hempel (1965). A key aspect of Hempel's account is a *welfare* provision: "a function is supposed to confer a good or benefit on some system *S* or to contribute to the welfare of that system" (McLaughlin 2001, 69). Functions can thus be attributed only to systems for which normative considerations apply, relating to what is inherently good or bad for the system itself (Bedau, 1992a, 1992b). A machine has no welfare, only organisms do. This welfare provision is removed from subsequent etiological accounts (with the exception of Ruse, 1981). Wright (1973) is the first to drop the welfare provision. This exclusion causes the two main shortcomings of etiological approaches, which must: i) Attribute a function to traits that have the proper causal history but are no longer useful to the system, while ii) Deny function to novel traits that are currently useful but have not yet had the corresponding history of selection. The same is true for Godfrey-Smith (1994), Millikan (1989) and Neander (1991).

The notion of 'means' defines the extrinsic teleological character of artifacts: artifacts are teleological insofar as they are means to realize a purpose that is external to them. The justification of the purpose of the artifact does not need to be inherent to the artifact itself, it is sufficient that the purpose be ascribed to it from without. Also in this case, however, we fall into a form of infinite regress. The grounding of the purpose of an item is found in another item that is always external to it, until one finds a stoppage point in an intentional agent who designed or employs the artifact as a means to their own purposes. This works in the case of artifacts, but again, if we admit no intrinsic purpose, the teleological nature of the intentional stopping point is taken as a brute given.

Etiological approaches attempt to provide an objective foundation for natural teleology in the feedback mechanism of natural selection, which in turn, as in the case of teleosemantics (MacDonald & Papineau, 2006; Millikan, 1984, 2017; Neander, 2017), provides a naturalistic foundation for the very existence of intentional agents. By benefitting the system S, the *token* of a trait leads to the re-occurrence of its *type*. This reoccurrence *retroactively* justifies the ascription of function to the token. But the token per se does not have any function until it has undergone this feedback process of selection and retroactive justification. This leads to the key issue mentioned above: new traits that benefit the system in its present state but did not undergo the feedback process cannot be properly considered functional. This is the consequence of an

understanding of teleology as means: only an intentional agent (in the case of artifacts) or the feedback loop of natural selection (in the case of organisms), can *extrinsically* attribute function to a trait. In this case, organisms are understood as just a passive object of natural selection, not an active evolutionary agent (Lewontin, 2000; Walsh, 2015).

Hegel elaborates on this understanding of teleology in the second part of his teleology chapter. When teleology is understood in terms of means, the purpose is grounded in "an *external* existence indifferent towards the purpose itself and its realization" (Hegel, 2010a, p. 659). In the case of artifacts, the characterization of an item as a means comes with the ascription of utility for an external intentional agent, in the case of organisms, it comes with the utility posthumously derived by the feedback loop of natural selection. In both cases, purposiveness is an extrinsically ascribed predicate, not something established from within the boundaries of the system itself: the means "is a mechanical object that possesses purpose only as a determinateness, not as the simple concretion of totality" (Ibid, 660). Since the feedback loop is closed outside the boundary of the system, "the determinateness of the object through the purpose, by virtue of which it is a means" (Ibid, 661) is abstracted from it. In other words, "the purposive activity with its means is still directed outward, since the purpose is also not identical with the object" (Hegel, 2010b, §208). The system is thus (at best) the product of an extrinsic feedback loop, not a self-grounding 'strange loop' itself (Hofstadter, 2007, see also Marques & Brito, 2014).

Since Kant, the circularity of causes and effects has been defined as the hallmark of teleological dynamics, because the conditions of existence of a purposive system (which in a linear, hierarchical understanding of causality should be understood as the effects) are what determines, as a goal, the activity of a system. This circular dynamics takes place both in the case of *extrinsically* and *intrinsically* purposive systems, but with a key difference. In the former case the circular relation between causes and effects requires an external entity to close the loop: an artifact exists because the effects it produces benefit an external entity (e.g. the function of washing machines is to help me do my laundry). In this case, the regress stops and is turned into a loop in virtue of the purposive activity of an intentional rational agent. The artifact is said to be extrinsically purposive, because the circular relation is closed beyond its own boundaries. In the latter case, the loop between causes and effects can be closed *within* the boundaries of the system. When this happens, the system realizes a form of self-determination, because it establishes by itself its own conditions of existence, without the reference to an external entity to close the loop (see Gambarotto & Mossio, 2022 for a discussion).

The theory of natural selection grounds the difference between organisms and artifacts by providing an account of teleology not as the product of intelligent design, but as the product of the feedback mechanism of natural selection. And yet in both cases the feedback loop that grounds teleology is closed beyond the boundaries of the system. This happens because etiological approaches abide by a purely historical notion of function, with no relation to the system in its current state. Moreover, as philosophers and theoreticians have recently begun to argue the purposive character of living organisms is not a *consequence* of natural selection but rather its *condition*: natural selection results from the pressures exerted on organisms by environmental

factors and it explains the evolution of organismal form and function; but, in order for this process to unfold, intrinsically purposive organisms must exist and be struggling for existence in first place (Mossio & Bich, 2017; Toepfer, 2012; Walsh, 2015). As McLaughlin (2001, p. 149) puts it, in fact, "what has to be explained is not simply how the parts of the system got functions of any kind whatsoever, but how they got internally teleological functions." The mere reference to natural selection, and the corresponding 'juggling of types and tokens,' is not going to get us a satisfying answer. From a dialectical standpoint, in fact, this requires a different understanding of functionality as an intrinsic purpose, to which we now turn.

5 Nomological machines and organizational functions

So far, we have attempted to show how the first two determinations of teleology proposed by Hegel, the subjective purpose and the means, can be used to point out some key shortcomings in the dispositional approach to functions embraced by new mechanists, and the etiological account of function embraced by adaptationists. For the new mechanist, function is the extrinsic product of perspective; for the adaptationist, function is the objective yet also extrinsic product of the feedback loop of natural selection. Winning (2020a) defines these two approaches as 'external perspectivism' and 'non-perspectivism' respectively.

In this section, we explore a third alternative, coherent with Hegel's understanding of teleology as 'realized purpose,' where function is understood as the intrinsic product of system organization. This approach is consistent with McLaughlin's (2001) emphasis on self-reproducing systems, the organizational account of functions (Mossio et al., 2009) and the 'internal perspectivism' advocated by Winning (2020a, pp. 33–34), where "the proper function of a trait within a given system depends on the perspective had by the *system itself*." In this kind of approach, as argued by Hofmeyr (2017, p. 121), "while it is perfectly possible to describe any part of a system fully in terms of its constituents only, it is impossible to understand why that part of the system has the properties it has without considering it in the context of the intact, whole system."

Hegel's notion of a realized purpose aims to overcome the extrinsic nature of subjective purpose and means, and thus provide an objective foundation for the functional features of the system under consideration. This approach has an advantage over the former two insofar as, by grounding functionality from within the system itself, it avoids falling into forms of infinite regress. According to Hegel, "purpose must not determine the immediate object *as something external* to it," i.e. function needs to be grounded in the "self-determining activity" of the system itself. Extrinsic functional ascriptions are described by Hegel as a form of *violence* perpetrated on the object, "inasmuch as purpose appears of an entirely different nature." To overcome this we need to leave behind the idea of functions as subjective ascriptions or selected effects and embrace the idea of function as determined by the organization of the system. In such a conception, "the purpose does not just keep outside the mechanical process; on the contrary, it keeps itself in it and is its determination" and in this sense "it is equally the truth of mechanism existing in and for itself" (Hegel, 2010a, p. 663).

The point of a power ontology is to ascribe causal efficacy to dispositions that are inherent to objects. The dispositional account embraced by neo-mechanists is dispositional only in a subjective sense, being projective and instrumental. The etiological account embraced by adaptationists is categorical because dispositions are reducible to the genetic program as their causal basis. In an organizational approach, the components of a system become functionally determined only once they are embedded in an appropriate framework of enabling conditions, which allow them to exercise their causal power (Austin & Marmodoro, 2018 speak of 'structural powers' grounding the 'homeodynamic' unity of organisms). If this is the case, it is fair to say that the organization of a system causes the phenomena for which we hold mechanisms responsible. It is common to reject this inference, because parts are usually thought to determine wholes but not vice-versa. And yet this circularity of causes and effects is precisely what happens in an organized system, where the determination of each part is provided by the 'totality as form.' Against the idea that parts, and parts alone, determine wholes, teleology as a realized purpose implies that it is the whole which determines parts *qua* parts. Objects are determined as parts of a mechanism only on account of a particular organization, which additionally gives stability to the relations among parts. On account of the whole, the relation among parts is not simply contingent, but regular, and regularity is a fundamental feature of what we call a mechanism. Insofar as the whole is stable, the effects it produces are systematic and thus predictable.

The idea that a mechanical entity is given its determination as a cause by an objective context is not entirely unheard of. Articulating a dialectical view, Levins and Lewontin (1985) emphasized the role of the whole in determining the causal roles of parts. They argue that:

> It is not that the whole is more than the sum of its parts, but that the *parts* acquire new properties. But as the parts acquire properties by being together, they impart to the whole new properties, which are reflected in changes in the parts, and so on. Parts and wholes evolve in consequence of their relationship, and the relationship itself evolves. These are the properties of things that we call dialectical: that one thing cannot exist without the other, that one acquires its properties from its relation to the other, that the properties of both evolve as a consequence of their interpenetration (Levins & Lewontin, 1985, p. 3).

Another quasi-dialectical account of functions as determined by interaction is found in Cartwright (1999), who relates the limited value of general laws, as tools to explain particular phenomena, with the importance of context and interaction in determining causal effects. She expresses this idea with the concept of a 'nomological machine.' A nomological machine is "a fixed (enough) arrangement of components, or factors, with stable (enough) capacities that in the right sort of stable (enough) environment will, with repeated operation, give rise to the kind of regular behavior that we represent in our scientific laws" (1999, p. 50).

A system is 'nomological' if it produces phenomena that comply with a 'law.' But the law they comply with does not exist before the mechanism is operative—thus, the nomological machine produces a law: "Laws hold as a consequence of the repeated, successful operation of […] a *nomological machine*" (1999, p. 4). The idea of 'autonomy' as the capacity of a system to give itself its own law (Varela, 1979), as well as

the notion of an 'autopoietic machine' (Maturana & Varela, 1980), goes largely in the same direction. The arrangement of the system determines the exercising of causal powers in its members, which determines consistent, stable, or 'shielded' mechanisms, that in turn produce regular phenomena. Thus, if organization were merely occasional, ephemeral, it would make little sense to speak of a mechanism to begin with. On the other hand, it also makes little sense to think that we could recognize a series of causal events as a mechanism without the series somehow repeating itself (or having repeated itself often). In this sense, organization is essential to the determination of mechanisms with stable functions. As Cartwright and Pemberton (2013, p. 94) argue:

> What happens when a power exercises depends on the context. It generally, maybe even always, takes what Cartwright has called a 'nomological machine' to underwrite causal relations (Cartwright, 1999). Nomological machines produce the causal relations they do because of the way the exercisings of the various causal powers involved combine in the context of the machine to produce changes in the machine arrangement.

In this respect, "the machine arrangement dictates what can happen—it has emergent powers which are not to be found in its components." But if it is organization (defined as the stable relation between parts within the same system) which grounds causal roles, what explains the emergence of organization? To avoid infinite regress, this emergence must be grounded in a causal process that no longer has its determination outside itself, but rather within itself (or at least within the system of which it is a part). That is, the causal organization of mechanisms must have its origin in a process of *self-organization* which produces non-contingent effects. This implies that purely mechanical explanations are insufficient. This idea is not entirely dissimilar to the classical argument by Kauffman (1993), who submits that we cannot account for the origins of order via the exclusive reference to mechanisms, and rather need to uncover the principles of self-organization responsible for the production of systems capable of generating the genetic and phenotypic variation which selection can operate on (see Harris, 1998 for an excellent account of how this relates to Hegel).

This highlights the fundamental distinction between the previous determinations of teleology (subjective purpose and means) and the realized purpose. In the former case, the understanding of teleology does not go further than *extrinsic* purposiveness, falling into a form of infinite regress, in the latter case, teleology is understood as self-grounding *intrinsic* purposiveness. In the former case, the source of determination is found outside of the system: in the external perspective of the observer (dispositional account/external perspectivism), in an external intentional agent (artifacts), or in a feedback loop that extends beyond the boundaries of the system itself (etiological account/non-perspectivism); in the latter case, the grounding is found in the internal organization of the system.

Perspectivism is grounded on a key assumption: the fact that explanation is something done by rational agents who choose a specific stance from which to interrogate objectivity. And yet, the fact that there are rational agents to begin with, on which different stances rely, is something that does not get questioned further. A dispositional account of functions needs to assume perspectives as a brute given, evading the question concerning how it is possible that there are rational, intentional agents capable

of having perspectives and setting explanatory goals in the first place. The etiological approach, in the particular form of teleosemantics, attempts to provide an objective account of how rational, intentional agents come about, by reference to the feedback mechanism of natural selection, but since this feedback loop always extends beyond the boundaries of the individual organism, determination is still extrinsic and cannot account for functional traits of the organism in its present state. It is in this sense that intrinsic purposiveness should be considered more fundamental than extrinsic purposiveness: because extrinsic determination is fundamentally grounded in the intrinsic purposiveness of autonomous systems.

The way we should account for intrinsic purposiveness is the object of an ongoing debate, which goes under the rubric of organismal agency and whose central options are organizational and ecological approaches. Gambarotto and Mossio (2022) argue that this distinction can be characterized as the clash between Kantian and Hegelian stances. While the Kantian stance is concerned with "providing a mechanical explanation for the intrinsic purposiveness of organisms, which in turn requires decomposing the whole into its parts," the Hegelian stance implies a primacy of intrinsic purposiveness over both mechanism and extrinsic purposiveness, as the most adequate tool to account for biological and cognitive systems. In the former case, agency needs to be explained by articulating the features that make a system into an autonomous agent, with key importance to notions such as closure, regulation and control; in the latter case, agency is understood as a primitive notion, which needs to be assumed to provide an adequate explanation of gross biological behavior. In the remainder of this section, I briefly sketch these two different versions of an agent theory.

The organizational approach is Kantian, but in a distinct way. Kant's legacy for contemporary biology is very controversial and in fact "references to Kant as a 'notable precursor' can be found among philosophers and theoreticians with diverging, sometimes even opposed, research agendas" (Gambarotto & Nahas, 2022, p. 48). This is largely due to what some have defined as Kant's 'unstable position' with regard to teleology (Guyer 2001; Weber & Varela 2002). Such an unstable position has led to a division between heuristic and naturalistic interpretations of Kant's legacy. Dispositional and etiological accounts are both Kantian in the heuristic sense: in both cases teleology is just a manner of speaking, ultimately conceived as projective-instrumental or as teleonomy, i.e. the execution of a mechanistically established genetic program. Organizational accounts are Kantian in a different sense, in that they try to provide a naturalistic foundation for Kant's notion of intrinsic purposiveness.

The crucial tool in this endeavor is the notion of *constraint*, employed across the board to explain the emergence of goal-directed behavior. The concept was first formulated by Patteee (1973) and plays a central role in the work of Deacon (2011), Juarrero (1999), Kauffman (2000), Montévil and Mossio (2015) and Nicolis and Prigogine (1977). In general terms, constraints are items of a system that enable processes but are not affected by the processes themselves. In the autonomy tradition, the notion of constraint is fundamentally connected to the notion of 'work,' i.e. the constrained release of energy. Constraints are what allows the release of energy to produce work. An autonomous system is a system that harnesses that energy to produce the very constraints that are needed to produce work in the first place. This circular self-determining nature is what allows us to characterize such systems as intrinsically purposive. This

view is slowly beginning to make way in the neo-mechanist literature, which has most recently been engaged with the metaphysical foundations of mechanistic explanation (Winning & Bechtel, 2018; Winning, 2020a, 2020b) and its relation to the autonomy tradition (Bechtel & Bich, 2021; Bich & Bechtel, 2021, 2022a, 2022b).

Self-determination occurs in degrees and its particular nature is an open issue in the literature. Most notably, the question whether dissipative systems can be qualified as purposive, or whether such characterization should be reserved for biological systems, is still ongoing. In this respect, Kauffman (2000) considers autocatalysis as the minimal example of a 'Kantian whole,' i.e. a system that can be qualified as an autonomous agent; Toepfer (2012) concurs with this general appraisal, arguing that physical cycles (such as the water cycle) can be properly qualified as teleological. On the other hand, Deacon (2011) proposes a fundamental distinction between 'morphodynamics,' the self-organizing processes in the physical regime such as candles or whirlpools, and 'teleodynamics,' the goal-directed behavior of biological agents: (see also Deacon & Cashman, 2013). Mossio and Bich (2017) embrace a similar distinction between cycles in the physical and the biological regimes, grounded on the idea of 'closure of constraints,' which would be instantiated by the former but not by the latter. Beyond these intramural controversies, however, there seems to be a general agreement on the idea that mechanistic powers are grounded in the organization of the system, which in turn is grounded in the constraints that such organization imposes on its parts.

The ecological approach is not rooted in autonomous systems research and rather grows out of evolutionary biology. A key reference in this respect is Lewontin's (2000) notion of organisms as active subjects of their own evolution, which is making a comeback on the background of current debates over the explanatory limits of the Modern Synthesis (Laland et al., 2015; Pigliucci & Müller, 2010). Most notably, Walsh (2015) argues that, being based on population genetics, the Modern Synthesis is an 'object' theory and that, as such, it cannot accommodate organismal agency. Object theories attempt to explain the dynamics of objects within a given state space, but the principles governing the dynamics are extrinsic to the objects themselves. Applied to organisms, object theories expunge all forms of autonomy and frame them as passive objects of evolutionary pressures. An 'agent' theory, instead, is committed to the idea that (at least some of) the principles governing the behavior of organisms come from within the organism itself and have causal efficacy over external conditions.

The organizational approach is dialectical in that it qualifies organisms as autonomous systems marked by a co-determination between parts and whole, the ecological approach is dialectical in that it qualifies organisms as agential units marked by a fundamental co-determination with their environment. The organizational approach implies a naturalist interpretation of Kant's philosophical legacy; the ecological approach displays a more distinctive Hegelian flavor.[6] The key difference

[6] It is worth mentioning that proponents of the ecological approach such as Fulda (2017) and Walsh (2018) refer to Aristotle as their theoretical background. The characterization of their approach as Hegelian, however, is legitimate both on historical and theoretical grounds. Historically, Hegel's account of teleology is adequately characterized as a combination of Kant's notion of intrinsic purposiveness with Aristotle's idea of purposiveness as an objective feature of organisms (Michelini, 2012). Theoretically, the ecological approach complies with the Hegelian stance on intrinsic purposiveness (as defined by Gambarotto and

between Kantian and Hegelian approaches turns on whether teleology can be reconciled with mechanism or should be taken as an explanatory primitive. Hegel did not try to address Kant's problem, namely the reconciliation between teleology and mechanism, and rather maintained that teleology is the truth of mechanism. This statement can be interpreted as meaning that agency should be taken at face value as an observable property of organisms as integrated wholes in relation to their environment (Gambarotto & Mossio, 2022). Historically, agency has either been reduced to mechanical processes, like the genetic program, or reserved to full-fledged cognitive capacities with propositional attitudes, considered to be above the mechanical level. The challenge of the ecological approach is putting forth a picture of organisms as neither dominated by pure mechanisms, nor as cognitive agents (Fulda, 2017). Organismal agency should thus be understood as a fundamental property of the gross behavior of organisms, that ought to be accounted for in its own right.

In this sense, agency is not something to be 'reconciled' with mechanism, because "agency and mechanism are not exclusive categories. Agents are mechanistic. However, although agency is mechanically realized, agency is not itself a mechanism but a gross dynamical pattern of adaptive, purposive behavior" (Ibid, 4). Agency should rather be assumed as a 'primitive' notion that is used to do the explaining, implying a full battery of theoretical concepts such as "*goal*, *means*, *affordance*, *repertoire*, *salience*, *reciprocal constitution, normative requirement*, *hypothetical necessity*, *teleology*" (Walsh, 2018, p. 274). This is a fundamentally anti-reductionist strategy: explanation does not consist in reducing a particular level of description to a more fundamental one, but rather in postulating theoretical tools that are adequate to the particular level of description we are interested in. When it comes to biological and cognitive systems, teleology is the right tool to use. Interpreted in this light, Hegel's scandalous thesis might appear more palatable, perhaps even reasonable, to the contemporary philosopher of biology.

6 Conclusion

In this study, I have proposed a dialectical approach to our understanding of the relation between teleology and mechanism. This approach has been dialectical both in form and content. In *form*, because what I have proposed is, at its core, a contemporary interpretation of Hegel's metaphysical account of teleology. This account, like the entirety of Hegel's philosophy, is grounded in a dialectical methodology that consists in scrutinizing the inherent limitations of a theoretical position that lead it to suppress itself and evolve into a better one. I have applied the same methodology to the long-standing function debate. For Hegel, teleology can be understood in three main variants, which can be fruitfully mapped onto the three main positions of the function debate.

Hegel's notion of teleology as a 'subjective purpose' has been used to make sense of the dispositional account of function, embraced by the new mechanism, according to

Footnote 6 continued
Mossio, 2022): it takes purposiveness as a primitive concept of organismal behavior and uses it to account for the organism-environment relation.

which the determination of mechanical entities is the result of the extrinsic perspective of the researcher. This option dissociates function from teleology and classically ends up with a deflationary understanding of functionality as mere effect. It moreover falls into a form of infinite regress insofar as perspective is assumed as a brute given that is always open to further negotiation. The second variant of functional ascription is a characterization of teleology as 'means,' which has been used to make sense of the etiological account, embraced by adaptationism, which implies a more or less explicit assumption of an artifact model of the organism. Teleology is thus ascribed to the system from the outside and produces the classical issue where new traits that contribute to the welfare of the system, but have not yet undergone the feedback loop of natural selection, cannot be properly considered functional.

These shortcomings are overcome in the idea of teleology as a realized purpose, which can be considered as the mark of many systemic approaches: those that attempt to ground functional ascriptions on the organizationally closed nature of biological and cognitive systems. I have tried to show how this notion fits into current conceptions of organismal agency, which come in two main variants: organizational and ecological. The organizational variant attempts to reconcile the Kantian antinomy of teleology and mechanism by showing how regulation and control come about in an organizationally closed system that constrains the causal powers of their members into a self-maintaining regime. Such an understanding, classically associated with the autonomy tradition, has most recently begun to make a mark on a minority of mechanists who are coming around to take the intrinsically purposive nature of autonomous systems seriously. The ecological variant takes the Hegelian route, considering teleology as a primitive concept that cannot and should not be explained mechanistically, but rather employed to explain the organism-environment relation. Thus, my approach has been dialectical also in *content*, as I have been arguing that the most appropriate account of teleology is itself dialectical: it relies on the fundamental relation of co-determination between parts and whole in the organism, as well as between organisms and environment.

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