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Discussion

Complexity, adaptive complexity and the Creative View of natural selection

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ABSTRACT

In this paper, I respond to arguments proposed by Brunnander in this journal issue concerning my position regarding the Creative View of natural selection (Razeto-Barry & Frick, 2011). Brunnander argues that (i) the Creative View we defend does not serve to answer William Paley's question because (ii) Paley's question is "why there are complex things rather than simple ones" and (iii) natural selection cannot answer this question. Brunnander's arguments for (iii) defend a Non-creative View of natural selection (*sensu* Razeto-Barry & Frick, 2011). Here I claim that Brunnander's arguments for (iii) are mistaken and I also argue that even accepting (iii) we do not have to accept (i), given that statement (ii) is historically and conceptually flawed. Thus here I analyze Paley's question from a historical point of view and from a contemporary perspective in a quest for the potential conceptual relevance of Paley's question today. In this vein I argue that from a contemporary point of view statement (iii) may be correct but for different reasons than those adduced by Brunnander.

1. Introduction

The explanatory role of natural selection has been a hotly debated issue in evolutionary biology and philosophy of biology (Razeto-Barry & Frick, 2011). Razeto-Barry and Frick (2011) recently formalized several views of natural selection as *explanans* using the probabilistic concepts of causation and explanation and classical results of population genetics. One of the most important issues is the proposed explanatory role of natural selection called the "Creative View", according to which natural selection can be an *explanans* for the origin of traits. However, according to Razeto-Barry and Frick (2011) not every trait can be explained by natural selection; for example, natural selection cannot have an explanatory role in the origin of traits that arise by one mutation. In contrast, natural selection can have an explanatory role in traits that arose by a sequence of many mutations, as probably occurred with traits characterized by an "extremely intricate organization and complex order of the structure and functionality... whose integration and coordination with environmental cues confer to them the aspect of design" (Razeto-Barry & Frick 2011, p. 350). This kind of trait is traditionally called "complex adaptation", and this outstanding property (this complex, intricate functional organization) is called "complex design", "adaptive design", "adaptive complexity" and "irreducible complexity".[1] Thus complex adaptations are clear candidates as *explananda* of natural selection; then part of the Creative View includes the claim that natural selection can explain the origin of this interesting property of many traits, namely, their "complex design".

Given that the question about the complex design of biological traits is related to Paley's (1802, 1809) central arguments, Brunnander (this issue) correctly claims that our interpretation of the Creative View implies the statement that natural selection can answer Paley's question about complex design. However when Brunnander asks about the contrast inherent in Paley's question of "adaptive complexity" he answers: simplicity. That is, according to Brunnander Paley's question is: "why there are complex things rather than simple ones?" However, Brunnander's analysis of "adaptive complexity" (or "complex design") was focused on

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[1] I will use these terms as synonyms. Note that "irreducible complexity" is a term coming from the religious dispute on "intelligent design"; however, it can be used in the previously indicated sense when the term is defined objectively. See, for example, Behe (1996, p. 39) and Demski (2002, p. 285).

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"complexity" rather than on "adaptiveness" (or "design"), even though an obvious contrast in Paley's question is "why are there adaptive (designed) things rather than non-adaptive (non-designed) ones?" In the following sections I will argue that Brunnander's focus on complexity (rather than on adaptiveness) not only is historically flawed but also misguides the understanding of the current importance of the Creative View of natural selection in the light of contemporary evolutionary biology. Thus, first I will analyze the historical aspect of the problem showing that the focus of Paley's (and Darwin's) question was adaptiveness (or design) rather than complexity. Thus, even if we assume that natural selection cannot not explain "why there are complex things rather than simple ones?", this does not affect the explanatory role of natural selection in answering Paley's question. Secondly, I will analyze the problem from a contemporary point of view showing that, effectively, natural selection might not explain "why there are complex things rather than simple ones" but for different reasons than those indicated by Brunnander. This discussion helps clarifying what specifically should be the current role of natural selection in the explanation of adaptive complexity and thus what is the relevance of the Creative View in contemporary evolutionary biology.

2. Paley's question and the Creative View of natural selection

2.1. What was Paley's question?

According to Brunnander the Creative View does not serve to answer Paley's question. But, what was Paley's question? Brunnander correctly claims that the contrast inherent in Paley's question was 'why there was adaptive complexity rather than not'. However, in the following paraphrases of this idea Brunnander gives an apparently slight but actually significant twist, avoiding the term "adaptive" and focusing on "complexity". Brunnander claims that Paley's question was 'why there is something as complex as a watch rather than all and only considerably less complex things like stones' and generalizes the question as: 'Why are there complex structures like us rather than all and only much less complex ones?' and 'why there are complex traits rather than all and only non-complex traits?' Although in some cases Paley used stones as a contrast to complex adaptations, stones are not only simple but they also are clearly not "adaptive" (i.e., they do not display any appearance of "design"). As a matter of fact, we can reconstruct Paley's question in many ways but Brunnander's reconstruction is clearly misguided: Paley's focus was not on why there are "non-simple" things in the organic world. The abundant examples of trait properties mentioned by Paley were focused on the idea that organic traits show some kind of "design" or "contrinvance". For example, '...whether he had found a watch or a stone...in the watch which we are examining, are seen contrivance, design, an end, a purpose, means for the end, adaptation to the purpose. And the question which irresistibly presses upon our thoughts is. Whence this contrivance and design?' (Paley, 1802, p. 18). 'Contrivance' refers to the empirical fact that the various parts (of both organisms and watches) appear arranged as if for a purpose (see also Gardner, 2009, p. 861). Paley's examples were clearly focused on the ideas of "purpose", "design", "perfection", "adaptation", rather than on "complexity". Complexity without purpose or design is not an issue in Paley's thought. Even many of Paley's examples were focused on adaptive *differences*, which, as differences, are simple; for example, analyzing the difference between aquatic and terrestrial animals eyes:

> "[L]aws require, in order to produce the same effect, that the rays of light, in passing from water into the eye, should be refracted by a more convex surface, than when it passes out of air into the eye. Accordingly we find that the eye of a fish, in that part of it called the crystalline lens, is much rounder than the eye of terrestrial animals. What plainer manifestation of design can there be than this difference? What could a mathematical-instrument-maker have done more, to show his knowledge of his principle, his application of that knowledge, his suiting of his means to his end; I will not say to display the compass or excellence of his skill and art, for in these all comparison is indecorous, but to testify counsel, choice, consideration, purpose?" (Paley, 1809, pp. 18–19, see also p. 452)

The convexity of a lens is not a complex property. What is relevant in this example is the *adaptiveness* of the convexity of these lenses for the particular function of seeing. The contrast inherent in this Paley's example is non-adapted convexities, not more "simple" convexities (whether the latter has any sense). Numerous cases analyzed by Paley are centered on the idea of the "perfection", for example, of the loin of veal (Paley, 1809, p. 100), of the teeth of insects' larva and of the horns of animals (p. 254) rather than on their "complexity" (note that the latest examples are considered "perfect", i.e., functional, even though they are not particularly "complex").

Although Paley recognized the importance of the "complexity" of complex designs for his arguments (1802, p. 247), Paley's concept of "complex" is clearly not interchangeable with "adapted". Indeed, in some examples what would manifest the action of a Designer is that some traits (e.g., tongue muscles) can be functional even *in spite of* their high complexity:

> 'nevertheless—which is a great perfection of the organ [tongue muscle]—neither the number nor the *complexity*, nor what might seem to be the entanglement of its fibres, in any wise impede its motion, or render the determination or success of its efforts uncertain...Where various functions are united, the difficulty is to guard against the inconveniences of a too great complexity.' (Paley, 1802, pp. 94–95, see also p. 110)

The contrast inherent in this example of Paley is non-adaptive complexity; in spite of its complexity this trait performs appropriately its function or purpose. Thus the contrast here is an equivalently complex trait but without this "adaptive" or "designed" feature. From this point of view, Brunnander's focus on explaining complexity in contrast with simplicity is misinterpreting the essence of Paley's question. Therefore, if Darwin's theory can explain "why there are adaptive (designed) things rather than non-adaptive (non-designed) ones?" or "why there is this kind of complexity [adaptive complexity] rather than some other kind of complexity [non-adaptive complexity]", then Darwin answered Paley's question.

2.2. What was Darwin's question?

According to Razeto-Barry and Frick (2011), natural selection theory can explain at least (a) the maintenance of traits (by negative selection), i.e., the resistance of species to change in spite of mutation pressures because of the negative fitness effect of new variants; (b) the propagation of traits (by positive selection), i.e., the change of species by the spread of new mutations with higher fitness; (c) the forming of new traits (by cumulative selection), i.e., the generation of new traits because of an intergenerational, directional accumulation of advantageous mutations integrated in some common function or structure. This third point is by and large the most controversial, but Darwin was very clear in claiming that some traits can be "formed", "produced" or "made" by natural selection. For example, in the Chapter: 'Organs of extreme perfection and complication' Darwin claims that 'an organ so perfect as the eye could have been *formed* by natural selection' (Darwin, 1859, p. 204, this and all highlights in this paper are mine), 'the eye, with all its inimitable *contrivances* for adjusting the focus to

different distances, for admitting different amounts of light, and for the correction of spherical and chromatic aberration, could have been *formed* by natural selection' (Darwin, 1859, p. 186). Darwin clearly explains this creative power of natural selection in analogy with artificial selection:

> 'We cannot suppose that all the breeds were suddenly *produced* as perfect and as useful as we now see them; indeed, in several cases, we know that this has not been their history. The key is man's power of *accumulative selection*: nature gives successive variations; man adds them up in certain directions useful to him. In this sense he may be said to *make* for himself useful breeds. The great power of this principle of selection is not hypothetical…' (Darwin, 1859, p. 30)

As is clear from the previous quotations, Darwin defended a Creative View of natural selection for the origin of traits, particularly those characterized by an 'extreme perfection and complication' such as 'the eye, with all its inimitable contrivances for adjusting the focus…' Thus, clearly Darwin's question is Paley's question, which is a historically continuous English issue trying to relate the explanation of natural adaptive design with the existence of a supernatural "designer" (Gould, 1998). Neither Paley nor Darwin was focused on "complexity" itself, instead they were clearly centered on "adaptiveness" (usually both also called it "perfection"), which is the natural focus for one who wants to prove the existence of a supernatural "designer" (Paley) and for one who is showing the effect of traits improving reproductive success (Darwin; note that it is adaptiveness and not complexity that increases reproductive success). Thus, Brunannder's statement (ii) is a failed interpretation of Paley's question. "Simple" things like stones only are a particular case of non-designed things, not the essential ones.

Then if Darwin is right in the idea that natural selection can form or create complex adaptations, then Darwin answered Paley's question and Brunnander's statement (i) is false. However, Brunnander denies that 'natural selection creates complex adaptations'. I now move to this second issue.

3. The Non-creative View of natural selection and Brunnander's arguments

The Non-creative View of natural selection is a long-term one that remains until now (Razeto-Barry & Frick, 2011, Table 1). Some examples:

> 'I regard it as unfortunate that the theory of natural selection was first developed as an explanation for evolutionary change. It is much more important as an explanation for the maintenance of adaptation.' (Williams, 1966, p. 139)
> 'Natural selection cannot explain the origin of new variants and adaptations, only their spread.' (Endler, 1986, p. 51)
> 'Starting in the 1970s, many biologists began questioning its [neo-Darwinism's] adequacy in explaining evolution…Microevolution looks at adaptations that concern the survival of the fittest, not the arrival of the fittest.' (Gilbert, Opitz, & Raff, 1996, p. 361)
> 'Since the emphasis in neo-Darwinian theory is on selection, it is also, inevitably, on destructive rather than creative forces. Selection can only retain, spread, or remove variants that are already in the population; it cannot itself create any new variants.' (Arthur, 2000, p. 50)
> 'Research on selection and adaptation may tell us why a trait persisted and spread, but it will not tell us where a trait came from.' (West-Eberhard, 2003, p. 197)
> 'Selection has no innovative capacity: it eliminates or maintains what exists. The generative and the ordering aspects of morphological evolution are thus absent from evolutionary theory.' (Muller, 2003, p. 52)

What is common in the Non-creative View of natural selection is that the origin of traits is related exclusively to genetic variations (mutations or recombinations) and not to natural selection (Razeto-Barry & Frick, 2011). This view strongly contrasts with the proponents of Darwin's Creative View of natural selection (see Razeto-Barry & Frick, 2011, Table 1). For example:

> 'Selection molds the separate units of heredity into a coordinated whole, a process as truly creative (although of course not planned or directed) as the combination of separate bricks into a building.' (Simpson, Pittendrigh, & Tiffany, 1957, p. 413)
> 'Is selection destructive or creative?…Is not a sculptor creative, even though he discards chips of marble?…Characters are the developmental product of an intricate interaction of genes and since it is selection that 'supervises' the bringing together of these genes, one is justified in asserting that selection creates superior new gene combinations.' (Mayr, 1963, pp. 201–202)
> 'Several evolutionists, as J. Huxley, Dobzhansky, and Simpson, have called selection a creative process. This designation is justified because…[selection] creates abundant new genotypes.' (Mayr, 1988, pp. 99–100)
> 'Selection acts as the primary creative force in building evolutionary novelties.' (Gould, 2002, p. 20)
> 'Natural selection is much more than a "purifying" process, for it is able to generate novelty by increasing the probability of otherwise extremely improbable genetic combinations. Natural selection in combination with mutation becomes, in this respect, a creative process.' (Ayala, 2007, p. 8571)

Razeto-Barry and Frick (2011) formalized the Creative and Non-creative View in terms of population genetics, showing that the common use of causal terms such as 'generate', 'build', 'create', 'form', etc. can be justified via a probabilistic concept of causation when traits need more than one mutation to be formed. From this perspective natural selection cannot be considered causally relevant in those cases in which traits arose by one mutation. Thus, the Non-creative View is surely correct only for this last kind of trait. In contrast with this, Brunnander defends a Non-creative View of natural selection even for cases in which traits require cumulative evolution.

According to Brunnander there is 'a significant problem with sayings such as "natural selection drives evolution" or "natural selection creates complex adaptations"'. He uses a thought experiment (Dull Earth vs. Earth) to defend the same idea as the partisans of the Non-creative View. In Dull Earth only two different proto-life varieties are possible which undergo a continuous process of replacing each other non-randomly by natural selection. According to Brunnander 'the contrast between Earth and Dull Earth resides in the fact that more complex varieties have kept appearing on Earth but not on Dull Earth'…'what is in fact the relevant difference-maker: the varieties that actually arise'…'The occurrence of cumulative, rather than non-cumulative, selection is simply the consequence of the continuing appearance of novelty'…'what accounts for the difference between Earth and Dull Earth…the crucial difference…is "mutational generosity"'…'What has "driven" evolution isn't selection but the continuing appearance of *novelty, including adaptive novelty* once in a while'. Finally, using the idea of natural selection as a two-step process (mutation and selection), according to Brunnander what makes the difference is that 'the first step [i.e., mutation] of this two-step process is much friendlier to accumulation of structure on Earth than it is on Dull Earth'. Dull Earth shows that mutations

are necessary for complexity but not that natural selection is not necessary for complexity (neither adaptive complexity).

The difficulty of the thought experiment proposed by Brunnander will help me to explain the contrasting context of the Creative View on adaptive complexity. If we want to know in what sense natural selection makes a difference we must imagine counterfactual worlds in which natural selection does not exist, but in which the mutational capacity remains unchanged. However, between Dull Earth and Earth there are differences not only in natural selection but also in 'the varieties that actually arise', in 'mutational generosity', in the extent of mutations that are 'friendlier to accumulation of structure'. A different thought experiment (that I will call the Neutral Earth) for the contrasting context of the Creative View was proposed by Razeto-Barry and Frick (2011, note 15): 'in an alternative and more significant version of the Creative View the thought experiment would be a world where all mutations are effectively neutral or deleterious, i.e., where all new traits do not confer a significantly higher reproductive success to the possessors. Thus, the explanatory role of natural selection in the origin of traits could be reformulated by the assertion that the probability that the types of traits observed on Earth [i.e., complex adaptations] would have arisen without positive natural selection is lower than with it' (p. 350). In the Neutral Earth thought experiment the mutational features are maintained the same, only differing in the selective effect of mutations. Although it is very possible that in the Neutral Earth scenario "complexity" will increase (see below), the Creative View states that "*adaptive* complexity" will hardly arise on Neutral Earth. Thus, if it is the case that natural selection is explanatorily relevant for the very existence of adaptive complexity on Earth (not only in particular cases of adaptive complexity) then again Brunnander's statement (i) is false.

4. The Creative View of natural selection from a contemporary perspective

Although Paley and Darwin could hardly be aware of the power of non-adaptive evolution in the generation of complexity, contemporary evolutionary biology is increasingly acknowledging that the default expectation of evolution, even in the absence of natural selection, is an increase in complexity (McShea & Brandon, 2010; Razeto-Barry & Díaz, 2013). This fact clearly highlights the current importance of the contrast between "adaptive complexity" and "non-adaptive complexity". For example, although neutral evolutionary processes can explain organic complexity (see Razeto-Barry, 2013 for a review), it is not clear whether this kind of complexity may be called "adaptive". For example, neutral evolutionary processes have been described that result in "bureaucratic" rather than "adaptive" complexity (Doolittle, 2012; Gray, Lukes, Archibald, Keeling, & Doolittle, 2010). Thus, variations (with heredity) are *sufficient* conditions to explain why there are complex things rather than simple ones (McShea & Brandon, 2010). Of course these ideas probably were not in the minds of Paley and Darwin but given that their arguments were focused on adaptiveness (design) rather than on complexity, their questions remain open in this scenario.

Additionally, a different version of the Dull Earth example may be a useful tool to show that variations (with heredity) are not only *sufficient* but also *necessary* conditions to explain why there are complex things rather than simple ones. Imagine a second version of Dull Earth (hereafter Dull Earth 2): a planet completely similar to Earth at 3.5 billion years ago or so but with the only difference that there are not genetic mutations (or mutations are extremely infrequent). Under these conditions there is no increase of complexity in spite of the sameness of the selective conditions between Dull Earth 2 and Earth (at least as it was 3.5 billion years ago). However, this thought experiment does not play against the Creative View of natural selection; in fact, on this Dull Earth 2 natural selection cannot contribute to the origin of traits with adaptive design because one of the assumed conditions of the Creative View is not satisfied: there are no variations to select from. Thus, if we claim that variations and heredity are necessary and sufficient conditions to explain the very existence of complexity on Earth, we can claim that natural selection may not be probabilistically relevant for the existence of complexity in contrast to simplicity. Thus (iii) would be true but not because the Creative View of natural selection is false or trivial, as Brunnander claims, but because with or without natural selection there will be complexity on the Earth (McShea & Brandon, 2010). What has been more difficult to believe until now is that "adaptive" complexity can increase without selection. If this were the case and natural selection would not change significantly the probability of adaptive complexity in the world (e.g., because it is completely expectable under neutral evolution), then Darwin's theory may not be a necessary explanation for Paley's question. However, proving this has seemed very implausible until now.

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References

Arthur, W. (2000). The concept of developmental reprogramming and the quest for an inclusive theory of evolutionary mechanisms. *Evolution and Development, 2*, 49–57.
Ayala, F. J. (2007). Darwin's greatest discovery: Design without designer. *Proceedings of the National Academy of Sciences, 104*, 8567–8573.
Behe, M. J. (1996). *Darwin's black box. The biochemical challenge to evolution*. New York: Touchstone.
Brunnander, B. (this issue). Did Darwin really answer Paley's question? *Studies in History and Philosophy of Biological and Biomedical Sciences*.
Darwin, C. (1859). *On the origin of species*. London: John Murray.
Demski, W. A. (2002). *No free lunch: Why specified complexity cannot be purchased without intelligence*. Maryland: Rowman & Littlefield Publishers.
Doolittle, W. F. (2012). Evolutionary biology: A ratchet for protein complexity. *Nature, 481*, 270–271.
Endler, J. A. (1986). *Natural selection in the wild*. Princeton: Princeton University Press.
Gardner, A. (2009). Adaptation as organism design. *Biology Letters, 5*(861), 864.
Gilbert, S. F., Opitz, J. M., & Raff, R. A. (1996). Resynthesizing evolutionary and developmental biology. *Developmental Biology, 173*, 357–372.
Gould, S. J. (1998). On transmuting Boyle's law to Darwin's revolution. In A. C. Fabian (Ed.), *Evolution: Society science and universe*. Cambridge: Cambridge University Press.
Gould, S. J. (2002). *The structure of evolutionary theory*. Harvard: Belknap Press.
Gray, M. W., Lukes, J., Archibald, J. M., Keeling, P. J., & Doolittle, W. F. (2010). Irremediable complexity? *Science, 330*, 920–921.
Mayr, E. (1963). *Animal species and evolution*. Cambridge, MA: Harvard University Press.
Mayr, E. (1988). *Toward a new philosophy of biology*. Cambridge: Belknap Press of Harvard University Press.
McShea, D. W., & Brandon, R. N. (2010). *Biology's first law. The tendency for diversity and complexity to increase in evolutionary systems*. Chicago: University of Chicago Press.
Muller, G. B. (2003). Homology: The evolution of morphological organization. In G. B. Muller & S. A. Newman (Eds.), *Origination of organismal form. Beyond the gene in developmental and evolutionary biology*. Boston: The MIT Press.
Paley, W. (1802). *Natural theology; or, evidences of the existence and attributes of the deity*. New York: American Tract Society.
Paley, W. (1809). *Natural theology; or, evidences of the existence and attributes of the deity* (12th ed.). London: J. Faulder.
Razeto-Barry, P., & Díaz, J. (2013). A multidimensional model of neutral phenotypic evolution. (in review).
Razeto-Barry, P., & Frick, R. (2011). Probabilistic causation and the explanatory role of natural selection. *Studies in History and Philosophy of Biological and Biomedical Sciences, 42*, 344–355.
Simpson, G. G., Pittendrigh, C. S., & Tiffany, L. H. (1957). *Life: An introduction to biology*. London: Routledge & Kegan Paul.
West-Eberhard, M. J. (2003). *Developmental plasticity and evolution*. Oxford: Oxford University Press.
Williams, G. (1966). *Adaptation and natural selection*. Princeton: Princeton University Press.