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Functional Analysis and Proper Functions

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ABSTRACT

The etiological approach to 'proper functions' in biology can be strengthened by relating it to Robert Cummins' general treatment of function ascription. The proper functions of a biological trait are the functions it is assigned in a Cummins-style functional explanation of the fitness of ancestors. These functions figure in selective explanations of the trait. It is also argued that some recent etiological theories include inaccurate accounts of selective explanation in biology. Finally, a generalization of the notion of selective explanation allows an analysis of the proper functions of human artifacts.

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I INTRODUCTION

Etiological theories of 'proper functions' have become increasingly popular in recent years. Neander (1991) has effectively defended the approach against the criticisms directed by Boorse [1976], Prior [1985] and Bigelow and Pargetter [1978] against the early etiological theory of Wright [1973], [1976]. Millikan [1984], [1989b] has developed a complex and ingenious semantic theory using an etiological account of function. The analysis of proper function offered here differs from other etiological theories in two ways. First, it relates the etiological approach to Cummins' [1975] general account of function ascription. Second, it is sensitive to the real form of selective explanations in biology.

In Section 2, I discuss Cummins' account of the nature and purpose of function ascriptions. Cummins is primarily concerned with the role of

functions in the explanations of complex capacities. He is not concerned to distinguish teleological or 'proper' functions from other, non-teleological functions. This has led authors such as Millikan ([1989a], pp. 293–5) to think that Cummins' analysis does not contribute to the understanding of the 'proper functions' of biological items and human artifacts. Millikan notes that many 'Cummins-functions' are not proper functions. (Any function which derives from a functional analysis of a system is a Cummin-function. The Cummin-function of an item is always relative to the overall capacity under analysis.) Conversely, some proper functions are not Cummins-functions. These objections are correct, but they are not to the point. I show in Section **3** that the proper functions of a biological trait are the functions it is assigned in a Cummins-style functional explanation of the fitness of ancestral bearers of the trait. The adequacy of teleological explanations given using proper functions depends on the validity of these earlier functional explanations.

In Section **4** I discuss some shortcomings of Neander's [1990] analyis of proper function. The analysis is not adequate as it stands because of a mistake concerning the forms of selective explanation that back ascriptions of biological function. My own analysis, presented in Section **5**, is closer to some versions of Millikan's. It differs, however, because my central concern is to define a notion adequate to the purposes of biology; Millikan's concern is primarily with semantics. Thus, for example, Millikan does not distinguish vestigial traits from those which currently have functions. I discuss the distinction between functional traits and vestiges in Section **6**.

In the final sections of the paper I give an account of design processes which allows me to extend my analysis to the proper functions of artifacts, and suggest a general account of naturalistic teleology.

2 FUNCTIONAL ANALYSIS

Cummins argues that the practice of assigning functions to parts of systems derives from an explanatory strategy which he calls 'functional analysis'. Functions are assigned when analysing a complex capacity into a set of simpler capacities that are to be explained by subsumption under laws. The function of an item is its contribution to the overall capacity. The overall capacity is explained in terms of the contributing capacities, or functions, of parts of the system.

Cummins [1983] is concerned to show that functional analysis is the basic form of explanation in psychology (the form of explanation described by Lycan [1981], [1987] as the 'Homuncular' strategy). But functional analysis has application wherever the aim of scientific investigation is to explain the overall capacities of a complex system. One complex capacity which might be explained by functional analysis is the ability of an animal to survive and reproduce. This can be analysed into a set of simpler capacities, such as the

capacity to move about, to feed, to escape predation, to mate, and so on. Each of these can in turn be analysed into even simpler capacities. In the case of feeding, the ability to ingest food, masticate it, break it down into simple nutrients, to absorb these, and so forth. These capacities in turn can be analysed into still simpler capacities, arriving eventually at such simple capacities as that of a membrane to permit diffusion of some substance. These base level capacities are directly explicable by physical laws. Each capacity at each level can be attached to some sub-system of the organism. The function of this sub-system is the capacity which it realizes, and which contributes to the overall capacity of the organism.

A similar strategy can be applied to artifacts. Artifacts have capacities, often very complex ones, which suit them for their intended uses. The various parts of the artifact have functions which contribute to this overall capacity.

The overall capacity explained by functional analysis need not be one that will yield so called 'proper' functions. The human body has capacities to die of various diseases. Each of these complex capacities can be analysed in the way Cummins suggests, yielding some very strange functions for the various body-parts. Similarly, Cummins' strategy can be applied to a bit of dirt which has become stuck in a pipe. We can regard this as a one-way valve, and use this assignment of function to explain the overall capacity of the pipe to control flow.

3 PROPER FUNCTIONS

Proper functions are the sorts of functions that biologists assign to the organs of animals, and the sorts of functions that human artifacts have. The notion is sometimes introduced by pointing out that proper functions are what things are *for*, whilst other functions are not. It is also possible to distinguish *having the function* F from merely *functioning as an* F. Both these linguistic distinctions can be used to mark a rough boundary for the class of proper functions.

Proper functions differ from other functions in that they can be cited to explain the presence of a functional item. The presence of the liver can be partially explained by its capacity to store glycogen and secrete bile. These functions enter into an evolutionary explanation of the presence of the liver. But the presence of the liver cannot be explained by its capacity to accommodate liver flukes. This is the Cummins-function of the liver relative to the capacity to die of fluke infestation, but it is not a proper function of the liver.

In the same way, the presence of a bit of dirt in a pipe cannot be explained by the fact that it functions as a one-way valve. This is not a proper function of the piece of dirt. The presence of one-way valves in human veins and in man-made pumps can be explained by the fact that they perform this function. It is a proper function of these features to act as one-way valves.

Explanations which cite an item's proper functions are philosophically

interesting because they are teleological. The existence and form of an item seems to be explained by its goal, or purpose, rather than its antecedent causes. The etiological approach to proper functions is an attempt to demystify these teleological explanations. On this view to ascribe a proper function to an item is to claim that earlier items of the same type had the effect which we now label a proper function and that their having had that effect helps explain the presence of later items of the type.

The aetiological approach was inspired by the attempts of evolutionary biologists to explain their use of teleology. In evolutionary biology it is natural to interpret the claim that a trait of an animal has the proper function F as the claim that F is the property in virtue of which the trait evolved. Lorenz, for example, states explicitly that he intends his use of function locutions in ethology to be interpreted etiologically:

> If we ask 'What does a cat have sharp, curved claws for?' and answer simply 'To catch mice with', this does not imply a profession of any mythical teleology, but the plain statement that catching mice is the function whose survival value, by the process of natural selection, has bred cats with this particular form of claw. Unless selection is at work, the question 'What for?' cannot receive an answer with any real meaning (Lorenz [1963], p. 9).

We can incorporate the etiological approach into the Cumminsesque picture of function ascription. The proper functions of a biological trait are the functions it is ascribed in a functional analysis of the capacity to survive and reproduce (fitness) which has been displayed by animals with that feature. This means that a feature will have a proper function only if it is an *adaptation* for that function. The trait must have been selected because it performs that function.

This picture of proper functions gives them a role in two kinds of biological explanation. First, the biological fitness of a type of organism can be explained by Cumminsesque functional analysis. An organism's fitness is a measure of its overall capacity to survive and reproduce, relative to the capacities of competing types in the population. (The classical fitness of a trait is a measure of the average expected number of offspring of systems with that trait. The trait may be genotypic or phenotypic. It is relative fitnesses within a population that are of interest to population genetics, and fitness values are usually normalized so that the fittest trait in a population has the value 1.) The analysis of this capacity will reveal a number of 'fitness components'. Fitness components are those effects of traits which enhance the fitness of their bearers. They are the Cummins-functions of those traits relative to the overall capacity of the animal to survive and reproduce (fitness). The proper functions of a trait are those effects of the trait which were components of the fitness of ancestors. They are the effects in virtue of which the trait was selected, the effects for which it is an adaptation.

I have already noted that proper functions are characterized by their capacity to enter into a second kind of biological explanation, the teleological explanation of the presence of certain traits. Proper functions can be used in this second kind of explanation precisely because they figure in the first kind of explanation (though they need not figure there as *proper* functions). The proper functions of traits are those effects for which they are adaptations. To explain a trait by alluding to its proper function is to explain it as the result of natural selection, in the way with which we are all familiar.

4 CURRENT ETIOLOGICAL THEORIES

The main etiological accounts currently on offer are those of Millikan [1984], [1989a], [1989b] and Neander [1991]. (Neander's work is well known to those working in the field. See Prior [1985], and Lycan [1987].) Millikan's main aim is to give an account of intentionality in terms of the proper functions of systems, such as people, which contain and produce representations, and the derivative functions of those representations themselves. It is impossible to do justice here to the elaborate system that Millikan devises to this end. She herself gives a sketch of the central element of her theory as follows:

> very roughly, for an item A to have a function F as a 'proper function', it is necessary (and close to sufficient) that . . .[1] A originated as a 'reproduction' (to give one example, as a copy, or a copy of a copy) of some prior item or items that, due in part to possession of the properties reproduced, have actually performed F in the past, and A exists because (causally, historically because) of this or these performances.

This captures the central element of the etiological approach, the idea that the effects of past tokens of a type provide an explanation for the existence of current tokens of that type, but it does not spell out exactly which explanations in biology support function ascriptions. For example, this analysis and the more formal analysis of 'direct' proper function given elsewhere ([Millikan [1984], p. 28]) make no distinction between currently functional traits and vestiges of past adaptations. I am inclined to take Millikan at her work when she describes her analysis as a tool forged for a specific job in the philosophy of language ([1984] p. 18). My own interest is in deriving a notion of proper function adequate to the purposes of biology. The two accounts are certainly in sympathy, but there are distinctions, such as that between functional traits and vestiges, which are important to biology, and which Millikan has only minimally gestured at [*e.g.* [1984], p. 32].

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[1] Millikan offers a pair of disjoint conditions, but the second condition is satisfied by 'derived proper functions' and need not trouble us here.

Neander's account, on the other hand, is explicitly intended to capture the use of function ascriptions in biology. It is conceptual analysis, but of the concepts of current biologists, not of ordinary people. According to Neander:

> It is a/the proper function of an item (X) of an organism (O) to do that which items of X's type did to contribute to the inclusive fitness of O's ancestors and which caused the genotype, of which X is the phenotypic expression (or which may be X itself where X is the genotype) to increase proportionally in the gene pool (Neander [1991]).

This analysis fails to capture the notion of function in use in modern biology because of the requirement for proportional increase. It is commonplace for a population to contain several competing traits, whose proportions vary. In such circumstances there are many legitimate selective explanations that do not explain the proportional increase of a trait in the population. They explain the current level, which is often the result of a recent decrease. So the function of some traits is to do that which has led to their representation at a reduced level in the population. I shall give detailed examples of this in a moment, after dismissing some possible replies to the general point.

Neander might reply that whatever proportion of the population currently display a trait, that trait must have originated in one or a few individuals, and spread because of its adaptive value. So her requirement for proportional increase may be taken to refer to the spread of the trait after its initial introduction. But this reply would leave her unable to distinguish vestigial traits, such as the appendix, which have lost their functions. In fact, Neander makes it quite clear that 'the etiological theory looks back to the recent evolutionary past' and that functional traits are distinguished from vestiges by the fact that selection for them has occurred fairly recently.

Neander might say that the function of a trait is the effect which figured in the most recent episode in which it did proportionally increase. But this will not do either. Traits arise and spread for non-adaptive reasons, perhaps as side-effects of adaptive traits, and only later acquire a function. It is also common for traits to lose old functions and acquire new ones. Neither of these cases could be accommodated on the current proposal unless each acquisition of function were accompanied by an increase in the proportion of the trait in the population. It can easily be shown that this need not occur.

Darwin [1982] describes a scenario in which the utilitarian function of certain facial expressions declines, whilst their importance in intraspecific communication increases. Tooth-baring in certain primates evolved as a perparation for attack. It later acquired the function of expressing anger. Finally, in man, it has become purely expressive and is vestigial with respect to its original function. (The notion of vestigiality relative to a particular function is formally defined in Section 6). There is no reason to assume that the acquisition of the new function must have increased its prevalence in the population.

There are also standard scenarios in evolutionary theory where a trait acquires a new function whilst the proportion of the population with the trait actually decreases. This happens in versions of the hawk/dove game (Maynard-Smith [1982]). Imagine a population in which all resource disputes are settled by conventional posturing. Any animal subject to a serious attack retreats. This is the 'Dove' trait. A new trait is introduced by migration or mutation. Animals with the new trait, 'Hawks', attack and defend resources to an extent where serious injury can occur. Selection between these two traits is frequency dependent. Under certain assumptions about costs and pay-offs the following picture holds. When Doves are common, Hawks are fitter than Doves, as they can capture a large share of resources with little risk. However, as the proportion of Hawks increases, the cost of being a Hawk also increases. If the proportion of Hawks rises above a certain level, Doves become fitter than Hawks, as their reduced risk of injury outweighs any loss of resources. Under certain assumptions, the proportion of Hawks to Doves will settle at an equilibrium level such that any proportional increase in Hawks would reduce the fitness of Hawks below that of Doves.

The persistence of the Dove train in the population is explained by the selective advantage that accrues to Doves in virtue of their avoiding injury. The exact proportion of Doves at any generation can be explained by the relative fitness of Hawks and Doves in past generations. Given the underlying rationale for the etiological approach, the conclusion is clear. In organisms whose ancestors competed with Hawks, one of the proper functions of Dove behaviour is to reduce the chance of injury. But Dove behaviour acquired this function whilst the proportion of Doves in the population decreased. Neander's requirement for proportional increase is inappropriate.

5 A NEW ETIOLOGICAL THEORY

The etiological theory can avoid these pitfalls if reformulated:

Where i is a trait of systems of type S, a proper function of i in S's is F iff a selective explanation of the current non-zero proportion of S's with i must cite F as a component in the fitness conferred by i.

This analysis avoids the assumption of proportional increase and differs from Neander's analysis in two other, relatively minor ways. First, it is phrased in terms of classical fitness. It is not always realized that classical fitness includes kinship effects (Grafen [1982]). The considerably more complex notion of inclusive fitness simply makes these effects more perspicacious. Second, it leaves implicit various points about the gene/phenotype relation. The analysis indexes any function to a class of systems. In many cases the system will be the organism which bears the trait in question, but there are two alternative cases.

First, there are cases where genes have evolved adaptations which benefit only the gene itself. Certain genes have the capacity to subvert the normal mechanisms of cell division so as to ensure their over-representation in the sex cells. These genes are more highly prevalent than they would otherwise be. In one of the best documented cases (Lewontin and Dunn [1960]), this allows an allele to survive despite disastrous effects on organisms which are homozygous for the allele. In such cases the advantageous trait of the gene must be assigned functions relative to the gene itself, not the organism at whose expense it survives. Speculations on 'intragenomic conflect' between nuclear and mitochondrial DNA (Cosmides and Tooby [1981]) suggest that phenotypic features may also have functions relative to a particular segment of DNA, rather than the entire organism.

Second, there are cases where a trait of one phenotypic individual has a function for another individual. Dawkins [1982] has drawn attention to this phenomenon under the slogan of the 'extended phenotype'. The galls which grow on oak trees are the product of selection acting on the genes of gall-wasps, not the genes of oak trees. They have a function for the wasp but are functionless for the tree. Both these cases and the genic cases can be accommodated on my account, simply by choosing the right class of systems S.

Neander has pointed out to me that allowing extended phenotypic traits to have functions lets in some very strange cases. The items of food which come into an animal's possession are assigned the function of feeding the animal, for example, because there is a selective explanation of why current animals have these items of food which cites feeding the animal as the effect by which the bits of food possessed by ancestors enhanced the ancestors fitness. Although my analysis could be reformulated so as to exclude these cases, I do not wish to do so because the selective stories which back them seem sound, and because I can see no way of excluding them which would not also exclude such highly plausible claims as the claim that the function of the discarded mollusc shells possessed by hermit crabs is to protect them from predators.

6 VESTIGIAL TRAITS

Any theory of proper functions needs to distinguish currently functional traits from vestigial traits. The idea of vestigiality is linked to the notion of regressive evolution. This is the process whereby useless traits tend to atrophy because of the costs of producing them. Perhaps the most striking example is the evolution of subterranean forms ('troglobytes'. Cave-dwelling populations from many different taxonomic groups display a characteristic pattern of evolution. As well as losing pigmentation, such animals characteristically possess vestigial eyes, reduced in size, complexity and effectiveness.

Whilst the classic examples of vestigiality are atrophied in this way, not all vestiges need be so. There are two obvious cases. First, a trait may change its

function but be preserved intact in virtue of its performing a new function. Darwin regards facial expressions as vestiges relative to their original, utilitarian functions, although they are currently selected for their value in intraspecific communication. Second, a useless trait may subsist for an extended period of time simply because there is no genetic variation. Evolutionary forces are not platonic entities, and where there is no variation there are no selective forces.

A successful account must allow non-atrophied vestiges. But it will not do to make every trait that cannot perform its functions vestigial. First, as Neander has pointed out, a malfunctioning trait cannot perform its proper function. But it must still have the function in order to count as malfunctioning.[2] Second, it is important for traits to be able to have proper functions they cannot perform in order to prevent functions fluctuating wildly in response to temporary environmental changes.

It is possible to allow for non-atrophied vestiges without objectionably reifying selective forces, and without classifying every trait which ceases to function as vestigial. Define an evolutionarily significant time period for a trait T as a period such that, given the mutation rate at the loci controlling T and the population size, we would expect sufficient variants for T to have occurred to allow significant regressive evolution if the trait was making no contribution to fitness. A trait is a vestige relative to some past function F if it has not contributed to fitness by performing F for an evolutionarily significant period. A trait is a vestige simpliciter if it is a vestige relative to all its past functions. This account allows a trait to become a vestige relative to one function whilst remaining intact in virtue of its other functions. It also allows a trait to become vestigial whilst remaining intact because of a lucky absence of mutations. Interestingly, it makes it possible for the trait to be a vestige in one population but not in another. This seems to accord with biological usage.

The functional trait/vestige distinction is not made explicit in the analysis given above. The current prevelence of the human appendix, for example, can be given an explanation that involves selection. There were, presumably, distant ancestors for whom the appendix was an adaptation. It is possible to express it by saying that it *had* this function. If it is to have a function at the ancestors. But it is more natural and sits better with the notion of vestigiality to express it by saying that it had this function. If it is to have a function at the present time, selection for it must have occurred in the last evolutionarily significant time period. We might incorporate this into the definition by defining a *proximal* selective explanation as one that involves the action of selective forces during the last evolutionarily significant period, or would have

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[2] Non-etiological accounts of proper function can try to incorporate this feature by appealing to 'normal' circumstances. Millikan [1989a] has suggested that this involves an implicit reference to evolutionary history. Neander [1991] has pointed out that it fails to handle pandemic diseases, such as the viral infections of some plants.

involved such action during that period had the mutation rate not fallen below expectation.[3] The functional trait/vestige distrinction can then be made explicit:

Where i is a trait of systems of type S, a proper function of i in S's is F iff a proximal selective explanation of the current non-zero proportion of S's with i must cite F as a component in the fitness conferred by i.

7 ARTIFACT FUNCTIONS

The other main class of objects that have proper functions are human artifacts. A corkscrew is for removing corks. Damaged, malformed and badly designed corkscrews retain this function although they cannot perform it. Most importantly, the existence and form of artifacts can be explained by alluding to their functions. Why are there so many corkscrews? They are for removing corks. Why are they shaped thus and so? In order to better remove those corks.

The teleological properties of artifacts are often though to be unproblematic. Before presenting my own analysis of artifact functions, I want to show that this is a mistake. Providing an adequate account of artifact teleology is not a trivial task.

A first suggestion might be that the functions of artifacts are their intended uses. In support of this it might be said that artifacts can be explained by their functions because they have been designed to fulfil their intended uses. But it is not just artifacts as wholes that have proper functions. Their parts and features have proper functions too. Nearly every detail of a car, down to the last shim, has a function. Something has to be said about how to determine these functions from the overall function.

One obvious way would be to perform a Cummins-style functional analysis of the car's ability to fulfil its intended uses. The parts of the car contribute to its capacity to fulfil its intended uses. These contributions are their functions. But not all functions which come out of this analysis will be proper functions. Some items may make additional, accidental contributions to the car's capacity to perform its intended use. These contributions cannot be used to explain the items, and are not proper functions.

This problem can be avoided by saying that the function of every part is its *intended* contribution to the overall use. But this solution leads straight into another difficulty. Many features of artifacts make no intended contribution and yet have proper functions. In societies with low-level technologies, artifacts are often designed by trial and error over periods of many generations.

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[3] I am grateful to Karen Neander for pointing out the necessity of this last clause. It excludes counterexamples parallel to those which led me to include a probabilistic element in my definition of a vestige. A trait might be thought to be currently contributing to fitness although it is not being selected because of an improbable absence of mutations.

The contribution that a feature makes to the performance of overall function may never be appreciated. Such features do not have an intended use but they do have functions, and they can be explained by their functions. Various shapes of a tool are tried out. One is more effective than the others because, for example, it is better balanced. This shape is copied more than the others and eventually becomes the norm in that culture. The function of the shape is to balance the tool and the occurrence of the shape can be explained by the fact that it balances it. The shape retains this function even when it cannot perform it. A badly made or broken tool still has the shape, and the functional explanation can still be given. The shape can even become vestigial, when the tool is reproduced in jade as a votive object. The shape's function is, I contend, a proper function.

The account of artifact function I offer here is able to avoid the problems just discussed. It does not assign proper functions to artifact traits which accidentally contribute to intended uses. Conversely, it does assign proper functions to artifact traits that arise as a result of trial and error.

8 ETIOLOGY AND ARTIFACTS

Artifact functions can be handled in a manner analogous, although not identical, to my treatment of biological functions. The etiological account can be extended to artifacts because human selection does for artifacts what natural selection does for organisms. The prevalence of an artifact, or an artifact trait, can be explained by selective processes in which people meet their needs, sometimes by conscious design, sometimes by trial and error, and sometimes by an amalgam of the two.

The extension of my account requires a 'selection type theory' (Darden and Cain [1989]) of the processes that give rise to artifacts. I exploit the fact that these processes share certain features with natural selection to construct selective explanations for the features of artifacts. It turns out that this can be done in such a way that the formal analysis given above can be applied directly to artifact functions.

Although artifacts are not in actual competition with other artifacts during the design process, they are in hypothetical competition. The designer conceives a range of alternatives and chooses amongst these in virtue of their perceived possession of certain capacities. Some are more capable of performing the intended use than others. As in biological competition, there is only a certain range of available alternatives. Maori canoe designers did not have to consider the idea of the winged keel. It was not part of the 'population' of designs which were in competition at that time.

The 'fitness' of an artifact or artifact trait is a rather vaguer notion than the fitness of a biological system or trait. It is still the propensity of the system or trait to be reproduced, relative to the alternatives. (Note that the fitness of an

artifact is its propensity to be reproduced, not its efficiency in fulfilling its intended use.) But this class of alternatives will be hard to specify once hypothetical selection is admitted, and accurate measures of fitness will not be possible. However, as I remarked above, some artifacts and artifact traits are not consciously designed but occur through trial and error. In such cases the selection process which has produced the current design has involved selection between actual alternatives in virtue of actual performances. (An explanation of the spread of iron weapons and farming gear might take this form.) In such cases the class of alternatives will be easier to specify, and a more accurate assessment of fitness may be possible.

The other major element of my account of biological function, the theory of vestiges, also has its artifact analogue. There are many vestigial artifact traits, from those elements of classical stone architecture derived from wood construction to Maori 'fish-hook' pendants. They are vestiges, not merely because they cannot perform their original function but because they have not been selected in virtue of their original function for so long that they would have been eliminated if they had not acquired a second, decorative function.

There is one major superficial difference between biological functions and artifact functions. The overall capacity to which biological functions contribute is the animal's fitness—its relative capacity to survive and reproduce. The overall capacity to which artifact functions contribute is usually thought to be the capacity to perform the intended use. If the design of artifacts is to be assimilated to natural selection in the way described, this difference will have to be overcome. I suggest that the function of an artifact is its intended use only because its ability to fulfil its intended use gives it a propensity to be reproduced. The overall capacity to which the proper functions of artifacts contribute is the capacity to be reproduced, but they contribute to this capacity via the capacity to fulfil the intended use.

When we say of a whole artifact 'this is what it is for', we refer to a *penultimate* level capacity, realized by the general configuration of the artifact. There may be several such capacities, as an artifact can have more than one intended use. The ultimate capacity which gives rise to functions is the capacity to be reproduced, just as it is with biological systems. An analogue to the overall function of an artifact might be the ability of an animal to occupy its niche. What is a wolf for? To be an effective predator in temperate climates.

The subordination of intended use to this secondary role might seem to give rise to a difficulty. If an artifact's function is its intended use, it can have a function which neither it nor any ancestor has ever performed. Consider the tapered tail of an old racing car. This feature is intended to streamline the car, to reduce its drag coefficient. But it does not do this, and nor have any of the other designs it has 'evolved' from. They are all based on a false theory about drag. It is hard to see how there could be a selective explanation of a trait of this

kind. There have, it seems, been no episodes when it has performed well, and hence been selected.

This type of situation cannot arise with biological functions. Natural selection can only operate on a trait in virtue of something it actually does. A trait may cease to perform its function, but it must at one time have performed it.

The solution to this difficulty is actually implicit in what has already been said. I have shown how to create a more abstract notion of 'selective process' by allowing selection amongst hypothetical alternatives. This selection amongst hypothetical alternatives occurs in a hypothetical environment constituted by the beliefs of the designer. When the designer has false beliefs about the real world this results in artifacts functioning well in his hypothetical environment when they do not function in the real environment. The tail of the facing car did perform its function, but only in the mind of its designer.

9 CONCLUSION

There are considerable differences between the kinds of selective processes that give rise to artifact teleology and those that give rise to biological teleology. Artifact functions are not just the biological functions of inanimate objects! This can be seen clearly by considering the contrasting artifact and biological functions of traits of selectively bred animals. Suppose pigeon breeders select a long tail because they falsely believe that it will make the pigeon fly faster. Its artifact function will be to make the pigeon fly faster. Its biological function, however, must be a property it actually has, since only actual properties can be subject to natural selection. In this case, its biological function will be to fool people into thinking it is useful, just as the biological function of the yellow stripes on a harmless insect is to fool other organisms into thinking it dangerous!

So I cannot offer a unified theory of proper functions. But I can offer a unified theory of naturalistic teleology. Both kinds of proper function derive their teleological force from the contribution of past performances of function to reproduction. In the case of artifact teleology, however, these performances are frequently hypothetical, and sometimes occur in an unrealistic hypothetical environment.

There may be other types of process that give rise to teleology supporting functions. Darden and Cain [1989] have pointed out analogies between biological evolution and other 'selection type theories', such as the clonal selection theory of antibody production. I believe it is to be a general characteristic of such theories that they allow the prevalence and form of selected traits to be explained by the effects of these traits on survival and reproduction. They will, therefore, give rise to proper functions. But there

should be nothing surprising in the fact that wherever there is selection, there is teleology.

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