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A PLEA FOR THE PLURALITY OF FUNCTION

TONY CHENG

h.cheng.12@ucl.ac.uk

University College London

ABSTRACT. In this paper I defend a pluralistic approach in understanding function, both in biological and other contexts. Talks about function are ubiquitous and crucial in biology, and it might be the key to bridge the “manifest image” and the “scientific image” identified by Sellars (1962). However, analysis of function has proven to be extremely difficult. The major puzzle is to make sense of “time-reversed causality”: how can property P be the cause of its realizer R? For example, “pumping blood” is a property of hearts, but a *property* of hearts cannot be the *cause* of the presence of hearts, since properties cannot predate their realizers and be causes of them. In section 2 I discuss Wright’s etiological analysis, Cummins’ causal-role analysis, and their critics. In section 3 I defend a version of the “consensus without unity” strategy proposed by Godfrey-Smith from Christopher Boorse’s recent critique (2002). In Section 4 I conclude by reflecting on the relation between functional discourses and physicalism.

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[It is] difficult for any one who tries to make out the use of a structure to avoid the word purpose.

—Charles Darwin, a letter to A. de Candolle

1. Function and Its Place in Nature

Talks about function are ubiquitous not only in daily life, but also in biological sciences. “The function of the heart is to pump blood” is a proposition that is accepted by most lay people and biologists. However, to provide a satisfactory analysis of function is never an easy task. As Peter Godfrey-

Smith once observes, “[t]hrough the 1960s philosophers became accustomed to long and intricate definitions of functions – at least six lines long and four variables deep” (1993/1999, p. 186). This situation has been changed dramatically after we had the more elegant analyses provided by Larry Wright (1973) and Robert Cummins (1975) respectively. However, the matter has not been settled until today, since there are still many putative counterexamples to both of them, and philosophers are still trying very hard to improve this or that analysis, as we shall see.

But one might wonder why we should care about this project in the first place. After all, talks about function seem to be very ordinary, and philosophers do not analyze ordinary notions we use unless the notions in question carry special theoretical weights. So what is so special about function? There are many ways to see this, but one vivid way is to consider Wilfrid Sellars' distinction between the “manifest image” and the “scientific image” (1962). On the one hand, as a *teleological* notion “function” seems to be a denizen of the former, but if so how can biology as a *science* invoke it at all? On the other hand, we do also talk about function all the time when we describe inanimate stuffs as well, such as artifacts, and they fit well in the mechanical worldview. So in other words, if we cannot make intelligible our reliance on function, then the status of biology is in trouble, but if we make it intelligible successfully, then it can be the key of bridging the two worldviews. Given this, analyzing the notion(s) of function is not simply an intellectual exercise of philosophers. It is a project that if we fail to carry out, we are in trouble, but if we succeed, we will thereby steps forward in answering the big question about human nature.

For those who are unimpressed by the Sellarsian worry, here are some more examples why we should care about this. Within biology, evolutionary biology deals with DNA, and the distinction between junk and functional DNA becomes important in these years; there are substantive disagreements about how to understand the notion of function in that context (Germain, Ratti, and Boem 2014). Some have used cases in molecular biology to argue for etiological selectionism, i.e., against Cummin's account (Sustar and Brzovic 2014). In neuroscience, the discussion of biological function has become important too (Craver 2013; Garson 2011). Similar can be seen in the context of medical science as well (Holm 2014). Function talk in biological sciences is indeed ubiquitous; this by itself is enough for us to worry about analysis of function.

In section 2 I will introduce Wright's etiological analysis, Cummins' causal-role analysis, and their critics. In section 3 I defend a version of the “consensus without unity” strategy proposed by Godfrey-Smith from Christopher Boorse's recent critique (2002). In Section 4 I conclude by reflecting on the relation between functional discourses and physicalism.

2. Etiology, Causal Role, and Their Critics

Before introducing both influential analyses, some more backgrounds are needed. We have seen that there is a potential tension between teleology and the rest of the world, but there is a more urgent, concrete problem with the teleological talks. This is the so-called “time-reversed causality.” Consider the function of the heart again. Biologists once asked, “why do vertebrates have hearts?” The answer seems plain: “they have hearts *because* hearts pump blood.” But this generate a puzzle: “pumping blood” is a property of hearts, and a *property* of hearts cannot be the *cause* of the presence of hearts, since properties cannot predate their realizers and be causes of them. This problem is more pressing than the general problem identified in the first section, because the present one is not about how biology can be a real *science*, but about whether biology conforms general *metaphysical* principles: a property P cannot be the cause of its realizer R, since properties cannot reverse time.

Now how does Wright’s analysis avoid this problem? Let’s introduce the analysis first. For Wright, “the function of X is Y” should be analyzed as:

- (a) X is there because it does Y,
- (b) Y is a consequence (or result) of X’s being there. (1973, p. 161)

The example of the function of the heart, then, should be analyzed as (a) hearts are there because they pump blood, and (b) pumping blood is a consequence of hearts’ being there. Here the “because” in (a) captures the teleological aspect of function, and crucially, Y as a property of X does *not* predate and cause X; it instead is an effect of X. To situate this in an evolutionary context, “[t]he key to understanding how functions explain the presence of the traits or behaviors is to recognize that a trait’s having a function is a matter of its *etiology*, the historical circumstances of its emergence” (Rosenberg and McShea 2008, p. 89, original emphasis). Thus the problem of reversing time has been avoided. It is often related to the selected-effect view (SE) developed later.

Not surprisingly, however, this analysis also has its weakness. First of all, it has some putative counterexamples (e.g., Boorse 1976). Secondly, proponents of this analysis need to make a choice between distance past, recent past, and present when it comes to details about how natural selection favors a trait’s effect for it to be its function (Kitcher 1993, Boorse 2002). Moreover, although modified Wrightian analysis might be good at capturing functions in behavioral ecology, there are many other domains “such as biochemistry, developmental biology and much of the neurosciences, which are hard to fit into this mold, as functional claims in these fields often appear to make no reference to evolution or selection” (Godfrey-Smith 1993/1999, p. 189). To

say all these is not to say that Wright and his followers cannot make improvements on the analysis; it shows, however, why some others are attracted by a very different view. This is where the analysis offered by Cummins emerges (the “causal-role” analysis, CR).

One main difference of Cummins’ analysis is its generality (recalled the third point mentioned just now). The way to achieve this is to eliminate the supposed teleological content. This analysis is more complicate than Wright’s one so I do not quote it here, but the idea is this: suppose we have a function F to be accounted for. Cummins argues that attributions of functions are always relative to some “analytical account;” in order to understand F, we need to understand how F contributes to certain more complicated capacity within a given system. Again consider the function of the heart. An organ is a heart relative to an analytical account of how its capacity to pump blood contributes to the circulation of the organisms that contain the organ. One can understand this as a more deflationary account of function. Since it is more deflationary, it can accommodate more varieties of function than the Wrightian one does. However, this induces an opposite worry. As Cummins himself notices, one might suspect that on his account “the function of the heart is to produce a variously tempoed throbbing sound” (1975/1999, p. 78). Again, this is of course not to say that the analysis is thereby defeated, and Cummins himself does try to get around it. We will see more putative counterexamples in section 3. Now I shall discuss the relations between these two mainstream analyses.

There are various ways to respond to the current situation. One can keep refining the analysis she favors. One can also propose an entirely different analysis (e.g., Wimsatt 1972, 2002). If one finds both Wright’s and Cummins’ views plausible, one can either try to unify them or give a pluralist account. Phillip Kitcher (1993), for example, attempts to unify the two analyses with the notion of “design.” Godfrey-Smith (1993) instead offers a pluralist view against the unity view. In the next section I further defend the pluralist view, but obviously I cannot defend it from criticisms from all other views. I shall only briefly talk about some *prima facie* reasons for the pluralist view over the unity view.

One common intuition in this context is that unity should be the default view. As Godfrey-Smith puts it, “many people will find a fused or unified concept of function more attractive...” (1993/1999, p. 190). But what is the justification of this preference? One obvious source is the invocation of simplicity or parsimony. However, a reflection on Nelson Goodman’s famous example (1955) should show that simplicity is relative: for us, we use green and blue to understand grue and bleen. For another culture perhaps, they use grue and bleen to understand green and blue. That is to say, for them green is the property possessed by grue things before a certain date and by bleen

things after that date. Similar consideration can be found in W. V. Quine (1960) and Saul Kripke (1982). One does not need to buy the story of radical translation or deviant arithmetic to get the point against absolute simplicity.

I also do not think that the pluralist view is default here. I suggest that we look at particular examples to see whether they are indeed similar enough to support the unity account. On the face of it, Wright's analysis is very different from Cummins' one. The former takes the teleological content very seriously, while the latter denies it. It is not clear why one is motivated to offer unification except for the belief that unity is always better. Again, I do not pretend that this is an objection to Kitcher's view. I offer only some reasons to think that the theoretical motivation behind the unity view is not as strong as it appears. I now turn to the pluralist account.*

3. Pluralism and Putative Counterexamples

Pluralism in this area can at least be traced back to Ruth Millikan (1989). The view can be stated like this: "We should accept both senses of function, and keep them strictly distinct" (Godfrey-Smith 1993/1999, p. 190). Although disunity is generally not welcomed in philosophy, this view has become more popular perhaps due to the difficulties of other views. As Boorse observes, "all the writers [e.g., Millikan 1989, Neander 1991, Godfrey-Smith 1993, Griffith 1993] seem to be CR-SE 'pluralists,' a recently popular view..." (2002, p. 66). In criticizing this pluralism, Boorse identifies three scope problems:

- (1) SE (the Wright analysis) is too narrow for biology.
- (2) SE is too broad in some other cases.
- (3) CR (the Cummins analysis) is too broad.

Now, as Boorse says, (1) is not really a problem for the pluralist view, since "it escapes the SE view's excessive narrowness by shunting onto a CR alternative any unselected functions that arise in anatomy, physiology, exaptation, mutant individuals, and so on" (2002, p. 67). The real troubles are (2) and (3): both disjuncts are too broad, though for different reasons. Boorse then compiles many putative counterexamples to support his claim. In this section I deal with these examples.

Let me start with (3). It implies that "the function of mists is to make rainbows" (Bigelow and Pargetter 1987, p. 184). This sounds off key since mists is not supposed to be something that has a function like this. People might use mist to do something and thereby endow a function to mists, but mists do not have any function by itself. It does not have a *purpose* in the world.

It is not very surprising that Cummins' analysis faces this seeming difficulty. After all, as we identified earlier the key of this analysis is to empty the teleological content. If so, then it does generate examples like the function of mists, since there is no teleological content in mists and their effects. Now why is this a problem? The reason, I submit, is that it sounds *weird* to us; we do not use the word "function" in this way. In other words, it looks problematic for semantic reasons. But we need to remember that we should not see ourselves as conducting linguistic analysis here. Although that might be what many philosophers have in mind, I submit that this is misleading. The reason is simple: in ordinary language, talks about function are *clearly* teleological. If someone proposes an analysis that aims at eliminating the teleological contents, as Cummins does, the more charitable interpretation is that in doing so, he is giving the word some new meanings. If not, then the analysis would be *obviously* a failure, since it fails to capture the core of ordinary discourses about functions. We should not see Cummins' project this way. He is providing a useful concept for some branches of sciences, for example anatomy and physiology, as quoted above. Since in those sciences we do need something like that, and both our folk notion and Wright's notion fail to capture it, Cummins' analysis is proposed in order to fill the lacuna.

A natural objection to this move is to say that this is simply a stipulation, and therefore not very interesting. Everyone can stipulate how to use words in certain ways, but this becomes a verbal game and there is nothing to take issue with. My reply to this is that although Cummins' analysis provides some new meanings of "function," it is not arbitrary at all, as the accusation of stipulation implies. It has independent reasons, that is, the analysis corresponds to what we need in certain branches of sciences. Now, the example of mists and their function is not within the domain of those sciences. Given this, no wonder it sounds strange, since the notion is not applicable outside certain domains. The word "function" is used in so many sciences and ordinary discourse, so it does not make sense to expect that we can distil a universal analysis of it and then apply the analysis to whatever other domains.

The line I am pushing is close to this thought from Godfrey-Smith: "there is no strong reason for using the same word." He does not propose other words for them, since he "doubt[s] if linguistic reform is possible here" (1993/1999, p. 197). I share this doubt too, but I still venture to propose a new phrase for Cummins, since even though in practice no one will cease to use "function" in Cummins' context, to propose the phrase can improve our understanding of it. The proposal is to replace "the function" for "one salient effect." We do not have teleology in the notion of "effect:" the movement of a billiard ball can be an effect of another movement from another billiard ball, and there is no function in any thick sense here. And it is only "a salient," not "the," since Cummins' analysis is broad enough to encompass more than one

effects of a given entity. Wright correctly observes that in his analysis, “a” and “the” do not make a difference (1973/1999, p. 31). This is another crucial difference of Cummins’ analysis. Consider the function of the heart again. One putative problem for Cummins is that according to his analysis, generating certain noises becomes a function of the heart too. However, if we instead use “a salient effect,” then the oddity evaporates: “a salient effect of the heart is to make certain noises.” This still sounds weird, but this is because Cummins’ analysis is not designed for this domain. This case is especially suitable for a Wrightian analysis, as we have seen. This is why we need a pluralist account.

In this way, we can explain away the oddities in other putative counter-examples. Consider “the function of rocks in a river is to widen the river delta” (Kitcher 1993, p. 390). It can now be paraphrased as “a salient effect of rocks in a river is to widen the river delta.” No problem. “The function of clouds [is] to make rain with which to fill the stream of rivers” (Millikan 1989, p. 294) becomes “a salient effect of clouds is to make rain with which to fill the stream of rivers.” The same goes for “the function of a piece of dirt stuck in a pipe is to regulate the water flow” (Griffiths 1993, p. 411). Similarly, our “liver’s capacity to house liver flukes” can have a salient effect of killing people (*ibid.*). Oncogenes (sadly) also have a salient effect of killing people (Kitcher 1993, p. 390), and so on.

Now let’s turn to (2). Wright’s analysis faces many putative counter-examples in non-biological domains too (Boorse 1976, p. 72; Bedau 1991, p. 648). However, since it is most powerful in the domain of biology, as the example of the function of the heart indicates, let’s focus on examples within biology. Here Boorse refers to examples from Godfrey-Smith: junk DNA, selfish DNA, and segregation distorter genes (1994/1999, pp. 203–4). These are difficult cases for Wright’s analysis since they do not seem to have any function (for the larger system) at all. However, I am puzzled by Boorse’s strategy here, since he refers to Godfrey-Smith’s examples without discussing his proposed solutions. I find two of Godfrey-Smith’s proposals initially plausible. The first is the “more heartless approach” (*ibid.*, p. 205) that “the theoretically important category of properties, the category our concept of function should be tailored to, is simply the category of *selectively salient powers and dispositions*” (my emphasis; he does not endorse this view). The second is a view similar to R. N. Brandon’s one (1990) which “requires that a functional trait increase the ‘relative adaptedness of [its] possessors’ (1990, p. 188)” (*ibid.*, p. 205). Since Boorse does not spell out his objection to any of these responses, I shall leave the point as it is now.

Before closing this section, I would like to discuss three analogies from other discussions of philosophy. The first is the analysis of knowledge. We are all familiar with the post-Gettier history of epistemology. In addition to

many unified account, we also see pluralist ones, for example Ernest Sosa's distinction between reflective knowledge and animal knowledge (1991). Again, this view does not become a consensus among philosophers, but one resistance is certainly from the longing for unity. Now, "function" is arguably a more ubiquitous notion than "knowledge," so it should be unsurprising at all if we need a pluralist account. Secondly, we have H. P. Grice's distinction between natural and non-natural meaning (1957). One case of non-natural meaning is that dark clouds mean that it might rain soon. Here one may object that this does not fit what we mean by "meaning," since often we treat it as manifestations of intentions, but clouds do not have intentions. This is similar to the objection to Cummins that according to him, functions become too broad. What we need to bear in mind is that the current project is not ordinary language analyses. What we need is to identify theoretically useful notions. If they sound different from ordinary usage, what we need to do is to use them with extra cares, as opposed to repudiate the theoretical usage altogether. This brings me to the third one, the notion of inference. Normally, we think of inference as consisting of premises and conclusions. They all have propositional contents, and the semantic or syntactic relations between them are inferences. Now, we also use the word "inference" to talk about, say, visual systems in psychology and neuroscience, but obviously visual systems do not conduct "arguments" like we do. What should we do about this? Should we pursue a unified analysis of "inference" so as to encompass its normal and scientific usages? Arguable not. We should respect both usages, and try to understand them respectively. If this is so, then it is not clear why in the case of function we should expect to have a unified account.

4. Function, Physics, and Physicalism

In this final section, I consider the relation between functional discourses, physics, and physicalism. Let's start with the first two items. One important feature of physics is that it does not contain any functional talks. As David Hull once puts it,

Just as a physicist might say that heating a gas causes it to expand, a biologist might say that heating a mammal causes it to sweat. But a biologist might also say that a mammal sweats when heated in order to keep its temperature constant, while no physicist would say that a gas expands when heated in order to keep its temperature constant – even though that is exactly what happens. (1974, p. 102)

Now given the above replacement of "the function" with "a salient effect," it is not a problem to have some deflationary talks about function in physics.

However, it should be obvious that in physics, we do not have more robust notion of function that has teleological contents. Thus the relation between function and physics is relatively straightforward.

The relations between functional discourses and physicalism are more complex. Moderate, non-reductive physicalism has it that everything is ultimately physical, but it does not mean that we can find bridge principles for every term in special sciences. Extreme, reductive physicalism has it that although it is hard to carry out in practice, in principle every significant term in special sciences should be able to be translated into a more fundamental level, and physics is the most fundamental one. The relation between gene and DNA is a paradigm example. Now why is this relevant to our discussion? Because if we hold reductive physicalism, then our talks about functions in biology should be translated, and perhaps thereby eliminated, at the end of the day. This is threatening for everyone who wants to keep talking about functions in biology, but it is especially bad for pluralism because the main point of it is to respect the view that talks about function are *ubiquitous*. This is exactly the opposite direction to reductive physicalism, which holds that there should be *none*.

A representative of this position is Quine. “Causal Explanations of psychology are to be sought in physiology, of physiology in biology, of biology in chemistry, and of chemistry in physics – in the elementary physical states” (1979/2008, p. 286). As far as I know, although Quine pushes strong physicalism in his entire life, he never really spells out how to deal with functional talks in biology. For him, everything normative should go. He does more in domains such as epistemology (1969), but the common reaction to it is that it thereby changes the subject. I suspect that it would be the common reaction too if one really tries to eliminate teleology and normativity in biology.

A different line of objection comes from John Searle. It has been called the “triviality argument” (Godfrey-Smith 2008). Searle writes,

For any program there is some sufficiently complex object such that there is some description of the object under which it is implementing the program. Thus for example the wall behind my back is right now implementing the Wordstar program, because there is some pattern of molecule movements which is isomorphic with the formal structure of Wordstar. But if the wall is implementing Wordstar then if it is a big enough wall it is implementing any program, including any program implemented in the brain. (1990/2008, p. 93)

One way to understand this is that the pluralist view we defend here does not go far enough. Indeed, anything with sufficient complexity can be interpreted

as having a certain function. In Searle's own term, "syntax is not intrinsic to physics." So similarly, he might want to say that function is not intrinsic to biology. Functional talks are at best some convenient shorthand, but talks about functions do not carve nature at its joints.

To evaluate this position in details is beyond the scope of the present inquiry (but see Godfrey-Smith 2008 for a full-fledged criticism). Here I just want to emphasize that like Quine, Searle never makes clear how it is possible to do away functions and keep doing biology. This is especially pernicious to his position since he holds the so-called "biological naturalism" that "mental events and processes are as much part of our biological natural history as digestion, mitosis, meiosis, or enzyme secretion" (1992, p. 1). His solution to the mind-body problem relies heavily on our understanding of other biological phenomena. But this is at odds with his "debunking" of computations and functions unless he tells us, at least roughly, how to do away functions and keep doing our business in biology.

This completes my preliminary investigation of functional discourses in biology. Many issues are still unsolved and even untouched, but I believe the case for the pluralist view has been further strengthened.

NOTE

* Pluralism is not entirely new in this context. For example, Bouchard (2013) invokes ecosystem evolution to defend a version of it, and Brandon (2013) offers a general argument, as opposed to analysis of examples, for pluralism. The case in the current paper is compatible with their general direction.

REFERENCES

- Bedau, M. (1990), "Can Biological Teleology Be Naturalized?" *Journal of Philosophy* 88: 647–55.
- Bigelow, J., and R. Pargetter (1987), "Functions," *Journal of Philosophy* 84: 181–96.
- Boorse, C. (1976), "Wright on Functions," *Philosophical Review* 85: 70–86.
- Boorse, C. (2002), "A Rebuttal on Functions," in A. Ariew, R. Cummins, and M. Perlman (eds.), *Functions: New Essays in the Philosophy of Psychology and Biology*. Oxford: Oxford University Press, 63–112.
- Bouchard, F. (2013), "How Ecosystem Evolution Strengthens the Case for Functional Pluralism," in P. Huneman (ed.), *Functions: Selection and Mechanisms*. Dordrecht: Springer, 83–95.
- Brandon, R. N. (1990), *Adaptation and Environment*. Princeton, NJ: Princeton University Press.
- Brandon, R. N. (2013), "A General Case for Functional Pluralism," in P. Huneman (ed.), *Functions: Selection and Mechanisms*. Dordrecht: Springer, 97–104.

- Craver, C. F. (2013), "Functions and Mechanisms: A Perspectivalist Account," in P. Huneman (ed.), *Functions: Selection and Mechanisms*. Dordrecht: Springer, 133–158.
- Cummins, R. (1975), "Functional Analysis," *Journal of Philosophy* 72: 741–65.
- Garson, J. (2011), "Selected Effects and Causal Role Functions in the Brain: The Case for an Etiological Approach to Neuroscience," *Biology and Philosophy* 26(4): 547–65.
- Germain, P., E. Ratti, and F. Boem (2014), "Junk or Functional DNA? ENCODE and the Function Controversy," *Biology and Philosophy* 29(6): 807–31.
- Godfrey-Smith, P. (1993/1999), "Functions: Consensus without Unity," reprinted in D. J. Buller (ed.), *Function, Selection, and Design*. Albany, NY: SUNY Press, 185–197.
- Godfrey-Smith, P. (1994/1999), "A Modern History of Theory of Functions," reprinted in D. J. Buller (ed.), *Function, Selection, and Design*. Albany, NY: SUNY Press, 199–220.
- Godfrey-Smith, P. (2008), "Triviality Arguments against Functionalism," *Philosophical Studies* 145: 273–95.
- Goodman, N. (1955), *Fact, Fiction, and Forecast*. Cambridge, MA: Harvard University Press.
- Grice, H. P. (1957), "Meaning," *Philosophical Review* 66(3): 377–88.
- Griffiths, P. (1993), "Functional Analysis and Proper Functions," *British Journal for the Philosophy of Science* 44: 409–22.
- Holm, S. (2014), "Disease, Dysfunction, and Synthetic Biology," *Journal of Medicine and Philosophy* 39(4): 329–45.
- Hull, D. (1974), *Philosophy of Biological Science*. Englewood Cliffs, NJ: Prentice-Hall.
- Kitcher, P. (1993/1999), "Function and Design," reprinted in D. J. Buller (ed.), *Function, Selection, and Design*. Albany, NY: SUNY Press, 185–197.
- Kripke, S. (1982), *Wittgenstein on Rules and Private Language*. Oxford: Wiley-Blackwell.
- Millikan, R. (1989), "An Ambiguity in the Notion of 'Function,'" *Biology and Philosophy* 4: 172–6.
- Neander, K. (1991), "The Teleological Notion of Function," *Australasian Journal of Philosophy* 69: 454–68.
- Quine, W. V. (1960), *Word and Object*. Cambridge, MA: MIT Press.
- Quine, W. V. (1969), *Ontological Relativity and Other Essays*. New York: Columbia University Press.
- Quine, W. V. (1979/2008), "Facts of the Matter," reprinted in D. Follesdal and D. B. Quine (eds.), *Confessions of a Confirmed Extensionalist and Other Essays*. Cambridge, MA: Harvard University Press, 271–286.
- Rosenberg, A., and D. W. McShea (2008), *Philosophy of Biology: A Contemporary Introduction*. New York: Routledge.
- Searle, J. (1990/2008), "Is the Brain a Digital Computer?" Reprinted in his *Philosophy in a New Century: Selected Essays*. New York: Cambridge University Press, 86–106.
- Searle, J. (1992), *The Rediscovery of the Mind*. Cambridge, MA: MIT Press.

- Sellars, W. (1962), “Philosophy and the Scientific Image of Man,” in R. Colodny (ed.), *Frontiers of Science and Philosophy*. Pittsburgh, PA: University of Pittsburgh Press, 35–78.
- Sosa, E. (1991), *Knowledge in Perspective: Selected Essays in Epistemology*. New York: Cambridge University Press.
- Suster, P., and Z. Brzovic (2014), “The Functional Debate: Between Cheap Tricks and Evolutionary Neutrality,” *Synthese* 191(12): 2653–71.
- Wimsatt, W. (1972), “Teleology and the Logical Structure of Function Statements,” *Studies in History and Philosophy of Science* 3: 1–80.
- Wimsatt, W. (2002), “Functional Organization, Analogy, and Inference,” in A. Ariew, R. Cummins, and M. Perlman (eds.), *Functions: New Essays in the Philosophy of Psychology and Biology*. New York: Oxford University Press, 173–221.
- Wright, L. (1973), “Functions,” *Philosophical Review* 82: 139–68.