# Nativist Models of the Mind*

Michael E. Cuffaro

Nativism is the view that our minds come pre-equipped with significant amounts of information relating to specific problem domains: domains for low-level processes such as vision, as well as for more central aspects of cognition like reasoning and decision-making. Among nativists, however, there is much debate over the actual architecture of the mind; over the nature of the mental structures involved in cognition. My aim here is to give a defence of the Massive Modularity (=MM) hypothesis: the view that the mind is largely composed of discrete, *encapsulated*, informationally isolated *computational* structures (modules) - each of them dedicated to dealing with a particular problem domain.

MM is but one of a family of nativist views collectively referred to as the Computational Theory of Mind. Within this broader camp, MM contrasts with Psychological Rationalism: a view which holds that the mental structures involved in central cognition take the form of representational items (which are not encapsulated) corresponding to such things as beliefs, theories, logical truths, and the like - all of which are available as inputs to a *domain-general* computational processor. As far as cognitive architectures go, both models of cognition represent good designs, or so I will argue.

There are no 'knock-down' arguments that can be made against either view. It is not the case that the computations involved in solving adaptive problems are intractable for a domain-general mind. It is not the case that a massively modular mind is, *a priori*, better

*I am indebted to Professor Murray Clarke for his helpful comments on an earlier draft of this paper.

suited for solving these problems. It is not the case that *nothing but* a massively modular mind could conceivably have been selected for by natural selection. Likewise, it is not the case that a massively modular architecture is inherently self-defeating. But just as a boxer can win a match without scoring a knockout punch, one can declare a winner in the nativist debate without a 'knock-down' argument. I will argue that, although none of the above points of contention show *absolutely* that MM *must* be the winner, they all point to MM as a better explanation for how our minds deal with the adaptive problems that we face every day.

Before I begin I will make one final note: I will not attempt to address Fodor's locality objection to the Computational Theory of Mind. To address Fodor's objection satisfactorily in addition to what I will deal with here would require far more pages than I have available. More importantly, although I will not argue this here, I believe that Fodor's argument applies equally to both Psychological Rationalism and to MM. While both views propose different solutions to the abduction problem, it is beyond the scope of this paper to address them.[1]

## Psychological Rationalism

Psychological Rationalism is a nativist conception of cognition that traces its roots back to Plato. Something like it was defended by Descartes and most of the early modern philosophers of the rationalist tradition. With the rise of Hume and the empiricist tradition, however, Rationalism in psychology fell into decline. It was not until the second half of the twentieth century and Chomsky's work on language that the paradigm began to be taken seriously again. Chomsky used poverty of the stimulus arguments to show that some aspects of human grammar are not learnable through experience, i.e., that there are in-

[1] For Fodor's locality objection, see (Fodor 2000, 23-53). Some responses from MM theorists are: (Clarke 2004, 30-42; Pinker 2005; Carruthers 2005). Responses from Psychological Rationalists include (Samuels 2005; Shusterman & Spelke 2005).

nate representational items in the form of mental structures specially adapted for language acquisition.

What is common to the different variants of the psychological rationalist view is that at least some thoughts, beliefs, and desires have logical forms which determine the role they play in mental processes. For example, the belief that John loves both Mary and Rachel is a conjunctive belief that may cause me to believe that John loves Mary (i.e. that can be inferred from the conjunctive belief). Importantly, the *logical form* of a conjunctive belief is not something that is reducible to the empirically observed associations between John, Mary, and Rachel (Fodor 2000, 14-15). In other words, I do not need to observe John kissing Rachel in order to *infer* 'John loves Rachel' from 'John loves both Mary and Rachel'.

Through the influence of Fodor, most contemporary psychological rationalists believe that some 'low-level' mental processes, such as vision and language, are modular. That is, they believe that these mental processes are informationally isolated with regard to the types of inputs they can receive and constrained (encapsulated) with regard to the types of operations they can perform on these inputs. For example, the mental process associated with vision is domain-specific: it is able to operate on the domain consisting of shapes and colours but nothing else. But in contrast to these low-level processes, *central* cognition (reasoning) is believed to be *non-modular* and *domain-general*. If abstract reasoning is to occur in humans, it must be the case, for psychological rationalists, that there is some kind of domain-general processor that can operate on inputs from *all* domains.

**Massive Modularity**

If contemporary Psychological Rationalism can be said to be descended from the rationalism of Plato and Descartes, MM can be said to have its progenitor in Kant. Like Kant, MM theorists deny that there *must* be one place where central cognition occurs;[2] i.e. that this necessarily follows from the fact that we are able to reason. While they do not positively rule out that there is a central location in the brain that is analogous to the psychological rationalist's domain-general processor (e.g. see Clarke 2004, 32), they hold that most aspects of central cognition are largely modular in a loosely Fodorian sense. On the massively modular picture of the mind, the mental structures that are characteristic of most of central cognition consist of the conjunction of a domain-specific body of data with an encapsulated computational processor dedicated to it.

An example of a module relating to peripheral cognition is the vision module. Light waves are received by the eye and then represented to the module in varying degrees of lightness and darkness, various colours and shapes, various degrees of movement, etc. These latter representations, which constitute the module's domain, are recognized by the module's processor, which then acts on them. The vision module is informationally isolated since it only responds to input of a specific type. Even though I am certain, for example, that the road doesn't actually taper off to a point somewhere in the distance, the fact that I am certain of this doesn't affect the fact that this is what the vision module presents to me. I have no way of bringing this external knowledge to bear on it. It does not belong to the module's domain.

In addition to the vision module, MM hypothesizes that we have modules for each of the other senses, for language, and for most of the aspects of central cognition. Some MM theorists have hypothesized that we may have hundreds, if not thousands of modules for

[2]For example, Kant writes: "Hence here, just as in the previous paralogism, the formal proposition *I think* remains the whole basis on which rational psychology ventures to expand its cognitions. But this proposition is, of course, not an experience, but is the form of apperception. Although this form attaches to and precedes every experience, it must still always be regarded only as concerning a possible cognition as such, viz., as *merely subjective condition* of such cognition. We wrongly turn this subjective condition into a condition of the possibility of a cognition of objects, viz., into a *concept* of a thinking being as such. ... Moreover, the simplicity of myself (as soul) is not actually *inferred* from the proposition *I think*; rather, the former proposition, *I am simple*, already lies in every thought itself" (Kant 1996, A354)

such things as spatial reorientation, cheater detection, theory of mind, sexual jealousy, and on and on. That said, most MM theorists leave open the possibility that other aspects of our cognitive architecture are not modular in the Fodorian sense. We can illustrate some of the possibilities as follows:

| | Domain-specific processors (Darwinian Modules) | Domain-general processors |
|---|---|---|
| Domain-specific bodies of data (Chomsky modules) | A | B |
| Domain-general bodies of data | C | D |

Box A, in this figure,[3] corresponds to the "Fodorian" module that we have been discussing so far. While MM theorists believe that our cognitive architecture is mostly made up of structures corresponding roughly to box A, they by no means rule out that some parts of the mind correspond to boxes B, C, and D.[4] Indeed, the division into boxes A,B,C, and D is perhaps a little too neat. For example, some MM theorists question whether the modules making up central cognition can be said to belong to box A in the strict sense. Carruthers, for example, hypothesizes:

> Since central modules are supposed to be capable of taking conceptual inputs, such modules are unlikely to have proprietary transducers;[5] and since they are charged with generating conceptualized outputs (e.g., beliefs or desires), their

[3]This illustration is taken from Clarke 2004, 6

[4]This is a point that critics of MM often fail to take account of.

[5]In *Modularity of Mind*, Fodor defines a transducer as that part of the module which transforms environmental inputs into a form that can be used by the module.

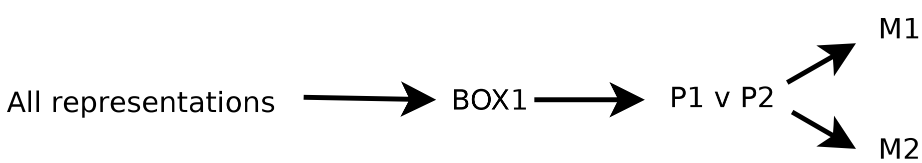
> outputs cannot be shallow.[6] Moreover, since central modules are supposed to operate on beliefs to generate other beliefs, for example, it seems unlikely that they can be fully encapsulated - at least *some* of the subject's existing beliefs can be accessed during processing by a central module (Carruthers 2005, 70-71).

So it is conceivable that in central cognition we could have a module which receives inputs from two or more downstream modules, combines them, and then outputs the result (which is perhaps used as a part of the input to some other module).

**Fodor's Input Problem**

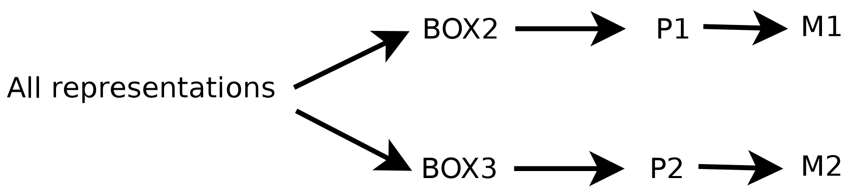
One of the most important objections to the MM hypothesis is what Fodor calls the *input problem* (Cf. Fodor 2000, 71-78). The input problem presents a difficulty both on theoretical and empirical grounds. Indeed, if Fodor is correct, the input problem shows, *a priori*, that the MM hypothesis is inherently self-defeating. The problem is this: suppose that we have a mind consisting of two modules, M1 and M2. M1 is for thinking about squares but not about triangles, while M2 is for thinking about triangles but not about squares. Now both M1 and M2 respond to the syntactic properties of their input representations; call these P1 and P2. M1 is turned on only when it encounters P1, and M2 is turned on only when it encounters P2. The question then arises: what is the procedure that assigns the inputs to M1 and M2? Two options present themselves:

**Option 1:**




[6]Another Fodorian term, which can be translated as "simple."

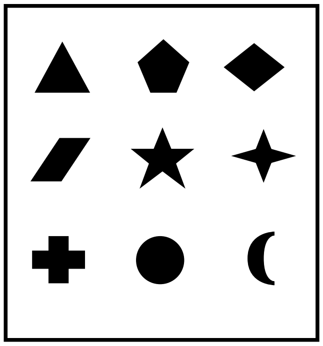
**Option 2:**




If we go for option 1, then this undermines MM, for we need to say that BOX1 is less modular than either M1 or M2 (in fact, in this simplified example it is completely domain-general). On the other hand, if we go for option 2, then we court a regress, for something must determine which of the "all representations" go to BOX2 and which go to BOX3. As Fodor puts it: "each modular computational mechanism presupposes computational mechanisms less modular than itself, so there's a sense in which the idea of a *massively* modular architecture is self-defeating" (Fodor 2000, 73). MM theorists cannot get around this problem by saying that the mind is not made up entirely of "Type A" modules. Typically those alternative types of modules are appealed to when we need to explain how inputs from *other modules* are combined and represented in a more central module. But as the name implies, the input problem relates to the input itself. We cannot even get past the first stage, it seems, without having something there to identify and route the various inputs to their respective modules. But then why would we need the modules at all if this 'something' has already done the difficult job of identifying the various inputs?

One response is to question Fodor's basic premise that the inputs need to be "identified" and "assigned." Fodor assumes that something, either the module itself, or some other mechanism further up the chain, needs to "decide" that such and such an input belongs to such and such a module. But consider the following analogy. Suppose you have a strip of cardboard with holes cut into it like so:[7]

[7] I call this argument the 'geometry' argument, due to the analogy with geometrical shapes. The same basic idea, however, is also expressed in (Clarke 2004, 22-25). Clarke hypothesizes that modules may be turned on 'automatically' by environmental or other stimuli. In (Cuffaro 2005), I present the 'cocktail party' argument,



Now imagine someone *randomly* throwing wooden blocks of various shapes at this cardboard strip (perhaps all at once). It is evident that only the star-shaped blocks will fit into the star-shaped hole, only the triangular-shaped blocks will fit into triangular-shaped hole; some will miss the strip entirely; some will be the right shape for a hole but will not be aligned with it properly, etc. The cardboard strip does not need to "think" in order to decide which blocks go into which holes. That the square block fits into the square hole is determined by the structure of the hole, the structure of the block, and the way it is thrown.

The "structure" of a module, shaped as it were, by natural selection over many generations, can be such that it will only operate on inputs of a certain type and not on others. If this were the case, then when an input of a foreign type entered a module, analogously to the case where the square block fails to get into the round hole, the processor would simply fail to compute and continue waiting for the next block. We would still need some in-between device to send all of the inputs to the various modules, but this device, call it a multiplexer, would not need to be intelligent at all. It would simply need to receive the outputs of the sensorium as input, and then combine these - *blindly* - into an output stream that could then be duplicated and sent to the various modules.

Now it is all well and good to talk about relatively simple things like geometrical shapes,

where I illustrate a mechanism by which modules can 'turn on' in a way analogous to radio receivers in the channel access method known as 'Code Division Multiple Access' (CDMA). Modules are compared to actual computer processors in (Collins 2005), and to enzymes in (Barrett 2005). I believe the geometry argument that I present in this paper is intuitively clearer than all of these.

but in the real world what distinguishes one scenario from another is vastly more complicated. It is far from obvious, for example, what all cheater-detection scenarios have in common that serves to distinguish them from non-cheater-detection scenarios. I agree, and I think that MM theorists should be very careful and take these points into consideration before hypothesizing that we have a specialized module for some specific function. That said, I think this is an empirical matter. There is no *a priori* reason why central cognition could not be, to some extent at least, modular in the way described. Moreover, as long as we do not hold that the cheater detection module needs to get its input at the first stage - from raw sense representations - but that it can be fed in part, say by the Theory of Mind module, and perhaps by another module telling it that it is dealing with conspecifics, etc. then the job is that much easier (see Collins 2005, 14).

### The Intractability Argument

In their seminal article, *Origins of domain specificity: The evolution of functional organization*, Cosmides & Tooby present three *reductio ad absurdum* arguments (Cosmides & Tooby 1994, 91-95) designed to show why the MM hypothesis must be true. Taken as a group, we may call it the *intractability* argument for MM. It begins:

> For a domain-general system to learn what to do, it must have some criterion of success and failure; trial and error learning requires some definition of error. But there is no domain independent criterion of success or failure that is correlated with fitness. This is because what counts as fit behaviour differs markedly from domain to domain (*Ibid*.).

To illustrate, consider the following example. Sexual intercourse is vital to our fitness as a species, but from that it does not follow that sexual intercourse is fitness enhancing in every context. In some contexts, having sex may be either neutral or it may even have a fitness cost. Sexual intercourse with, for example, family members is not fitness enhancing.

Of course, if an organism could determine which context it were in, then it could make an appropriate decision. It could evaluate an if-statement: "If (context X) Then have sex Else don't have sex." But this is where the next part of the intractability argument comes in:

> A domain general evolved architecture is defined by what it lacks; it lacks any content, either in the form of domain specific knowledge or domain specific procedures ... a domain general system must evaluate all alternatives it can define (*Ibid.*).

Now as the complexity of a problem domain increases, the number of distinct states that are associated with that problem domain increases exponentially. To take a simple example: the number of distinct combinations in the truth table for a logical expression in sentential logic is $2^n$, where $n$ is the number of elementary propositions. With as few as thirty-two propositions there are $2^{32} = 4,294,967,296$ possible truth assignments. Now consider an organism trying to decide whether to have sex. How many imaginable contexts would you say that the organism could be in? Far more than $2^{32}$, I imagine. Since the mind is content-neutral, it cannot know *a priori* which situations should be ruled out. Since it is domain-general, it cannot choose a subset of its knowledge and evaluate that in isolation. *Every piece of knowledge that the organism has access to has the potential of bearing on every other piece.* It must consider everything it knows, whether or not it is relevant, even to solve the simplest, most constrained problems, let alone to determine whether or not it is in a situation in which sexual intercourse is appropriate. Such an organism would have to take into account, e.g., the knowledge that she stubbed her toe three months ago, that her Uncle Bob wore plaid yesterday, that it was Newton who formulated the Universal Law of Gravitation (assuming she has taken a Physics course), and that Ray Charles was visually impaired; all in order to determine whether it is appropriate in the current circumstances to have sexual intercourse. Due to combinatorial explosion it is unlikely that a domain-general, content-neutral mind could solve any problems at all, let alone solve them fast enough to be adaptive. Thus even if she could construct a massive if-statement to determine whether or not to have sexual intercourse, she could never get through it (the if-statement, not the sex).

Finally: even if, miraculously, a domain general mechanism could get through that if-statement fast enough, it would be impossible for it to get all of the data it needs to arrive at the correct (i.e. adaptive) result. As Cosmides & Tooby put it:

> Many relationships necessary to the successful regulation of action cannot be observed by any individual during his or her lifetime ... Adaptive courses of action can be neither deduced nor learned by general criteria alone because they depend on statistical relationships between features of the environment, behaviour, and fitness that emerge over many generations and are, therefore, often not observable during a single lifetime (*Ibid*.).

Take cheater detection, for example. The view here is that it is implausible, given the complexity of detecting a cheater in a given context, that one human being could learn all that needs to be known in order to do this successfully. Strategies for dealing with cheater scenarios will be far more successful if trial and error experiments are run over many lifetimes rather than just one. While one human being cannot live many lives, Natural Selection can. Natural selection can 'observe' these statistical relationships over many generations, and can design specific mechanisms that are useful for solving these problems, in the form of modules specialized for specific problem domains.

Now Fodor, responding to Cosmides and Tooby's first argument (that there is no domain-independent criterion of success or failure), points out:

> If, however, you're prepared to accept that a domain-general mechanism could learn that sexual intercourse is a necessary condition for producing offspring, it's unclear to me why the same domain-general mechanism mightn't be able to learn how much is likely to suffice, and hence when to stop (Fodor 2000, 66).

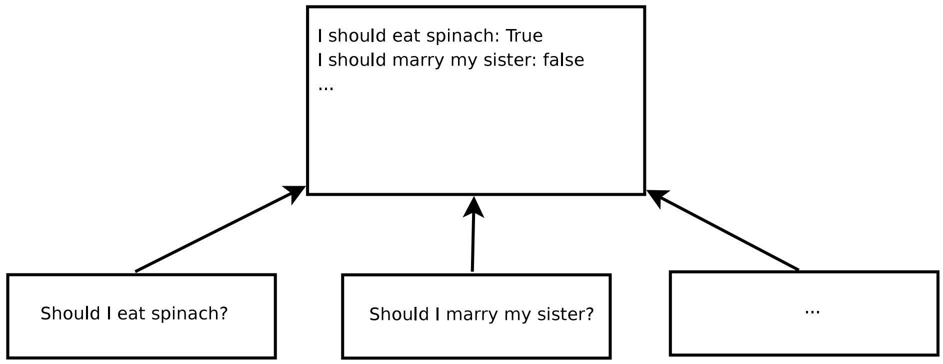
Fodor, however, fails to consider that the arguments that Cosmides and Tooby give are only really strong when they are taken together. As I pointed out above, when we conjoin the fact that a) for a domain-general mechanism there is no domain-independent criterion of success or failure, with the fact that b) a domain-general mechanism must evaluate all the alternatives it can define, then it follows that c) the domain-general mechanism cannot limit the available alternatives it must consider based on their content. It can only determine when enough is enough by bringing to bear every single bit of knowledge it has in order to carry out the computation. While this is in principle possible it is quite certainly intractable.

More to the heart of the matter, however, Fodor argues that it is simply not the case that there is no domain-independent criterion of success or failure; for *truth* is such a criterion. He proposes that we may have a domain-general mechanism whose function is to fixate true beliefs: "perhaps a cognitive system that is specialized for the fixation of true beliefs interacts with a conative system that is specialized to figure out how to get what one wants from the world that the beliefs are true of" (Fodor 2000, 67). But while it may be evident that something like *modus ponens* is true in any context, it does not seem clear that normative claims are.[8] It does not seem to be the case that the proposition: "I should eat spinach for it will make me strong" is true *regardless* of context. What if I am allergic to spinach? As Clarke points out:

> What counts in a particular type of context as error is variable. But, of course, that fact is compatible with the fact that truth will be important regardless of the context. When Cosmides and Tooby suggest that there is no domain-general criterion of success or failure that is correlated with fitness, what they mean is that there is no particular factual matter that all situations of error have in common (Clarke 2004, 26).

But perhaps Fodor's claim is merely that we may have something like a database of true beliefs. Something like:

[8] See (Cosmides, Tooby, & Barrett 2005) for a discussion of normative or valuative considerations.




MM does not, *a priori*, rule something like this picture out. If we view the boxes containing the questions not as a single 'conative system that is specialized to figure out how to get what one wants,' but as a collection of modules, then such a picture is actually similar to the picture of cognition given by Clarke (Clarke 2004, 40-42), and also to the picture given by Carruthers (Carruthers 2005, 83-85). On Carruthers' view, for example, the contents of the "truth" module would be the outputs of language modules: sentences in natural language.

With regard to Cosmides & Tooby's last argument, however, that "many relationships necessary to the successful regulation of action cannot be observed by any individual during his or her lifetime," Fodor makes the point, I think correctly, that innateness has nothing to do with modularity *per se*: "you can thus have perfectly general learning mechanisms that are born knowing a lot, and you can have fully encapsulated mechanisms (e.g. reflexes) that are literally present at birth, but that don't know about anything except what proximal stimulus to respond to and what proximal response to make to it" (Fodor 2000, 69). Samuels also presses this point:

> Though frequently presented as an objection to non-MM accounts of cognitive architecture, this argument is really only a criticism of theories that characterize cognitive mechanisms as suffering from a particularly extreme form of informational impoverishment ... But this conflates claims about the need for *informationally rich* cognitive mechanisms ... with claims about the need for modularity; and although modularity is one way to build specialized knowledge into a system, it is not the only way (Samuels 2005, 114).

It certainly is conceivable that we could have one domain-general processor with access to innate databases of specialized, domain-specific, knowledge; just as conceivable as a picture where we have many modules. And once we accept this, the other two legs of the intractability argument fall away. The organism deciding whether to have sexual intercourse, upon being exposed to certain environmental cues, would have her domain-general processor run specialized processes over, say, the 'romance' domain, and could completely ignore the fact that Uncle Bob wore plaid yesterday.[9] While the intractability argument is a highly effective one when directed against a classical empiricist view of cognition, it loses much of its force once it is directed at an alternative nativist conception of the mind.

I think that a proponent of MM needs to concede this point. However I do not think that that is the end of the story. We may rightly press the psychological rationalists and ask how, exactly, is the domain-general processor to decide that such and such an environmental stimulus belongs to the romance domain? Unless we have a domain-general, *content-neutral* processor, it is difficult to see how this can be done. At some point it will need to be able to differentiate undifferentiated environmental stimuli. But Cosmides & Tooby's intractability argument shows us that this is impossible in practice. This is the input problem in a different form, and it is just as potent an objection to psychological rationalism as it is to MM.

Now the psychological rationalist can counter this objection in the same way that the MM theorist does: by simply saying that the domain-general processor does not need to 'decide': inputs can be differentiated solely by virtue of their structure. Thus behind the 'cardboard strip' we can say that we have a *domain-general* processor. As soon as this processor detects that a representation has come through the 'square' hole, it runs a specialized process designed to act on 'square' representations. That is fine. But then how

[9]Since that representation would belong to the 'bad fashion sense' domain. These examples are, of course, merely toungue-in-cheek. But I hope that they serve to illustrate, in an intuitive way, the concept of a 'domain'.

exactly, is this really different from the massively modular view? Just as in MM, we have specialized processes that are *constrained in the types of inputs that they can accept*. All that is different is that we have many *processes* instead of many *processors*. Something very similar to MM seems to be *required* in order to solve the input problem.

Moreover, the complexity that is built into this domain-general processor will have to be enormous. It will have to have access to thousands upon thousands of different 'holes' in the strip corresponding to every kind of environmental stimulus. Of course, instead of a flat strip it may be structured so that there are many successive strips, each more refined than the other. Thus the first level might only differentiate between shapes that fit into rectangular holes, and shapes that fit into circular holes (hexagonal shapes might fit into the circular hole, for example). The second level might have more refined shapes: squares, triangles, hexagons, pentagons, and so on. But this is beginning to look *even more similar* to a massively modular picture of cognition. This picture of the mind has, *logically* speaking anyway, all of the same features as the massively modular picture. Again, the only real difference here is that instead of many encapsulated processors, we have many encapsulated processes. But this difference seems almost trivial. Surely it is not the view of MM theorists that our modules *literally* have walls around them. It seems, to me anyway, that the 'domain-general' picture I have just described is actually a massively modular picture in all essential respects. But at any rate, let us grant to the psychological rationalists that this does at least constitute an architectural difference. I will now look at two arguments that deal more directly with this architectural issue.

**The Optimality Argument**

An argument that is often used against domain-general architectures is the so-called *optimality* argument. One way of putting this is to claim that domain-general architectures are committed to implementing optimization processes. What this means is that one needs to update all of one's prior beliefs every time new information is acquired. But since optimization processes have potentially huge (unbounded) costs associated with them, domain-general architectures can break down relatively easily and are therefore inferior, fitness-wise, to modular architectures. Putting the objection this way, however, is somewhat of a straw man, since proponents of domain-general mechanisms are certainly not committed to such a view of human reasoning (Samuels 2005, 115).

Another way of putting the optimality argument is to say that given the vast array of adaptive problems that our Pleistocene ancestors had to face, a massively modular mind with specialized modules for each of these problems would be likely to solve any particular problem far less expensively than a domain-general mind could: "as a rule, when two adaptive problems have solutions that are incompatible or simply different, a single general solution will be inferior to two specialized solutions" (Cosmides & Tooby 1994, 89). Samuels' response to this is along the same lines as his response to the intractability argument:

> Instead it may be the case that the mind contains innate, domain-specific bodies of information, and that these are employed in order to solve various adaptive problems. ... And it is perfectly consistent with the claim that we possess innate, domain-specific knowledge for solving adaptive problems that this information is utilized only by domain-general and, hence, nonmodular computational mechanisms (Samuels 1998, 587-588).

In other words, it does not follow from the fact that humans have a domain-general architecture that specializations cannot be built into it, in the form of innate, domain-specific bodies of data. In the same way that we have only one skin that covers all of our specialized internal organs, we can likewise have only one domain-general processor that "covers" all of our innate, specialized bodies of data.

Yet perhaps we can press the point a bit by appealing to performance considerations. While a modular architecture can run many processes in parallel (it is analogous to a multiprocessor), a domain-general processor must run its computations sequentially (or at most utilise some sort of pseudo-parallelism in the form of fast context-switching[10] between processes). Therefore a modular mind will tend to be faster than a non-modular one, and this surely has a fitness benefit.

But the psychological rationalist can answer that first, raw speed seems to be really only important with regard to peripheral modules. It is far less of a concern with regard to reasoning and other aspects of central cognition. Second, while it is *very* useful to be able to process perceptual inputs in parallel, it is less useful, perhaps even counter-productive, to have parallel *reasoning* processes occurring at the same time. Typically when we reason about something, say a problem in mathematics, we need to focus on *the* problem at hand, and chains of inference need to be given in sequential order if they are to be useful at all. It follows from this that third, a mind in which all central cognition was done in parallel might actually not be much faster than its sequential counterpart in many situations. Since reasoning is by nature sequential, the inputs will have to be synchronised (say, by a central module), adding significant overhead to the computations. More importantly, even if central cognition could be faster if some aspects of it were run in parallel, the trouble with running processes in parallel is that the synchronisation required introduces significantly greater likelihood of error. Certainly speed is not the *only* consideration that natural selection must take into account. If it can trade off speed for a greater likelihood at arriving at a correct result, then surely this needs to be added up in the fitness equation.

In response to this, however, I think we can say, on behalf of the massively modular view, that first: it seems correct to say that much of what goes on in our heads is done in parallel. Perhaps we must go through the steps of a mathematical proof in a sequential manner, but mathematical reasoning is not the only form of higher reasoning we engage

[10]Context-switching is used in single-processor systems to achieve the appearance of parallelism. One process runs for a short time, then is swapped out to allow another process to run, and so on. Over the lifetime of a particular process, it may be switched in and out many times.

in. ‘Cheater detection’, ‘theory of mind’, ‘sexual jealousy’ etc. are all aspects of central cognition, and all of these seem to be going on in parallel all the time. At the same time that Joanne writes her math exam, for example, she might detect someone attempting to steal her purse. Of course, a domain-general processor would be able to achieve pseudo-parallelism, when needed, through context switching, but what would be the advantage to that? It might decrease the likelihood of error when we need to reason sequentially, but it at least seems to be the case that *most* higher reasoning processes that we engage in happen at the same time. There is no *a priori* reason why a domain-general processor could not deal with this, but given that it needs to do so much of it, it would probably be inferior, adaptively speaking, to its massively modular counterpart.

Second, a massively modular picture is not a picture of utter chaos. There are likely only a few ‘really’ central modules that do the job of synchronisation, and just like all the others, these modules have been shaped by natural selection over many generations, therefore they are probably very good at what they do by now. Thirdly, we *do* make errors - often - in everyday life. Perhaps a domain-general architecture would be *too good* at avoiding error. The fact that quite a bit of our reasoning goes on in parallel is probably at least part of the explanation for why we make so many mistakes.

**The Argument from Biology**

Now the last argument for MM that I will discuss is the so-called argument from Biology, which goes something like the following: Natural Selection selects from among the genetic variants in a given population, those that tend to display the phenotypic properties that are the most fitness enhancing. Examples of phenotypic properties include such things as eye colour, skin colour, fur, etc. as well as various types of behaviours (e.g., mating rituals, and so on). Now behaviour is largely regulated by the mind, therefore it follows that the mind is one of the phenotypic properties that Natural Selection will select for.

Natural Selection aside, a very good strategy for assembling complex systems in general is to assemble them out of dissociable sub-components. For example, an airplane is usually not constructed in a hanger from scratch; in one go, so to speak. Rather the engines are typically assembled in one factory, the fuselage in another, the wings in another, etc., and at some point these are all put together. As Carruthers writes:

> Simon (1962) uses the famous analogy of the two watch-makers to illustrate the point. One watch-maker assembles one watch at a time, adding micro-component to micro-component one at a time. This makes it easy for him to forget the proper ordering of parts, and if he is interrupted he may have to start again from the beginning. The second watch-maker first builds sets of sub-components out of the given micro-component parts, and then combines those into larger sub-components, until eventually the watches are complete. This helps organize and sequence the whole process, and makes it much less vulnerable to interruption (Carruthers 2006).

Now with regard to organisms, very much evidence tells us that from the level of the individual cell all the way up to the organs, the components and sub-components of organisms have been designed and engineered by natural selection in this way. Since this is the case for everything else about us, it would seem to follow rather straightforwardly that the mind must likewise be so designed. Why should it be unique?

It could be objected that it does not follow from the fact that the mind must be modular that it must necessarily be *massively* modular. After all, psychological rationalists do admit to the former. But the problem with the psychological rationalist view is that the domain-general mechanism they postulate needs to have some significant complexity built into it. The domain-general processor must have access to *all* of the different input structures corresponding to environmental stimuli (recall the example of the domain-general processor behind the massive cardboard strip). It is a reasonable assumption that as complexity increases, so does the degree of modularity (Carruthers 2006). Are there any examples of complex organs that are not modular? Even relatively simple organs such as blood and skin are modular. Blood is composed of white blood cells, red blood cells, blood platelets, blood plasma, and so on. Skin is composed of many layers, not to mention hair and sweat glands. Unless we consider central cognition to be extremely simple, then it seems to follow that it must be modular to a significant extent; for as is entailed by the input objection, it must be composed of many, many *structures* which are able to take in the many, many types of representations that it can operate on.

While it probably is the case, for the massively modular picture, that there are some central modules that take inputs from various other modules, these need be nowhere near the complexity of the psychological rationalist's domain-general mechanism. Moreover, the central modules can evolve more or less independently of each other. The input structures that are a part of the domain-general architecture are always in a sense 'tied' to it. Unlike the case for a massively modular architecture, when one of the input structures changes, the - independently evolving - processor must change with it in order to recognize that input (otherwise that input is completely useless, and if it is useless, then it is hard to see why it should be selected for). Further, any major design flaw in a structure translates to a flaw in the whole system. It is analogous to building the watch or the airplane from scratch.

Now this is not an *a priori* argument. I could, in principle, assemble a team to design and engineer an airplane 'on the spot' that is just as good or perhaps even slightly better than one assembled in the second way. However it is more *practical* to build up a an airplane gradually, one sub-component at a time, and to design it so that it can be built up this way. And this is the way that natural selection, so far as we know, always does things.

## Conclusion

There are no *a priori* arguments for Massive Modularity. However there are *good* arguments for Massive Modularity, and I believe I have shown that. Although it is *in principle* able to overcome the intractability and input objections, psychological rationalism needs to borrow many of the features of a massively modular architecture in order to do so. Although it is *in principle* able to overcome the optimality objection, the way it does so does not seem to correlate with the way we actually think. Although it is *in principle* able to respond to the argument from biology, it is unable to do so without advancing an unrealistic and unsupported account of cognitive evolution. There has been no 'knockout punch', however I believe that the judges' decision, at the end of the day, will be a unanimous one.

# References

[1] Barrett, H. Clark. "Enzymatic Computation and Cognitive Modularity." *Mind and Language* 20 (2005): 259-287.

[2] Buller, David J., *Adapting Minds: Evolutionary Psychology and the Persistent Quest for Human Nature*, Cambridge: MIT Press, 2005.

[3] Carruthers, Peter, "Distinctively Human Thinking: Modular Precursors and Components," in *The Innate Mind: Structure and Contents*, edited by Peter Carruthers, New York: Oxford University Press, 2005.

[4] Carruthers, Peter, "The Case for Massively Modular Models of Mind," in *Contemporary Debates in Cognitive Science*, edited by Robert Stainton, Malden: Blackwell Publishing, 2006.

[5] Clarke, Murray, *Reconstructing Reason and Representation*, Cambridge: MIT Press, 2004.

[6] Collins, J., "On the Input Problem for Massive Modularity," *Minds and Machines* 15 (2005): 1-22.

[7] Cosmides, Leda, and Tooby, John, "Origins of Domain Specificity: The Evolution of Functional Organization," in *Mapping the Mind: Domain Specificity in Cognition and Culture*, edited by L.A. Hirschfeld and S.A. Gelman, Cambridge: Cambridge University Press, 1994.

[8] Cosmides, Leda, Tooby, John, and Barrett, H. Clark, "Resolving the Debate on Innate Ideas: Learnability Constraints and the Evolved Interpenetration of Motivational and Conceptual Functions," in *The Innate Mind: Structure and Contents*, edited by Peter Carruthers, New York: Oxford University Press, 2005.

[9] Cuffaro, Michael, *Theoretical Arguments for and Against Massive Modularity*, Unpublished, 2005.

[10] Kant, Immanuel, *Critique of Pure Reason*, Translated by Werner S. Pluhar, Indianapolis: Hackett Publishing Company, 1996.

[11] Pinker, Steven, "So How *Does* the Mind Work?," *Mind & Language* 20.1 (2005): 1-24.

[12] Samuels, Richard, "Evolutionary Psychology and the Massive Modularity Hypothesis," *The British Journal for the Philosophy of Science* 49.4. (1998): 575-602.

[13] Samuels, Richard, "The Complexity of Cognition: Tractability Arguments for Massive Modularity," in *The Innate Mind: Structure and Contents*, edited by Peter Carruthers, New York: Oxford University Press, 2005.

[14] Shusterman, Anna, Spelke, Elizabeth, "Language and the Development of Spatial Reasoning," in *The Innate Mind: Structure and Contents*, edited by Peter Carruthers, New York: Oxford University Press, 2005.

[15] Simon, H., "The architecture of complexity," *Proceedings of the American Philosophical Society* 106 (1962): 467-482.