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Evolutionary Psychology and the Massive Modularity Hypothesis

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ABSTRACT

In recent years evolutionary psychologists have developed and defended the Massive Modularity Hypothesis, which maintains that our cognitive architecture—including the part that subserves 'central processing'—is largely or perhaps even entirely composed of innate, domain-specific computational mechanisms or 'modules'. In this paper I argue for two claims. First, I show that the two main arguments that evolutionary psychologists have offered for this general architectural thesis fail to provide us with any reason to prefer it to a competing picture of the mind which I call the Library Model of Cognition. Second, I argue that this alternative model is compatible with the central theoretical and methodological commitments of evolutionary psychology. Thus I argue that, at present, the endorsement of the Massive Modularity Hypothesis by evolutionary psychologists is both unwarranted and unmotivated.

1 Introduction

A few decades ago the following claims held a dominant position in psychology and the behavioural sciences:

(i) *Anti-nativism:* The human mind contains little if any innate, psychological structure.
(ii) *Non-modularity:* What innate structure we possess is largely or entirely domain-general (or general-purpose) as opposed to domain-specific.

These claims appear to have been endorsed by theorists who agree on little else besides. So, for instance, according to many behaviourists, Piagetian psychologists, AI researchers and connectionist theorists, the innate structure of the human mind consists of little more than a general-purpose learning mechanism. According to these theorists, whatever differentiation into domain-specific cognitive systems there might be will reflect differentiation in the environment and not our innate endowments.

Over the past three decades, the assumptions of anti-nativism and non-modularity have increasingly come under attack. In linguistics, Noam Chomsky has argued persuasively for the existence of an innate, domain-specific language faculty—a cognitive system that is dedicated to the acquisition of natural language (Chomsky [1980]). Similarly, the philosopher Jerry Fodor has argued that so-called input systems—those systems responsible for perception and language processing—are innate, domain-specific modules (Fodor [1983]). But perhaps the most recent and most radical assault on the twin assumptions of anti-nativism and non-modularity has come from the newly emerging, interdisciplinary field of evolutionary psychology. Evolutionary psychologists defend a *massively modular* conception of mental architecture which views the mind, including those parts that subserve 'central processing', as composed largely or perhaps even entirely of innate, special-purpose information-processing organs or 'modules' that have been shaped by natural selection to handle the sorts of recurrent information-processing problems that confronted our hunter–gatherer forebears. I will call this the Massive Modularity Hypothesis (MMH).

In this paper I argue for two claims. First, I show that the two main general arguments which evolutionary psychologists have developed in support of MMH are unsuccessful.[1] In particular, these arguments fail to provide us with reason to prefer MMH to an alternative and incompatible conception of the human mind which, for want of a better name, I call the Library Model of Cognition (LMC). Very roughly, according to LMC, the human mind is not largely or entirely composed of special-purpose modules but does possess special-purpose bodies of information. Second, I briefly argue that there is no a priori reason why LMC should not be adequate for the general purposes of evolutionary psychology. Specifically, I argue that LMC is compatible with the central theoretical and methodological commitments of evolutionary psychology. Thus I argue that, at present, the endorsement of MMH by evolutionary psychologists is both unwarranted and unmotivated.

Before I can argue for the above claims, it will first be necessary to explain what the evolutionary-psychological view of the mind is. In Section 2 I specify

[1] Evolutionary psychologists have developed more than two arguments for massive modularity. But the two arguments discussed in this paper are by far the most interesting and most plausible. For further arguments see Tooby and Cosmides [1992] and Sperber [1994].

the claims (or more precisely, the range of claims) about the architecture of the human mind that evolutionary psychologists typically endorse. In Section 3 I contrast the massively modular conception of mind endorsed by evolutionary psychologists with LMC. Having dealt with these preliminary issues, in Sections 4 and 5 I focus on what I take to be the two main, general arguments that evolutionary psychologists have developed in support of MMH: what I call *the optimality argument* and *the solvability argument.* Both of these arguments were formulated by the prominent evolutionary psychologists Leda Cosmides and John Tooby, and each argument purports to show that we have general evolutionary grounds for thinking that minds are massively modular. I aim to show that neither of these arguments succeed in providing us with reason to reject LMC and, hence, to think that the human mind is massively modular. In Section 6, I very briefly discuss the current state of the experimental evidence for MMH and highlight some of the problems with providing experimental evidence that distinguishes between MMH and LMC. Finally, in Section 7 I argue that LMC is compatible with the general objectives of evolutionary psychology.

2 What is evolutionary psychology?

The first order of business is to say what the evolutionary-psychological conception of the mind is, and this is not an easy task since this interdisciplinary field is too new to have developed any precise and widely agreed-upon body of doctrines. There are, however, three basic ideas that are clearly central to the evolutionary-psychological conception of the mind. The first is that the mind is an information-processing device that can be described in computational terms. The second is that the mind consists of a large number of special-purpose systems—often called 'modules' or 'mental organs'. The third is that these systems, like other systems in the body, have been shaped by natural selection to perform specific functions or to solve information-processing problems that were important in the environment in which our hominid ancestors evolved—the environment of evolutionary adaptation (EEA). In this section I elaborate on these core claims in more detail.

2.1 Computationalism

Evolutionary psychologists typically adopt a computational account of the mind. In other words, they view the mind as a computer of sorts. So, for instance, the editors of the important anthology on evolutionary psychology, *The Adapted Mind,* suggest that the brain is an information-processing system,

> a computer made out of organic compounds rather than silicon chips. The brain takes sensorily derived information from the environment as input,

> performs complex transformations on that information, and produces either data structures (representations) or behaviour as output (Barkow *et al.* [1992], p. 7).

In expressing this view, evolutionary psychologists clearly see themselves as adopting the computational approach that is prevalent in cognitive science (*ibid.*, p. 7). Moreover, as will become clear in Section 2.2, evolutionary psychologists often appear to think of the human brain as composed of lots of distinct computational devices. In what follows I will assume that a computational account of the mind is correct.

2.2 Darwinian modules

Though the term 'module' has gained considerable currency in contemporary cognitive science, different theorists appear to use the term in importantly different ways.[2] Evolutionary psychologists seldom discuss what they mean by 'module' in any detail. Nevertheless, from what they do say, I think that it is possible to piece together an account of what I propose to call a *Darwinian module*, which can be viewed as a sort of prototype of the evolutionary psychologists' notion of modularity. Darwinian modules have a cluster of features, and when evolutionary psychologists talk about modules they generally have in mind something that has most or all of the features in the cluster.

The first feature of Darwinian modules is that they are *domain-specific*, as opposed to domain-general, cognitive structures. According to Cosmides and Tooby, our minds consist primarily of 'a constellation of specialized mechanisms that have domain-specific procedures, operate over domain-specific representations, or both' (Cosmides and Tooby [1994], p. 94). Very roughly, to say that a cognitive structure is domain-specific means that it is dedicated to solving a restricted class of problems in a restricted domain. For instance, the claim that there is a domain-specific cognitive structure for vision implies that there are mental structures which are brought into play in the domain of visual processing and are not recruited in dealing with other cognitive tasks. By contrast, a cognitive structure that is *domain-general* is one that can be brought into play in a wide range of different domains.

Second, Darwinian modules are *innate* cognitive structures whose characteristic properties are largely or wholly determined by genetic factors (Pinker [1994], pp. 419–20; Jackendoff [1992], p. 72). Indeed evolutionary psychologists also make the additional claim that mental modules are the products of natural

[2] So, for instance, the notion of a module has been developed in different ways by Jerry Fodor, David Marr and Noam Chomsky. For a review of the various ways in which cognitive scientists use the term 'module' see Segal [1996].

selection (Cosmides and Tooby [1992]). So, for example, according to Cosmides and Tooby, modules are 'kinds invented by natural selection during the species' evolutionary history to produce adaptive ends in the species' natural environment' (Tooby and Cosmides [1995], p. xiii). Thus, not only do evolutionary psychologists commit themselves to the claim that modules are innate, they also commit themselves to a theory about how modules came to be innate, namely natural selection. As we will see in Section 6 this claim plays an important role in structuring the research program that evolutionary psychologists pursue.

Third, evolutionary psychologists often insist that modules are *universal* features of the human mind and thus that we should expect to find that all (normally functioning) human beings possess the same, specific set of modules. As Tooby and Cosmides put it: 'Infants everywhere are born the same and have the same . . . evolved psychology' (Tooby and Cosmides [1992], p. 25). According to evolutionary psychologists, then, not only has natural selection designed the human mind so that it is rich in innate, domain-specific structure, but it has also given us all more or less the same design.

Finally, Darwinian modules are a species of *computational mechanism*. But it would seem that there is a systematic equivocation in the work of many evolutionary psychologists concerning what is meant by 'computational mechanism'. This equivocation is suggested in the following attempts by Cosmides and Tooby to formulate their modular conception of the mind:

> [T]he brain must be composed of a large collection of circuits, with different circuits specialized for solving different problems. One can think of each specialized circuit as a minicomputer that is dedicated to solving one problem. Such dedicated minicomputers are sometimes called *modules* (Cosmides and Tooby [1997], p. 81).

> [S]pecialized mechanisms enable competences and actions that would not be possible were they absent from the architecture. This rich array of cognitive specialization can be likened to a computer program with millions of lines of code and hundreds or thousands of functionally specialized subroutines (Tooby and Cosmides [1992], p. 39).

Notice that in the first quotation modules are said to be functionally specific *computers*. This claim is most naturally interpreted as a claim about the existence of specialized pieces of computational *hardware*; neural computers that are specialized in much the same way in which a pocket calculator is a specialized computer. We can call this the *hardware conception* of modules. By contrast, in the second quotation, modules are likened to specialized *subroutines* within a computer program. This claim is most naturally interpreted as a claim about the existence of specialized mental programs or *algorithms*. We can call this the *algorithmic conception* of modules.[3]

The hardware and algorithmic conceptions of modules are nonequivalent. But there is a connection between them. For if the mind contains domain-specific computers, then it follows that the mind also employs domain-specific algorithms, since the behaviour of any domain-specific computational device can be characterized in terms of the algorithms that it employs. In short: the hardware conception entails the algorithmic interpretation. The converse, however, is not true. It does not follow from the claim that the mind employs domain-specific algorithms that it contains domain-specific computational devices. This is because it is possible to run domain-specific algorithms on a general-purpose machine. In order to see the point consider the computer that I am currently using in order to write this paper. It is a general-purpose computational device. None the less, there is a wide range of specialized programs that can be run on it—e.g. a word-processing package, an Internet program, a Tetris program, and so on. Similarly, if the computational theory of mind is correct, it may be the case that the mind contains a domain-general computational device which can be used in order to run lots of specialized programs. In short: the mind may be modular on the algorithmic conception of modules without being modular according the hardware conception.

One final point about the distinction between the hardware and algorithmic conceptions: it is unclear which conception of computational mechanisms (or modules) evolutionary psychologists intend to endorse. Nevertheless in what follows I will be concerned primarily with the algorithmic conception of modules. This is because my aim is to show that the evolutionary psychological arguments for massive modularity fail. But since the hardware conception entails the algorithmic conception of modules, it follows that if the evolutionary psychological arguments fail to show that the mind is massively modular on the algorithmic conception, then the arguments also fail to provide support for massive modularity on the hardware conception.

To sum up, a (prototypical) Darwinian module is a computational device—on either the hardware or algorithmic conception—that is naturally selected, innate, domain-specific and universal.

[3] Two points of clarification: (a) The notions of a program and an algorithm are not synonymous. But for our current purposes the differences do not matter. (b) When speaking of 'algorithms' and 'programs' I do not intend to refer to abstract sets of rules. Rather I use these terms in order to refer to the *implementation* of abstract rules in a machine, e.g. the human brain. Thus, according to the algorithmic conception, a module is not merely an 'inert' set of rules but rather the implementation of a set of rules in a computational mechanism. When speaking in this way I take myself to be following the lead of evolutionary psychologists. (See e.g. Cosmides and Tooby [1987], p. 293.)

2.3 Massive modularity

Until recently, even staunch proponents of modularity typically restricted themselves to the claim that the mind is modular at its periphery. So, for example, although the discussion of modularity as it is currently framed in cognitive science derives largely from Jerry Fodor's arguments in *The Modularity of Mind*, Fodor insists that much of our cognition is subserved by nonmodular systems. According to Fodor, only input systems (those responsible for perception and language processing) and output systems (those responsible for action) are plausible candidates for modularity. By contrast, 'central systems' (those systems responsible for 'higher' cognitive processes such as reasoning, problem-solving and belief-fixation) are likely to be nonmodular. As Dan Sperber has observed:

> Although this was probably not intended and has not been much noticed, 'modularity of mind' was a paradoxical title, for, according to Fodor, modularity is to be found only at the periphery of the mind.... In its center and bulk, Fodor's mind is decidedly *non*modular. Conceptual processes—that is, thought proper—are presented as a holistic lump lacking joints at which to carve (Sperber [1994], p. 39).

Evolutionary psychologists reject the claim that the mind is only peripherally modular in favour of the Massive Modularity Hypothesis (MMH): the view that the mind is largely or even entirely composed of Darwinian modules. Cosmides and Tooby elaborate on MMH as follows:

> On this [the modular] view, our cognitive architecture resembles a confederation of hundreds or thousands of functionally dedicated computers (often called modules) designed to solve adaptive problems (Tooby and Cosmides [1995], p. xiii).

They continue:

> Each of these devices has its own agenda and imposes its own exotic organization on different fragments of the world. There are specialized systems for grammar induction, for face recognition, for dead reckoning, for construing objects and for recognizing emotions from the face. There are mechanisms to detect animacy, eye direction, and cheating. There is a 'theory of mind' module... a variety of social inference modules... and a multitude of other elegant machines (*ibid.*, p. xiv)

What distinguishes MMH from the modularity hypothesis defended by Fodor is that according to MMH 'central capacities too can be divided into domain-specific modules' (Jackendoff [1992], p. 70).[4] So, for example, Steven Pinker

[4] It is unclear, however, that this claim is inconsistent with Fodor's claim that central systems are nonmodular. This is because evolutionary psychologists appear to have a different conception of modules to the one adopted by Fodor. First, according to Fodor, modules are pieces of hardware (Fodor [1983], p. 8). But, as we have already seen, evolutionary psychologists may be claiming only that the mind contains large numbers of domain-specific algorithms. Second, part of Fodor's reason for denying the existence of modular central systems is that he thinks that modules are encapsulated—i.e. have access to less than all of the information available to the mind as a whole—but that central systems are unencapsulated. But evolutionary psychologists do not require that modules be encapsulated.

has suggested that not only are there modules for perception, language and action, but there may also be modules for many tasks traditionally classified as central processes, including

> Intuitive mechanics: knowledge of the motions, forces, and deformations that objects undergo . . . Intuitive biology: understanding how plants and animals work . . . Intuitive psychology: predicting other people's behavior from their beliefs and desires . . . [and] . . . Self-concept: gathering and organizing information about one's value to other people, and packaging it for others (Pinker [1994], p. 420).

Thus, according to MMH, 'the human mind . . . [is] . . . not a general-purpose computer but a collection of instincts adapted for solving evolutionarily significant problems—the mind as a Swiss Army knife' (Pinker [1994]).

3 The Library Model of Cognition

Evolutionary psychologists often talk as if any theory which posits large amounts of innate, domain-specific cognitive structure is a version of MMH. This, however, is not the case. Computational mechanisms are not the only possible kind of innate, domain-specific psychological structure. Another possibility is that humans possess innate, domain-specific bodies of *knowledge*. Indeed, this claim has frequently been discussed and defended in cognitive science. So, for instance, Carey and Spelke claim that:

> [H]uman reasoning is guided by a collection of innate domain-specific systems of knowledge. Each system is characterized by a set of core principles that define the entities covered by the domain and support reasoning about those entities . . . Humans are endowed with domain-specific systems of knowledge such as knowledge of language, knowledge of physical objects, and knowledge of number. Each system of knowledge applies to a distinct set of entities and phenomena. For example, knowledge of language applies to sentences and their constituents; knowledge of physical objects applies to macroscopic material bodies and their behavior, and knowledge of number applies to sets and to mathematical operations such as addition (Carey and Spelke [1994], p. 169).

A few points of elaboration are in order. First, psychologists are often less than entirely clear about what they mean by 'innate, domain-specific bodies of knowledge'. Nevertheless, they often appear to mean that we possess innate systems of *mental representations* that encode various kinds of information (Elman *et al.* [1996], p. 364). Moreover, the systems of mental representations posited by psychologists are typically *truth-evaluable*—i.e. it makes sense to ask of the representations whether they are true or false.[5] So, for instance, Carey and Spelke appear to claim that we possess innate systems of mental representations that encode information about the behaviour of material objects and about number (Carey and Spelke [1994]). In what follows I assume that 'innate knowledge' refers to truth-evaluable systems of mental representations.

Second, I want to emphasize the fact that Darwinian modules and domain-specific bodies of knowledge are very different kinds of mental structure. There is a sense in which bodies of knowledge are 'inert'. They are systems of representations which only eventuate in behaviour as a result of being manipulated by various cognitive mechanisms. By contrast, Darwinian modules are a species of processing mechanism—they *manipulate* representations. However, domain-specific knowledge can coexist with Darwinian modules. Indeed it may be that innate domain-specific knowledge is manipulated by Darwinian modules. But it is also very important for our present purposes to note that the existence of innate, domain-specific bodies of knowledge does *not* entail the existence of domain-specific computational mechanisms (e.g. Darwinian modules) since it possible for a mind to contain innate, domain-specific bodies of knowledge but only contain domain-general computational mechanisms. For example, while humans may possess domain-specific systems of knowledge for physics or geometry, it does not follow that we possess domain-specific computational mechanisms for processing information about physical objects or geometrical properties. Rather, it may be that such domain-specific knowledge is only utilized by domain-general reasoning systems.

Finally, once we appreciate that the existence of innate, domain-specific knowledge does not entail the existence of innate, domain-specific computational mechanisms, it becomes clear that a theory which attributes innate, domain-specific cognitive structure to the human mind need not be a version of MMH. According to MMH, the human mind is largely or entirely composed of domain specific modular mechanisms. One might, however, deny this claim. Instead one might claim that the mind contains few modular mechanisms and that to the extent that the human mind contains domain-specific structure, most of this structure comes in the form of innate, domain-specific bodies of *knowledge* which are only operated on by *domain-general* computational

[5] One reason for characterizing these systems of mental representations as truth-evaluable is to distinguish between (a) the sorts of domain-specific mental structures that psychologists, such as Carey and Spelke, refer to as 'knowledge' and (b) domain-specific programs or algorithms. Programs can do a good job or a bad job at accomplishing a task. But since they do not make any claims, they are neither true nor false. A second difference between (truth-evaluable) knowledge and programs concerns their functional relationship to the processor: programs provide a processor with instructions about how to behave, items of knowledge do not. See Stich and Ravenscroft [1996] for further discussion of the distinction between (truth-evaluable) knowledge and programs.

devices.[6] I call this the *Library Model of Cognition* (LMC). It is important to note that, as I intend it, LMC does not deny that we possess *some* modular mechanisms. It may be the case, for example, that we have modular input systems for vision, audition and language (Fodor [1983]). What LMC insists is that *central* processes, such as reasoning and belief fixation, are not subserved by innate, domain-specific computational mechanisms. Instead LMC claims that the computational *mechanisms* which subserve central processes are domain-general. Thus, LMC is incompatible with MMH.[7]

4 The optimality argument

Is the Massive Modularity Hypothesis correct? Does the human mind consist largely or even entirely of Darwinian modules? This question is fast becoming one of the central issues of contemporary cognitive science. In this section I discuss the first of Cosmides and Tooby's general arguments for MMH—the optimality argument. I will argue that it fails to provide us with reason to adopt MMH.

Cosmides and Tooby's optimality argument focuses on the notion of an *adaptive problem* which they define as 'an evolutionary recurrent problem whose solution promoted reproduction, however long or indirect the chain by which it did so' (Cosmides and Tooby [1994], p. 87). So, for example, in order to reproduce sexually, an organism must be able to find a mate. Thus finding a mate is an adaptive problem. Similarly, in order to reproduce, one must avoid being eaten by predators before one mates. Thus predator avoidance is also an adaptive problem. According to Cosmides and Tooby, once we appreciate both the way in which natural selection operates and the specific adaptive problems that human beings faced in the Pleistocene, we will see that there are good reasons for thinking that the mind contains a large number of distinct, modular mechanisms.

In developing the argument, Cosmides and Tooby first attempt to justify the claim that when it comes to solving adaptive problems, selection pressures can be expected to produce highly specialized cognitive mechanisms, i.e. modules. According to Cosmides and Tooby:

[6] I do not intend to commit the proponent of LMC to any particular thesis about the manner in which domain-specific bodies of knowledge are stored. Nevertheless, one interesting possibility is that the 'mental library' is divided into distinct parts and that specialized parts of the brain are dedicated to storing one or another kind of information. So, for example, one specific neural region may be dedicated to storing folk-biological information where another is dedicated to storing folk physics.

[7] Although the expression 'the library model of cognition' is a novel one, the picture of the mind which it expresses is a familiar one. So, for instance, Gopnik and Meltzoff present a very similar account of the mind which they call 'starting-state nativism' (Gopnik and Meltzoff [1997], p. 51). See also Fodor [1968] for an early version of this view.

> [D]ifferent adaptive problems often require different solutions and different solutions can, in most cases, be implemented only by different, functionally distinct mechanisms. Speed, reliability and efficiency can be engineered into specialized mechanisms because there is no need to engineer a compromise between different task demands (Cosmides and Tooby [1994], p. 89).

By contrast:

> a jack of all trades is necessarily a master of none, because generality can be achieved only by sacrificing effectiveness (*ibid.*).

In other words, while a specialized mechanism can be fast, reliable and efficient because it is dedicated to solving a specific adaptive problem, a general mechanism that solves many adaptive problems with competing task demands will only attain generality at the expense of sacrificing these virtues. Consequently:

> (1) As a rule, when two adaptive problems have solutions that are incompatible or simply different, a single solution will be inferior to two specialized solutions (*ibid.*).

Notice that the above quotation is not specifically about cognitive mechanisms. Rather, it is supposed to apply generally to all solutions to adaptive problems. Nevertheless, according to Cosmides and Tooby, what applies generally to solutions to adaptive problems also applies to the specific case of *cognitive* mechanisms for solving adaptive problems. Consequently, according to Cosmides and Tooby, we should expect domain-specific cognitive mechanisms to be superior to domain-general systems as solutions to adaptive problems. Moreover, since natural selection can be expected to favour superior solutions to adaptive problems over inferior ones, Cosmides and Tooby conclude that when it comes to solving adaptive problems:

> (2) . . . domain-specific cognitive mechanisms . . . can be expected to systematically outperform (and hence preclude or replace) more general mechanisms (*ibid.*).

So far, then, we have seen that Cosmides and Tooby argue for the claim that selection pressures can be expected to produce domain-specific cognitive mechanisms—modules—for solving adaptive problems. But this alone is not sufficient to provide us with good reason to accept the claim that the mind contains a *large number* of modules. It must also be the case that our ancestors were confronted by a large number of adaptive problems that could be solved only by cognitive mechanisms. Accordingly, Cosmides and Tooby insist that:

> (3) Simply to survive and reproduce, our Pleistocene ancestors had to be good at solving an enormously broad array of adaptive problems—problems that would defeat any modern artificial intelligence system. A small sampling include foraging for food, navigating, selecting a mate,

> parenting, engaging in social exchange, dealing with aggressive threat, avoiding predators, avoiding pathogenic contamination, avoiding naturally occurring plant toxins, avoiding incest and so on (*ibid.*, p. 90).

Yet if this is true, and if it is also true that when it comes to solving adaptive problems, domain-specific cognitive mechanisms can be expected to preclude or replace more general cognitive mechanisms, then it would seem to follow that:

> (4) The human mind can be expected to include a large number of distinct, domain-specific mechanisms.

And this is just what the Massive Modularity Hypothesis requires.

Of course, the optimality argument is not supposed to be a deductive proof that the mind is massively modular. Rather, it is offered as a plausibility argument. It is supposed to provide us with plausible grounds to expect the mind to contain many modules. None the less, I think that the argument fails to achieve even this much. One line of criticism that is frequently developed in response to the kind of argument defended by Cosmides and Tooby focuses on the optimality principle—the principle that evolution produces optimal designs.[8] According to Cosmides and Tooby's argument, it is because modular systems are *superior* to nonmodular ones that we ought to expect evolution to have produced massively modular minds. So, if it were not the case that evolution, at least typically, produced optimal designs, then their argument would provide us with no reason to think that MMH is true. But the use of optimality assumptions in biology has been the subject of considerable criticism. It is not true that evolution always produces optimal designs.[9] Nor is it clear that evolution even typically produces optimal designs. Moreover, there are well-known problems with applying optimality assumptions in order to support claims about what specific phenotypic traits we possess. In the case of psychological traits, in order to use optimality considerations with any confidence one needs to know (a) what features were being optimized by the evolutionary process and (b) what range of phenotypes were available to natural selection. As a matter of fact, however, we have little knowledge about either of these matters.[10]

I have some sympathy for the above criticisms of optimality principles. But in this paper I do not intend to recapitulate the debate over optimality. Rather, I propose to pursue a different line of criticism. Let us suppose for the sake of

[8] Of course, this does *not* mean that the fittest of all possible (or imaginable) traits will evolve. Rather it means that the fittest of the traits *actually present in the reproductive population* will evolve (Sober [1993]. p. 120).

[9] See Stich [1990], Sober [1993], and Kitcher [1985] for further discussion of this point.

[10] See Fodor [1996] for a recent critique of adaptationist approaches in psychology. See also Dupré [1987] for an excellent anthology of papers on the use of optimality considerations in biology and the human sciences.

argument that optimality assumptions can be employed in order to establish conclusions about the architecture of the human mind. Even so, I think that Cosmides and Tooby's argument fails to provide us with reason to think that MMH is true. Premise (1) of the optimality argument states that:

> (1) As a rule, when two adaptive problems have solutions that are incompatible or simply different, a single solution will be inferior to two specialized solutions (*ibid.*, p. 89).

This is then used in order to support the claim that:

> (2) . . . domain-specific cognitive mechanisms . . . can be expected to systematically outperform . . . more general mechanisms (*ibid.*).

But if (2) is interpreted as a claim about the superiority of domain-specific, computational mechanisms (e.g. Darwinian modules) over domain-general computational mechanisms, then the inference is not a good one. For (1) is ambiguous and, depending on how we interpret it, either (1) fails to support (2) or else it is implausible to claim that (1) applies to the sorts of domain-general cognitive mechanisms posited by LMC. Let me explain in more detail.

There are two different readings of premise (1). On the first reading, the term 'solution' is read in a liberal fashion. According to this reading, 'solution' refers to literally any kind of solution to an adaptive problem whatsoever. A solution in this sense need not be a mechanism. Rather, it might be something else, such as a body of knowledge. On the second reading, however, 'solution' is given a more restrictive reading. According to this reading, when Cosmides and Tooby speak of solutions to adaptive problems, they really mean *mechanisms* for solving adaptive problems. In other words, premise (1) ought to be read as:

> (1′) As a rule, when two adaptive problems have solutions that are incompatible or simply different, a single *mechanism* for solving both problems will be inferior to two specialized *mechanisms*.

It should be clear that if we adopt the first reading, then premise (1) provides us with no reason to prefer the sorts of domain-specific cognitive mechanisms posited by MMH to the domain-specific bodies of knowledge proposed by LMC. Under the first reading, if we grant that (1) is true, all that follows is that we should expect natural selection to have contrived to provide the human mind with specialized solutions to adaptive problems. But it does not follow from this that these solutions will be specialized *computational mechanisms*. 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. Thus rather than exploiting Darwinian modules, our minds might instead contain specialized knowledge. 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.

But perhaps premise (1) is intended to be read as (1′). Even so, it is far from clear that we now have reason to prefer MMH to LMC. For while *some* general-purpose mechanisms may typically perform less well than more specialized ones, the sorts of mechanisms envisaged by LMC do not seem to be general-purpose mechanisms of this kind. When developing the claim that general-purpose mechanisms are inferior to more specialized ones Cosmides and Tooby focus on general-purpose mechanisms which make no specific provision for the different kinds of problems which they confront. Here is how Cosmides and Tooby characterize such general-purpose mechanisms:

> At the limit of perfect generality, a problem solving system can know nothing except that which is always true of every situation in any conceivable universe and, therefore, can apply no techniques except those that are applicable to all imaginable situations. In short, it has abandoned virtually anything that could lead to a solution (Tooby and Cosmides [1992], p. 104).

Thus the general-purpose mechanisms discussed by Cosmides and Tooby are general purpose in the sense that they treat all problems in an undifferentiated fashion. Let us call this the *problematic sense* of 'general-purpose mechanism'.

Now if *this* is what Cosmides and Tooby mean by 'general-purpose mechanism', then I concede that in most cases we would expect specialized mechanisms to outperform more general ones. But the sorts of domain-general mechanisms posited by LMC are not general-purpose in the above problematic sense. LMC does not propose the existence of mechanisms that treat all problems in the same way. Rather, the domain-general mechanisms posited by LMC treat different problems in different ways in virtue of using different bodies of specialized knowledge. Thus, far from abandoning all specialized knowledge that will aid in the solution of adaptive problems, LMC proposes that large amounts of domain-specific knowledge are utilized by cognitive processes. The domain-general mechanisms posited by LMC are, therefore, not general-purpose in the above problematic sense. But if LMC's domain-general mechanisms are not general-purpose in the problematic sense, then what reason do we have for thinking that domain-specific cognitive mechanisms (e.g. Darwinian modules) will outperform LMC's domain-general mechanisms? To my knowledge, Cosmides and Tooby do not address this question. Nor is it clear why they make the claim. Indeed in the absence of an argument it is surely very implausible to claim that Darwinian modules will outperform the domain-general mechanisms posited by LMC. And, at present, it is far from clear that anyone knows how such an argument would go.

5 The solvability argument

Let us now turn our attention to the solvability argument for MMH. According to Cosmides and Tooby, this argument is supposed to show that:

> it is in principle impossible for a human psychology that contained nothing but domain-general mechanisms to have evolved, because such a system cannot consistently behave adaptively: It cannot solve the problems that must have been solved in ancestral environments for us to be here today (Cosmides and Tooby [1994], p. 90).

Cosmides and Tooby claim that only a system which contains 'a constellation of specialized mechanisms' could have evolved (*ibid.* p. 94). In arguing for this claim, Cosmides and Tooby start by suggesting the following condition of adequacy on any hypothesis about the design of our cognitive architecture:

> *The Minimal Solvability Constraint (MSC):* In order for a proposed design to be an adequate hypotheses about our cognitive architecture, it must be possible, in principle, for the design to 'produce minimally adaptive behavior in ancestral environments' (*ibid.*, p. 91).

According to this constraint, then, any proposed architecture must, in principle, be able to 'solve all of the problems that were necessary to survival and reproduction in the Pleistocene' (*ibid.*, p. 91). The justification for this constraint is straightforward: human beings have survived until today and we would not have done so unless we were able to produce those behaviors that were necessary for survival and reproduction in our ancestral environment.

Clearly, MSC provides a basis for testing competing proposals about the architecture of the human mind. If it can be shown that a proposed design cannot satisfy MSC, then it follows that the mind does not have that design. The question that arises is this: are there any reasons for thinking that *only* a modular architecture could satisfy MSC? According to Cosmides and Tooby there are at least three such reasons:

Reason 1: The definition of error is domain-dependent.

The first reason exploits the fact that what counts as fit behaviour differs from domain to domain. In order to satisfy MSC one must avoid making the kinds of errors that prevent one from reproducing. And in order to avoid making such errors one must either innately possess knowledge of how to behave in different contexts or else possess the capacity to learn how to act in different contexts. Clearly, Cosmides and Tooby think that domain-general mechanisms cannot possess innate information of this sort. Consequently, such mechanisms must somehow learn to behave in a fitness-enhancing fashion. The question, then, is this: can a domain-general system learn to behave in a minimally adaptive fashion?

According to Cosmides and Tooby, the answer is no. In order to learn how to avoid making errors which result in maladaptive behaviour one must possess some standard of what counts as error. They maintain, however, that there is no domain-general criterion of success or failure that correlates with fitness. Rather, what counts as an error differs from domain to domain. So, for example, 'in the sexual domain, error = sex with kin. In the helping domain, error = not helping kin given the appropriate envelope of circumstances. In co-operative exchanges, error = being cheated . . . . When a lion is looking for lunch, error = offering yourself as an appetizer' (*ibid.*, p. 91). Cosmides and Tooby claim that this means that domain-general—hence nonmodular—mechanisms could not learn to behave in a minimally adaptive fashion. They illustrate the problem with an example:

> [s]uppose our hypothetical domain-general learning mechanism guiding an ancestral hunter-gatherer somehow inferred that sexual intercourse is a necessary condition for producing offspring. Should the individual, then, have sex at every opportunity? In fact, such a design would rapidly be selected out. There are large fitness costs associated with incest, to pick only a single kind of sexual error (*ibid.*, p. 92).

The problem faced by the domain-general learning system, then, is that it must somehow learn to produce adaptive sexual behaviour. Moreover, it must do so without over-generalizing so as to produce other maladaptive behaviours, too. And clearly Cosmides and Tooby think that it is exceedingly unlikely that a domain-general learning mechanism could successfully perform this task. On the basis of such considerations, Cosmides and Tooby conclude that:

> Because what counts as the wrong thing to do differs from domain to domain, there must be as many domain-specific cognitive mechanisms as there are domains in which the definition of successful behavioural outcomes are incommensurate (*ibid.*).

In short: the domain-dependence of error requires that we possess a large number of modular systems.

Reason 2: Many relationships necessary to the successful regulation of behaviour cannot be observed by an individual during his or her lifetime.

Cosmides and Tooby's second reason for thinking that a nonmodular mind cannot satisfy MSC concerns the claim that some information that is crucial for adaptive behaviour cannot be learned by an organism using only domain-general systems. According to Cosmides and Tooby, domain-general systems possess no innate, domain-specific information but are, instead 'limited to knowing what can be validly derived by general processes from perceptual information' (*ibid.*). Moreover, they argue that certain kinds of knowledge which are crucial to producing adaptive behaviour cannot be learned from perceptual information during the course of an organism's lifetime because 'they depend on statistical relationships . . . that emerge only over many generations' (*ibid.*). Cosmides and Tooby use Hamilton's kin-selection equation in order to illustrate this point:

> How would a general-purpose mechanism situated in an ancestral hunter-gatherer ever discover that it should regulate behaviour in approximate accordance with Hamilton's kin selection equation—that X should help Y whenever $C_x < r_{xy}B_y$?[11] When an individual sees a relative there is nothing in the stimulus array that tells her how much she should help that relative. And there is no consequence that she can observe that tells her whether, from the fitness point of view, she helped too much, not enough, or just the right amount (*ibid.*, p. 93).

According to Cosmides and Tooby, the problem is this: failing to act in rough accordance with Hamilton's kin selection equation can severely effect fitness. And since a domain-general system neither (a) innately possesses knowledge or procedures which enable it to act in accord with the equation, nor (b) can learn the equation, such a system will fail to behave in an adaptive fashion.

Reason 3: Combinatorial explosion paralyses any truly domain-general system when encountering real-world complexity.

Cosmides and Tooby's final reason for thinking that domain-general systems cannot satisfy MSC concerns the general computational problems that are faced by such systems:

> 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 that can guide it towards the solution of an adaptive problem (*ibid.*, p. 94).

From this they infer that 'a domain-general system must evaluate all alternatives it can define' (*ibid.*). And this raises an obvious problem:

> Permutations being what they are, alternatives increase exponentially as the problem complexity increases (*ibid.*).

According to Cosmides and Tooby, given this fact about the combinatorics, domain-general systems will almost invariably be unable to solve problems in the time available. In short: they will be unable to solve problems in *real-time*.

Why, then, is combinatorial explosion relevant to whether or not domain-general systems can satisfy MSC? The answer is, according to Cosmides and Tooby, that many adaptive problems are sufficiently complex to be unsolvable by domain-general systems in real-time:

> By the time you analyse any biological problem of routine complexity, a mechanism that contains no domain-specific rules of relevance, procedural

[11] 'C_x' and 'B_x' denote the costs and benefits for an organism x, measured as decreases and increases in x's chance of reproducing. $r_{x,y}$—the coefficient of relatedness between individuals x and y—refers to the probability that x and y share the same design features by virtue of common descent.

> knowledge, or privileged hypotheses could not solve the problem in the amount of time the organism has to solve it (*ibid.*).

Thus an organism that contained only domain-general systems would fail to be minimally adaptive—and, hence, to satisfy MSC—simply because it would be unable to perform in real-time many of the tasks that are essential to its survival. Cosmides and Tooby, therefore, conclude that:

> Although some mechanisms in the cognitive architecture may be domain-general, these could not have produced fit behaviour under Pleistocene conditions (and therefore could not have been selected for) unless they were embedded in a constellation of specialized mechanisms that have domain-specific procedures, or operate over domain-specific representations, or both (*ibid.*).

And this is, of course, precisely what the Massive Modularity Hypothesis requires.

The solvability argument fails to provide us with reason to prefer MMH to LMC. Suppose, for the sake of argument, that the solvability argument shows that the human mind must possess domain-specific structures in order to satisfy MSC. Perhaps this is all the argument is supposed to show. None the less, if it is supposed to show that the mind is largely or entirely composed of *Darwinian* modules, then it claims more than it is entitled to. This is because it does not provide us with reason to prefer the hypothesis that the mind contains lots of domain-specific computational mechanisms over the alternative hypothesis that the mind contains lots of domain-specific information that is deployed by domain-general, hence, nonmodular computational mechanisms. In order to see this we need to start by distinguishing two different notions of 'domain-general computational mechanism' that appear to be conflated in Cosmides and Tooby's argument:

(i)A domain-general computational mechanism is one that is not domain-specific, i.e. one that is not dedicated to solving problems in a specific cognitive domain.

(ii) A domain-general computational mechanism is one that is not domain-specific *and does not possess any innate, domain-specific knowledge or innate, domain-specific programs.*

A mind that contained only mechanisms that were domain-general in sense (ii) would contain no innate, domain-specific information whatsoever. It would be a *tabula rasa.* By contrast, a mind which contained only mechanisms that were domain-general in sense (i)—and so contained no Darwinian modules—might be anything but a blank slate. Indeed such a mind could contain huge amounts of innate, domain-specific information. As we have already seen, a mechanism can be domain-general in this sense and still have access to domain-specific information. It is in this sense that LMC posits the existence of domain-general mechanisms.

Let us assume for the sake of argument that the solvability argument shows that the human mind is not a *tabula rasa*. Even so, if the argument is supposed to show that the human mind contains Darwinian modules, then Reasons 1–3 fail to achieve this goal. This is clear once the above two notions of 'domain-general mechanism' are disentangled. First, consider the claim that definitions of error are domain-dependent (Reason 1). The problem that this is alleged to pose for domain-general systems is that they are unable to acquire knowledge of what the various standards of error are. Yet, on the face of it, it seems that a computational mechanism that is domain-general (in sense (i)) can possess innate knowledge of these various standards of error, in which case it does not face the problem of trying to learn these standards. Thus, the present consideration fails to provide us any reason to think that the mind must possess domain-specific computational mechanisms.

Second, consider the claim that certain relations which are essential to the regulation of adaptive behavior are unlearnable during a single lifetime (Reason 2). Even if this is true, it does not follow that there are domain-specific *computational mechanisms*. A computational mechanism that is domain-general in sense (i) can possess innate information about such regularities. So, for instance, a domain-general mechanism could possess innate knowledge of Hamilton's equation. But if this is so, then once more we do not have reason to infer that humans possess Darwinian modules.

Finally, consider Cosmides and Tooby's claim that domain-general computational mechanisms are subject to combinatorial explosion. The reason such mechanisms are supposed to face this problem is that they possess no domain-specific knowledge that can help them reduce the number of possibilities that need to be considered when solving a problem. But once more it seems that there is no reason to think that domain-general mechanisms (in sense (i)) cannot possess innate, domain-specific knowledge that helps constrain the search space for a given problem. Thus it is implausible to claim that the threat of combinatorial explosion provides us with reason to think that the mind contains domain-specific computational mechanisms.

To summarize: it would appear that the argument currently under discussion fails to provide us with reason to prefer the claim that the mind is largely or entirely composed of Darwinian modules over the claim that the mind contains innate information that is employed by domain-general mechanisms.

6 The experimental evidence for MMH

We have now considered the main, general arguments for MMH and found them wanting. But what of the empirical evidence? While a detailed discussion is beyond the scope of the present paper, in this section I very briefly discuss the current state of the experimental evidence for MMH and highlight some of the problems we confront in trying to provide data that distinguishes between MMH and LMC.

While there is a fair amount of evidence for modularity in the literature, it is widely agreed that the best—indeed virtually *all*—the available empirical evidence concerns peripheral as opposed to central systems. For instance, there is considerable evidence for the existence of cognitive modules for language and vision[12] which are paradigmatic cases of Fodorian input systems.[13] And since LMC does not deny the existence of modular input systems, this evidence clearly does not provide us with reason to favour MMH over LMC.

But *why* is there so little experimental evidence for the existence of modular central systems? In particular, why is there so little evidence that would enable us to distinguish MMH from LMC in central cognition? Part of the answer is that, until relatively recently, people simply hadn't looked too carefully. And part of the reason why they hadn't looked was that few theorists had taken MMH seriously. This, however, is not the only reason for the paucity of evidence distinguishing MMH from LMC. A second reason is that it is *very hard* to find data in favour of one and against the other.[14] In order to illustrate this point consider a claim that has received considerable attention in recent years, namely that we possess a 'Theory of Mind' (ToM) module that is dedicated to reasoning about the mental states and behaviour of people (Baron-Cohen [1995]).

ToM constitutes perhaps the most well-developed experimental case for a cognitive module that is not peripheral in character. None the less, it is still far from clear that the currently available data provide us with reason to prefer the

[12] See, for example, Garfield [1989].

[13] Although a wide variety of different sorts of evidence have been invoked in support of claims about the modularity of vision and language (Fodor [1983]), let me briefly mention only two. One important kind of evidence comes from neuroscience and neuropsychology where both invasive studies and studies of selective impairments strongly suggest that there are specialized neural regions that are dedicated to specific visual and linguistic functions and operate largely independently of those cortical regions that subserve central processes. (Garfield [1989]; Shallice [1988] Gazzaniga [1995]) Another important source of evidence for the modularity of input systems comes from attempts to provide computational models of perception and language processing. The explanations that have emerged are rich in detail and well developed by contrast to the accounts of central processes that we possess. Moreover—and this is my main point—the best explanations of language processing and perceptual processes that we currently possess all presuppose the existence of domain-specific, computational systems (Chomsky [1988]; Marr [1982]; Pinker [1994, 1997]). This, I take it, strongly suggests that many input systems are modular in character. The situation is rather different when we turn to such central processes as reasoning and belief revision, however. Here we possess no plausible computational models and, as will soon become apparent, the evidence from neuropsychological studies is exceedingly difficult to interpret.

[14] Of course, this raises the interesting question of what sorts of evidence *would* distinguish between LMC and MMH. This is an issue I take up elsewhere. See, for example, German and Samuels [in preparation]

claim that the there is a ToM module over the competing claim that there is a domain specific body of ToM *knowledge*.[15] The main source of experimental evidence for a ToM module comes from dissociative studies: studies which demonstrate that, in one group of subjects, ToM capacities are selectively impaired, while in another group they are selectively spared.[16] And of these dissociative studies perhaps the most well known concern 'standard' false belief tasks.[17] Numerous studies have been conducted in order to determine who can and cannot pass these tasks.[18] For our present purposes, one particularly relevant case concerns two groups of psychopathological subjects: autistics and people with Williams syndrome. The experimental data shows that adolescents and adults with autism, even with IQs within normal range, have considerable difficulty passing false belief tasks—tasks that are routinely passed by normal 4-year-old subjects (Leslie and Frith [1988]). By contrast, in spite of having wide ranges of cognitive impairments (e.g. in number and spatial cognition) and low IQs (full IQ in the 50s–60s), Williams subjects routinely pass the standard false belief tasks.

The above sort of data are often taken to provide strong evidence for the existence of a ToM module. After all, one obvious explanation of the fact that autistics fail the false belief task while Williams subjects do not is that there is a ToM module that is selectively impaired in the case of autistics but selectively spared in Williams subjects. It should be clear, however, that the proponent of LMC can mimic this explanatory strategy. According to this LMC-style explanation, autistics fail the false belief task because their specialized body of ToM *knowledge* is impaired whereas William's subjects solve the false belief task because their ToM knowledge is intact.

One might think that the above LMC-style explanation for the dissociative data is unsatisfactory because it does not account for the fact that individuals with Williams can pass the false belief task in spite of being severely mentally

[15] Incidentally, if it turned out that there is a ToM module (and perhaps a small number of other modular, central systems), it would be easy to revise my formulation of LMC in order to accommodate these cases. It is still an interesting empirical claim that central processing is subserved *almost entirely* by nonmodular mechanisms and that the domain-specific structures involved in central processing *almost always* take the form of bodies of knowledge as opposed to modules. Moreover, this claim is incompatible with MMH.

[16] Indeed the main source of evidence for virtually all hypotheses about modular, central systems comes from the study of dissociations.

[17] False belief tasks are intended to evaluate whether or not experimental subjects understand when someone might hold a false belief. One 'standard' version of the task—sometimes called the 'Sally-Ann Task'—involves watching Sally put a marble in one place (location A) and later, while Sally is away, Anne putting the marble elsewhere (location B). The subject is then asked, 'Where will Sally look for her marble?' In order to answer this question correctly, the subject needs to appreciate that, since Sally was absent when her marble was moved from A to B, she will have the false belief that it is at A (Baron-Cohen [1995], p. 70.)

[18] For example, numerous studies have been conducted which establish that normal (i.e. unimpaired) 3-year-olds typically do not pass this task whereas normal 4-year-olds do (e.g. Wimmer and Perner [1983]; Perner, Leekham, and Wimmer [1987]).

retarded.[19] According to this criticism, if psychologists are right that there is such a thing as a general 'g' factor in intelligence, then it looks like this is what is affected in those who are severely mentally retarded. But, presumably, if LMC is true, then the 'g' factor is a measure of the general computational resources which access and process the contents of the various bodies of domain-specific knowledge. In which case it would seem that Williams people with low (full) IQs should be retarded across the board. But they aren't. Among other things, they are able to solve ToM tasks. According to the objection, this is easy to explain if there is a ToM module that is intact, but not so easy to explain if what they have is an intact body of ToM knowledge that is operated on by a general-purpose mechanism.

I would concede the point of the above argument if it were true that (a) Williams subjects were good at all ToM tasks and (b) they could do little else besides. If this were so, then it would be overwhelmingly plausible to posit a ToM module that, in the case of Williams, was selectively spared. As a matter of fact, however, the situation is rather more complicated than this. First, while Williams subjects are typically severely retarded, they still have some general processing skills (average full IQ is in the 50s–60s). Second, recent work by Helen Tager-Flusberg suggests that while Williams subjects pass standard false belief tasks they fail a range of other tasks that she calls '"higher" theory of mind tasks'(Tager-Flusberg [1997]). How do we explain this pattern of results? It seems that there are at least three possible explanations:

(i) *The pure modular explanation.* There is a ToM module that is partially impaired but works sufficiently well to permit Williams subjects to pass some but not all ToM tasks.

(ii) *The mixed explanation.* There is a ToM module that performs basic ToM operations (e.g. those involved in the standard false belief task) but other, more general processes are recruited in addressing the 'higher' ToM tasks. Success in false belief tasks is explained by the fact that the ToM module is intact. Failure in the 'higher' ToM tasks is explained by the fact that general processing is impaired.

(iii) *The LMC-style explanation.* There is a general-purpose cognitive device that employs specialized bodies of knowledge. The body of ToM knowledge is intact and general processing is sufficiently unimpaired to permit Williams subjects to pass the false belief task but sufficiently impaired to prevent them from passing the 'higher' ToM tasks.

Which explanation is to be preferred? The answer, I maintain, is that it is unclear. All three hypotheses account for the data and none of the explanations

[19] This point was made by Peter Carruthers in response to an earlier draft of this paper.

is, in any obvious sense, more parsimonious or less *ad hoc* than any of the others. In short: if we take into consideration the range of currently available data, we do not have any reason to accept a modular explanation of ToM in favour of an LMC-style explanation.[20]

7 Evolutionary psychology and the Library Model of Cognition

In the preceding sections we saw that the two main general arguments that evolutionary psychologists have developed in support of massive modularity fail to provide us with reason to prefer MMH to LMC. Moreover, we have seen that the currently available experimental data fails to provide us with reason to prefer MMH to LMC. Let me now briefly point out that there is a sense in which the rejection of LMC by evolutionary psychologists is unmotivated since LMC may be adequate for the purposes of evolutionary psychology. Indeed it is perfectly consistent with the central commitments of evolutionary psychology (except, of course, for MMH). In order to see this let us take a very brief look at what I take to be four central claims shaping the evolutionary-psychological research program.

1: Conceptual integration. Evolutionary psychologists have argued that a prerequisite of successful progress in psychology and the behavioural sciences is that they 'should make themselves mutually consistent, and consistent with what is known in the natural sciences as well' (Barkow *et al.* [1992], p. 4). In particular, psychology should avoid making claims that are incompatible with

[20] In an interesting series of comments on an earlier draft of this paper, Peter Carruthers proposed two further empirical objections to LMC. First, he maintains, the LMC suggests that autism is curable by teaching. If what autistic people lack is simply a body of information about the mental domain, then, according to Carruthers, it looks like all we need to do in order to cure them is to systematically teach them the relevant information. This, however, is a mistake. As mentioned in footnote 6, according to LMC the mental library may be divided into distinct parts and specialized parts of the brain may be dedicated to storing one or another kind of information. If this is so, then spoon-feeding information will be of no use since if the dedicated neural region is damaged, it won't be possible to store the information.

Second, Carruthers has suggested that if LMC is true, then ToM performance should be slow since (a) we possess a lot of information about ToM and (b) according to LMC, the same computational processes are brought to bear on ToM as on a wide range of other domains of information. Carruthers claims, however, that our ToM performance is *remarkably fast* by comparison with our performance in many other domains about which we possess less information. Again, I don't find this argument persuasive. First, it is far from clear that ToM performance is either faster or more informationally intensive than processing in other domains—e.g. chess for chess players—where it is highly implausible to think that we possess modules. Second, the above argument assumes that, for general-purpose inferential devices, there is a linear relationship between the amount of information one possesses in a given domain and the speed of processing in that domain. But it is generally agreed that if, as seems highly likely, the processes that operate on knowledge in the human brain are implemented in a highly parallel fashion, then no such linear relationship exists (Falham [1986]).

well-entrenched theories from evolutionary biology. Evolutionary psychologists are, of course, correct to claim that we need to avoid inconsistency between the theories developed in psychology and those developed in other disciplines. After all, if two theories are mutually inconsistent, then it follows that at most one of them can be correct. Nonetheless, to my knowledge, there is no reason to suppose that LMC is incompatible with any highly confirmed theories from evolutionary biology or from any other science. Thus LMC is just as compatible as MMH with the adoption of conceptual integration as a constraint on theory-development in psychology.

2: There is a universal human nature. A central commitment of evolutionary psychology is that there is a universal human nature (Barkow *et al.* [1992], p. 5). That is, all (normal) human beings share essentially the same cognitive architecture. Again, there is no reason to suppose that LMC is incompatible with this claim.

3: Evolved psychological structures are adaptations. A third claim that evolutionary psychologists commit themselves to is the proposal that the evolved mental architecture of the human mind is composed of 'adaptations, constructed by natural selection over evolutionary time' (Barkow *et al.* [1992], p. 5). Here to, there is no incompatibility between LMC and the claim that psychological structures are adaptations. But where the proponent of MMH might claim that modules are adaptations the proponent of LMC will instead claim that the bodies of information are adaptations.

4: Evolutionary analysis is relevant to psychology. A central methodological claim of evolutionary psychology is that what I'll call *evolutionary analysis* can play a crucial role in helping us to construct plausible hypotheses about the human mind. Very roughly, an evolutionary analysis tries to determine as much as possible about the recurrent information-processing problems that our forebears would have confronted in the EEA. The focus, of course, is on adaptive problems whose successful solution would have directly or indirectly contributed to reproductive success. Some of these adaptive problems are posed by physical features of the EEA, others are posed by biological features and still others are posed by the social environment in which our forebears were embedded. Once such a problem has been identified and characterized, evolutionary psychologists suggest that we explore the hypothesis that the human mind contains specialized structures that would have done a good job at solving that problem in the EEA. In short, evolutionary analysis 'allows one to pinpoint the important, long-enduring adaptive problems for which human beings are most likely to have cognitive adaptive specializations—that is, it suggests what domains might be fruitful to investigate' (Cosmides and Tooby [1994], p. 94).

Evolutionary psychologists typically employ evolutionary analysis in order to generate hypotheses about the existence of Darwinian modules. So, for instance, Cosmides and Tooby [1992] use evolutionary analysis in order to develop the hypothesis that human beings possess a module that is dedicated to reasoning about social exchanges or 'social contracts'. None the less, there is no reason to suppose that evolutionary analysis could not equally well be employed in order to generate hypotheses about the existence of domain-specific bodies of information. Such bodies of information might have been utilized by domain-general cognitive mechanisms in order to enable an organism existing in the EEA to solve the sorts of problems confronted by our forebears. Thus even if MMH were false and LMC were true, evolutionary analysis might still prove to be a useful tool for generating hypotheses about the structure of the human mind.

8 Conclusion

We started by noting that evolutionary psychologists commit themselves to MMH—the hypothesis that our cognitive architecture is largely or perhaps even entirely composed of naturally selected, universal, innate, domain-specific, computational mechanisms or modules. We then saw that the two main evolutionary-psychological arguments for this general architectural thesis fail to provide us with any reason to prefer MMH to a competing picture of the mind which I call the Library Model of Cognition. We also saw that the currently available experimental evidence does not distinguish between these two hypotheses. Finally, we saw that LMC is compatible with the central commitments of evolutionary psychology. Thus not only do the main evolutionary psychological arguments fail to provide us with any reason to prefer MMH to LMC but there is also a sense in which the rejection of LMC by evolutionary psychologists is unmotivated. Now of course, it may turn out that there are excellent reasons to prefer MMH to competing hypotheses. I am, however, pessimistic about the prospects of providing plausible, *general* arguments in support of massive modularity. Rather, I suspect that if the case for MMH is to be made, it will only result from the successive accumulation of specific, empirical evidence for the existence of particular modules. Fortunately, the search for such evidence is under way. But it is early days yet and we are still a long way from providing convincing evidence for the general architectural hypothesis that the human mind is massively modular.

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