

Structural Flaws:

Massive Modularity and the Argument from Design

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Abstract: The ‘argument from design’ plays a pivotal role in Carruthers’ recent defence of the massive modularity thesis. However, as this paper seeks to show, there are major flaws in its structure. If construed deductively, it is unsound: modular mental architecture is not necessarily the best architecture, and even if it were, this alone would not show that this architecture evolved. If construed inductively, it is not much more convincing, as it then appears to be too weak to support the kind of modularity Carruthers is concerned with. The upshot of this is that whatever reason we might have for believing that the mind is massively modular, it is not based on the argument from design.

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1. Introduction

Peter Carruthers' ([2006]) account of mental architecture is an impressive and carefully laid out defence of the massive modularity thesis (MMT): the claim that the (human) mind is built out of functionally distinct, domain-specific components that can be altered independently from one another. Among the many arguments presented there, the 'argument from design' holds a pivotal place, as it presents some of the most important theoretical considerations supporting the MMT.¹ However, as this paper seeks to show, this argument contains a number of flaws, which ultimately make it unsuccessful in supporting the MMT.

The paper is structured as follows. Section 1 lays out two versions of Carruthers' argument from design. Section 2 shows why the deductive version is unsuccessful, and section 3 does the same for the inductive version. Section 4 summarises the discussion.

2. Carruthers' Argument from Design

Carruthers' ([2006]) 'argument from design' (a version of which he credits to Simon [1962]) constructs the case for a massively modular mental architecture on the fact that the (human) mind is an evolved, biological system, and thus obeys the same principles of design that other biological systems obey (Carruthers [2006], pp. 12-29). In particular, the (human) mind can be expected to be built according to the principle that *optimal organism design is modular* (the 'principle of optimal design' in what follows).

Expressed in more detail, this principle has it that organisms are optimally designed if they are hierarchically structured, with parts that are dissociable, functionally largely distinct and independently alterable (Carruthers [2006], pp. 13, 17-20; Simon [1962]). For a more general discussion of modularity, a precise definition of ‘dissociability’ and ‘functional distinctness’ would be required (see e.g. Carruthers [2006], pp. 7-12 and Cosmides & Tooby [1992], p. 163). For present purposes, though, it is sufficient to focus on the *independent alterability* of a module, as it is only this that plays a role in Carruthers’ argument (see e.g. Carruthers [2006], p. 25).²

In order to lay out the argument from design in more detail, it first needs to be noted that there is not just *one* such argument, but *two*: a *deductive* and an *inductive* one.³ Carruthers does not always distinguish them clearly (see e.g. Carruthers [2006], p. 25, where they are set out side by side), but for present purposes, it is important to keep them apart.

The deductive version proceeds as follows: Given the influence of natural selection on the evolution of complex features of an organism, we ought to expect that (1) (near-) *optimal* solutions to an organism’s adaptive problems evolve (Carruthers [2006], p. 21-2). (2) Modular design is optimal (this holds both for the whole organism as well as for its parts – Carruthers [2006], pp. 19-20). (3) The mind is an evolved part of an organism (Carruthers [2006], pp. 15-7). Therefore, we ought to think that (4) the mind is organised in a modular manner.

The inductive version begins by noting that the principle of optimal design supports the empirical generalisation that (1’) virtually all biological systems are designed in a modular way (Carruthers [2006], pp. 13-5, 414). It is furthermore the case that (2’) the

mind is a biological system (Carruthers [2006], pp. 15-7). Therefore, (1') and (2') provide inductive support for the conclusion that (3') the mind is modular.

The two versions of the argument rely on the 'principle of optimal design' in different ways: the deductive version uses it as premiss (2), whereas the inductive one uses it as *support* for premiss (1'). Since the principle is equally crucial for both versions, however, it is important to be certain that it is indeed *true*; to show this, Carruthers lays out the following two arguments.

Firstly, he notes that good designers build with the possibility of later alterations in mind. In order to be able to flexibly react to necessary changes in the future, it is good to construct an organism in such a way that its parts can be altered without other parts thereby being affected (Carruthers [2006], p. 25). The more integrated the parts of an organism are, the more wide-ranging the changes will have to be, up to the point where any change in one part of the organism essentially requires redesigning the whole. Since changes become more costly the more parts of an organism one has to change simultaneously, integration ought to be selected against.

Secondly, Carruthers supports the principle with evidence from computer science (Carruthers [2006], pp. 21-3); there, it has for some time been known that good programming is modular. Instead of writing a long list of convoluted instructions without isolable parts (a 'spaghetti code'), it is much more conducive for future improvements and alterations to construct virtual *objects* that are largely functionally independent of one another and are merely *coordinated* centrally.

While plausible on the surface, both versions of the argument from design face some major difficulties. To show this, it is best to discuss them individually, beginning with the

deductive version. However, due to the close connections between the two versions, parts of the discussion in the next section will also be important for that in section 3.

3. Modularity and Optimality: Problems for the Deductive Argument from Design

The first question that needs to be settled in discussing the deductive version (and, as will become clear below, the inductive version) is whether Carruthers is in fact successful in making the case for the principle of optimal design. To assess this, begin by noting that *integrative* design (the opposite of modular design) does not just have *costs*, but it also has *benefits*. This means that in order to mount a truly compelling argument for the conclusion that modularity is optimal, both costs *and* benefits of alternative designs must be taken into account. More specifically, it must be shown that the costs *always* outweigh the benefits for an integrative organism design. However, no such dominance argument is possible here.

The following stylised example brings this out clearly. Assume an organism contains two traits, T1 and T2, that can vary continuously along some scale. Assume further that there are two ways of constructing these traits, a modular one and an integrated one. Finally, assume that the organism only derives benefits from having these traits if they are employed in given fixed ratios, and that the organism bears costs if they are employed otherwise. In such a case, allowing the traits to vary independently from one another is *detrimental*—an optimal design is one that integrates the traits in such a way that changes in one engender changes in the other. This is because if traits are *functionally integrated*,

then *evolutionary integration* can be beneficial as well. Graphically, this can be shown as follows:⁴

[figure 1]

Here, the degrees to which traits T1 and T2 are exhibited in the organism are represented on the horizontal and the vertical axes, and the optimal ratios are depicted by a dotted line. Finally, the angled lines IB1-IB3 represent ‘iso-benefit lines’—lines along which the level of adaptiveness that comes from having the two traits in the ratio specified remains the same; benefit increases in the north-easterly direction. The key point to note is that changes in one trait while holding the other trait fixed are equivalent to a shift onto a *lower* iso-benefit line.

The existence of cases like this is more than just an abstract possibility. Concrete examples of traits related in this way abound. Two of them are particularly important: those where having one trait is only useful if it is accompanied in the right way by a second trait, and those where the two traits bring about extra benefits if employed jointly.⁵ In both of these cases, it is important to bear in mind that the issue is not whether the traits in question *actually* vary independently from one another (to which I shall return below), but whether they *optimally* do so.

For an example of the first case, consider strength in fighting and aggressiveness in behaviour. Being aggressive might be beneficial to an organism only if it is a strong enough fighter to back up that aggression. Equally, being a strong fighter without being aggressive might be detrimental if there are no benefits to fighting-strength other than the

ability to win fights, if being a strong fighter has costs (e.g. energetic ones), and if one lives in a population of organisms that do not pick fights themselves (but which fight back if attacked).⁶ In such a scenario, strength and aggressiveness are optimally designed as an *integrated* system.

The second kind of case is exemplified by traits that are related in such a way that their combination—if well coordinated—yields benefits over and above those that could be had from them individually. For example, if a bird gains computational benefits from using the way in which the horizon ‘curves away’ under it *together with* the fixed features of its environment to calculate its optimal landing speed and angle—i.e. if it derives informational gains from *integrating* the two modalities—then being able to independently change these abilities might *not* be optimal (see also Reed [1996], pp. 49-50).

At this point, the following objection might be raised: maybe we have been individuating the relevant traits wrongly. After all, nobody would presume that the length of an organism’s *leg* can be altered independently from that of the others—this is only *one* trait, not *multiple* (see also Sober [forthcoming]). So, the objector might continue, it is true that the optimal design of different traits and their relevant parts is modular; we just need to be careful that we individuate traits and their parts correctly.

However, it is not clear how this reply helps in the present case. In fact, it seems to merely re-describe the issues under discussion: instead of asking whether various traits ought to be expected to be modularly organised, we can also ask whether they are to be considered as different traits, or different parts (in the relevant sense) of the same trait. This makes the present discussion a verbal dispute—as long as it is accepted that some

features of an organism are best designed in an integrated way, nothing much hangs on whether these should be called *one* trait, or *multiple, integrated* traits.

In all: there are theoretical considerations that speak *against* modularity being always optimal, making an unrestricted version of Carruthers' principle of optimal design false. This has important consequences for the deductive version of the argument from design (and, as will become clear in the next section, for the inductive one as well).

Most obviously, the falsity of the principle of optimal design alone makes this version of the argument *unsound*. This should be troubling enough; however, the problems do not end there—for even if this principle *were* true, it would still not make this version of the argument sound, as premiss (1) (which provides its key inference) is *also* false.⁷

To see this, begin by noting that it is now widely accepted that optimality-reasoning alone is quite uninformative (Williams [1966]; Maynard-Smith [1984]; Sober [1994]): in 'optimal' circumstances, zebras would run at the speed of light and have machine-guns. What needs to be taken into account are the relevant *constraints*: since optimal solutions can at most be expected to evolve if the time is infinite,⁸ and since this is not true for us, optimality alone entails nothing about what traits actually did evolve (in fact, this seems to be accepted by Carruthers himself—see Carruthers [2006], pp. 23-6).⁹ There are three sorts of constraints in particular that need to be investigated before any further conclusions about the structure of our minds can be drawn.¹⁰

The first is the number of designs available to the organism (see also Dawkins [1986]). It may be that modular design is the best possible design; if, however, that design option never appeared in the lineage as a viable alternative, then the organisms had to do without

it. The *optimality* of the trait alone does not guarantee its existence as an alternative for finite populations.

The second constraint concerns the starting point of the organisms in question. It may be that the rudimentary minds we started out with were highly integrated (or even just less than *massively* modular). In such a case, it may have been cheaper to improve on the integrated minds, rather than rebuild the entire mind on a (massively) modular basis. This constraint gains in potency when combined with the first: given a highly enough integrated starting point, a (massively) modular *viable* alternative might never arise.

The third point takes this last insight one step further: there might be *structural constraints* on the organism that speak against parts varying independently from one another. For example, it might be physically impossible for the organism to alter in size without altering in mass at the same time. Similarly, it might be impossible—because of the way the brain is structured, say—that the vast majority of our cognitive skills can be changed independently from one another.

In short, it is important to keep in mind that optimal design is not identical with workable design (see also Sober [1981], pp. 110-1). This can be usefully illustrated with Carruthers' own analogy from computer science: it might be true that good programming is modular in nature; however, it is also the case that bad programming can be functional. It might be true that changing 'spaghetti code' can be very costly and time-intensive; however, it is also true that it might be less costly and time-intensive than re-writing the entire program in a modular way. The exact balance between costs and benefits depends on the details of the case: what we started out with, what the available alternatives are, and what the general constraints on programming feasibility are (e.g. what kind of

writing is being allowed by the programming language in question). The same holds for the evolution of a biological trait like the mind: without taking account of the biological details, determining its *optimal* structure does not say much about its *actual* structure.

However, the present version of the argument from design is in an even more precarious situation—for *even if* empirical evidence about the relevant constraints were taken into account, that argument would not be saved. To see this, note that Carruthers spends considerable time presenting evidence that suggests that many animals—including, in particular, the higher primates—have minds that are organised in a modular way (see e.g. Carruthers [2006], pp. 25-35, 95-136, 157-9). In the present context, this could be interpreted as an attempt to show that modular design was *available* to early hominids as a design option, and that their evolutionary starting points and structural (i.e. neurological) features did not preclude this option from being *taken up*.

However, contrary to appearances, the introduction of this evidence does nothing to help the argument from design. This is not so much because Carruthers' interpretation of this evidence can be disputed (though this may be the case, too) but because this evidence is the core of one of Carruthers' *other* arguments for the MMT—one which he calls the 'argument from animals' (Carruthers [2006], pp. 25-35, 414-5). This argument claims that since there is evidence for our ancestors' having had modular minds, and that since we have evolved *from* these ancestors, we are likely to have modular minds as well.¹¹

Importantly for present purposes, it is not clear what the argument from design can *add* to this argument—i.e. it is unclear why we need the argument from design *on top of* the argument from animals. If we have *empirical* reasons for thinking we have evolved massively modular minds, why should we be concerned with establishing that modularity

is optimal and can *therefore* be expected to have evolved? Adding empirical evidence to the deductive version of the argument from design merely turns that argument *into* the argument from animals—it does nothing to *strengthen* the former.¹²

4. Degrees of Modularity: Problems for the Inductive Argument from Design

Does the inductive version of the argument from design fare any better?

Unsurprisingly—given its connection to the deductive one—the answer to this is no. To see this, remember that premiss (1') of this version of the argument—its key proposition—is said to derive its support entirely from the principle of optimal design (Carruthers [2006], p. 25). However, as shown in the previous section, this principle is false. This means that if this version of the argument is to be considered compelling, other grounds for supporting that proposition must be found. This, though, turns out to be very difficult.

If (1') is to be at all plausible, it cannot be read as saying that—given finite evolutionary time—the parts of an organism can be altered *completely* independently from one another. This reading is much too strong and clearly false: sticklebacks might be able to get stronger body-armour, but only at the cost of swimming speed. Zebras might be able to run faster, but only at the cost of needing more food. A giraffe's neck can get longer, but only at the cost of the rest of her body getting bulkier. And so on.

This means that (1') has to be read more weakly as saying only that (virtually) all biological systems are modular *to some extent*. That is, to be plausible, it must appeal to a notion of modularity that is a matter of *degree* (Carruthers himself seems to accept this:

Carruthers [2006], pp. 14-5). This is also much more reasonable biologically: we always expect there to be *some* dependencies between the parts of organisms—traits are, at most, *quasi-independent* from one another (see e.g. Lewontin [1978] and Brosnan [forthcoming]). Further (as also noted by Carruthers himself: Carruthers [2006], p. 23), the degree to which they are quasi-independent varies from the very low (length of different legs, quality of eyesight and camouflage in arctic albino animals)¹³ to the very high (running speed and fur-length, plumage colour and singing pitch).

However, if *this* reading of (1') is taken as the basis of the inductive version of the argument from design, then that argument loses much of its bite. For in that case, all that the argument can establish is that the mind is as modular *as the rest of biology*.¹⁴ Since, as just noted, the extent to which the rest of biology is modular can vary widely, this makes the conclusion (3') of the argument a fairly weak claim. In particular, it makes (3') compatible with the mind being exactly the kind of general-purpose reasoning system the MMT is meant to rule out (see e.g. Cosmides & Tooby [1992], p. 34). That is, construed in this way, the inductive version of the argument from design cannot exclude the possibility that the mind consists of only a handful of distinct computational systems and a central processor (as e.g. laid out in Fodor [1983])—precisely the kind of mental architecture that is the *target* of this argument (see e.g. Carruthers [2006], pp. 2-3). However, no other plausible reading of (1') is available. Hence, the inductive version of that argument cannot be considered successful either.¹⁵

Carruthers might reply at this point that the *complexity* of the trait matters: it may be that some *non-complex* traits have only relatively low degrees of modularity. This,

though, does not hold for complex traits like the mind, which *do* tend to be highly modular.

The difficulty with this reply is that it simply seems false for the most plausible reading of ‘complexity’ that is not question-begging. Clearly, ‘complexity’ here cannot be understood as meaning that the trait has a (massively) modular structure—for that is what is to be *established*. By contrast, if traits are said to be complex because of the amount of *functions* they can perform—the most reasonable alternative characterisation, and one also accepted by Carruthers (in personal communication)—this just does not support the generalisation that these traits tend to be modularly designed. Chimps use their hands for grooming each other, fighting each other, climbing trees, digging in the ground, and many other things. However, it is not the case that a chimp’s hand is modularly designed *along these dimensions*. Similarly, just because the mind is able to perform many different functions—detect cheaters, find mates, predict other agent’s decisions, etc.—this does not mean that these have to be subserved by different modules. At least, this does not follow from how functionally complex traits are designed in biology in general—and this is all that this version of the argument from design has at its disposal.

5. Conclusion

I hope to have shown that both versions of Carruthers’ argument from design fail: the deductive one is unsound and the inductive one is too weak to support an interesting version of the MMT. Of course, this does not lead to the collapse of the MMT in general,

nor does it show that Carruthers is wrong in thinking that the mind is modular. It just means that the argument from design cannot establish the MMT, and that support for it must be found elsewhere (e.g. in the cognitive scientific applications that this hypothesis makes possible, as shown in the rest of Carruthers [2006]). The lesson to take away from all of this therefore is that, wherever the support for the MMT ultimately comes from, it will not be based on a non-trivial, universally applicable principle of optimal organism design – for there is no such principle.

Notes

¹ Note that this ‘argument from design’ clearly ought not to be confused with the similarly labeled argument that infers the existence of god from the complexity and purposefulness of organic life.

² This is a point about *evolution*, not *ontogeny* or *function*. However, as will become clear below, the optimality of a design from an evolutionary point of view might depend on its functional dependence on other traits.

³ I thank Peter Carruthers for helpful discussion about this.

⁴ Mathematically, it is easiest to describe this as follows: $IB_i = T1 + T2 - w|T2 - T1|$. If $w > 1$, then the angle θ between the two parts of the iso-benefit line is greater than 90 degrees. If $w = 1$, then θ is a right angle. Note furthermore that θ can be made arbitrarily small by increasing w , so that the range within which one trait is required to vary to maintain (or improve) a certain level of adaptiveness when changing the other trait can also be made arbitrarily small. In the limit (for w going to infinity), for every change in $T1$, there will be only one value of $T2$ that it is consistent with the combination of the two traits remaining beneficial. If $w = 1$ (so that $\theta = 90^\circ$), changes in one trait that are uncompensated by changes in the other trait leave fitness *unchanged*. For discussion of a similar formal approach to Temkin-inspired measures of inequality, see Cowell & Ebert ([2006]).

⁵ In the background here is also the distinction between *advantageousness* and *fit* (see Sober [1993]): not all individually advantageous traits also increase fitness, and vice-versa.

⁶ This is a variation on the well-known ‘hawk-and-dove’ game: see e.g. Sober ([1993]).

⁷ Samuels ([1998]) also notes that arguments for the MMT based on considerations of optimal design are flawed; however, the notions of modularity and optimality he is concerned with are importantly different from the ones under discussion here.

⁸ Note that even this is questionable from a probabilistic point of view.

⁹ Of course, this does not preclude optimality arguments from being useful heuristic devices. However, heuristic devices on their own do not give one reason to believe that the principles on which they are built are *true*. Assuming God designed organisms with their best interests in mind might be useful for finding out about adaptations, but that does not give one reason to believe that they were *actually* designed in this way.

¹⁰ For simplicity, I leave out of the present discussion factors other than natural selection. Introducing these explicitly, though, would only strengthen my argument, so that their exclusion is harmless.

¹¹ Note that this argument faces similar problems to the ones laid out here: just because the minds of our ancestors were *somewhat* modular does not, as such, entail that our minds are *massively* modular. Moreover, optimality considerations cannot be used to bridge this gap either, since, as just shown, Carruthers has not given grounds for thinking that a modular architecture is universally optimal.

¹² In personal communication, Carruthers has suggested that he is merely concerned with motivating the *plausibility* of the MMT as a possible design structure of the human mind. However, I take it that this much must be considered as already established – see e.g. Cosmides & Tooby ([1992]).

¹³ The last example is from (Stich [1990], p. 65).

¹⁴ Carruthers (in personal communication) accepts this as a hidden premiss of his argument.

¹⁵ Samuels ([2005], pp. 43-4) hints at a similar argument.

Acknowledgements

I thank Peter Carruthers and Elliott Sober for helpful discussions of previous versions of this paper.

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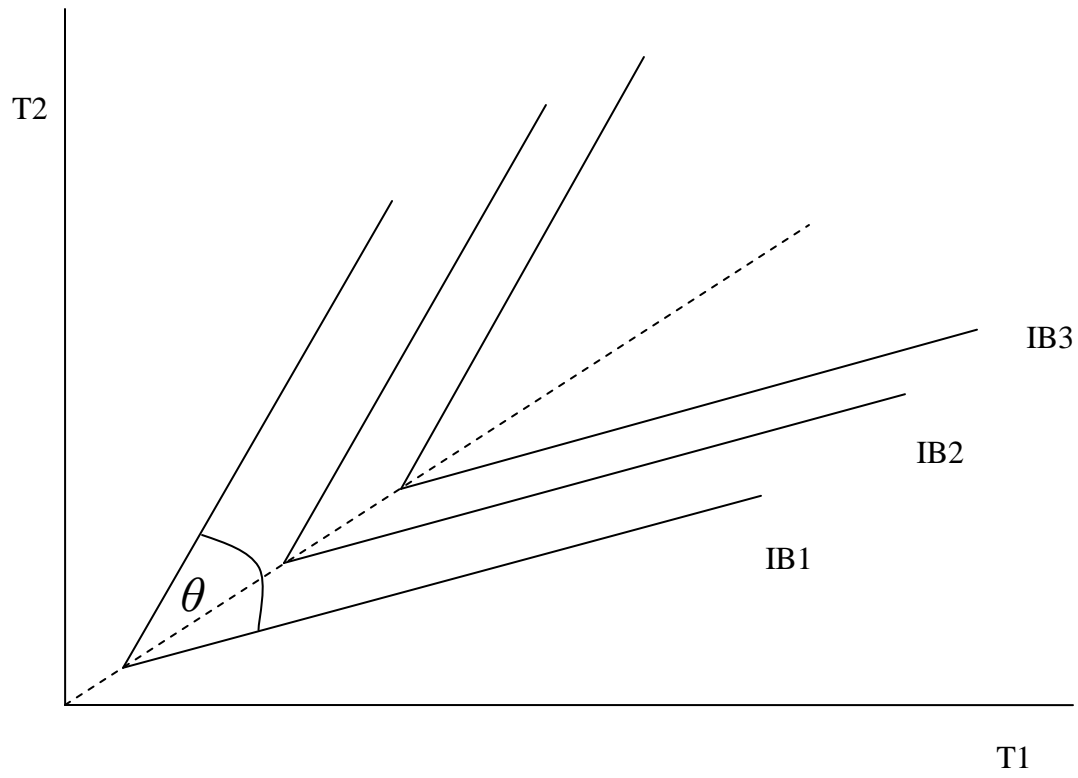
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[Figure 1]