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Massive Modularity: An Ontological Hypothesis or an Adaptationist Discovery Heuristic?

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Cognitive modules are internal mental structures. Some theorists and empirical researchers hypothesise that the human mind is either partially or massively comprised of structures that are modular in nature. Is the massive modularity of mind hypothesis a cogent view about the ontological nature of human mind or is it, rather, an effective/ineffective adaptationist discovery heuristic for generating predictively successful hypotheses about both heretofore unknown psychological traits and unknown properties of already identified psychological traits? Considering the inadequacies of the case in favour of massive modularity as an ontological hypothesis, I suggest approaching and valuing massive modularity as an adaptationist discovery heuristic.

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1. Introduction

Cognitive modules are internal mental structures. As such, their existence, if any, is a matter of inference and not something that can be determined by means of direct observation. In this respect, the truth of the hypothesis claiming that the mind is massively comprised of modules is open to a debate that is more theoretical than empirical in nature. How to ground a hypothesis that suggests the existence of a massive number of unobservable processes?

Some theorists (Fodor, 1983, 2000; Sperber, 1994) and empirical researchers (Baron-Cohen, 1995; Barrett & Kurzban, 2006; Buss, 1999) invoke modular internal structures in order to make sense of the mechanisms that underlie human cognitive capacities that are associated with the performance of tasks that are specialised and functional. Tellingly, cognitive modules also serve for making sense of intriguing psychological phenomena such as the persistence of perceptual illusions, selective impairments of cognitive capacities and double dissociations, among others.

Fodor (1983, 2000) considered that modules are useful only for explaining low-level mental systems. These are the systems involved in cognitive capacities like perception and language as well as in action and motor behaviour. In this respect, Fodor argued that the notion of cognitive modularity helps to understand the automaticity of perception as well as its suspected cognitive impenetrability.

For Fodor, the central (high-level) systems of mind—those involved in cognitive capacities like judgment (the 'fixation of belief' in Fodor's jargon), planning, decisionmaking, and so forth—are not explainable in terms of modular mechanisms. However, some other philosophers (Carruthers, 2006b) as well as proponents and practitioners of evolutionary psychology (Tooby & Cosmides, 1992, 1995) consider that it is reasonable to invoke modules for explaining the central systems of mind, too. In their view, modules count as the best explanation for a multitude of high-level and low-level cognitive capacities such as statistical reasoning, managing hazards, identifying threats, detecting cheaters in social exchange, child-care motivation, and so forth.

The debate over modularity is mainly a debate over the modularity of central systems (high-level cognitive capacities). Admittedly, it is also possible to raise doubts about the modularity of the peripheral systems of human mind (Prinz, 2006), but that kind of skepticism is not widespread in the literature. Indeed, there seems to be a consensus regarding the operation of modules in perception and language.[1] In contrast, both the empirical and the theoretical (a priori) cases built in favour of central modularity are usually contested on multiple fronts and in tough terms. In this respect, many authors (Buller, 2005; Gibbs & Van Orden, 2010) argue that the observations offered as positive empirical evidence of the existence of modular central systems are easily—and adequately—interpreted without invoking anything similar to cognitive modularity. It is also common to argue that the theoretical considerations advanced in favour of central modularity are unconvincing and sometimes inconsistent (Fodor, 2000; Frankenhuis & Ploeger, 2007). Certainly, the massive modularity of mind hypothesis has been under frequent and fierce criticism during the last three and a half decades. Among other things, it has been called a promiscuous view of modularity (Buller & Hardcastle, 2000) and 'modularity theory gone mad' (Fodor, 1987, p. 27).

As formulated by its main advocates, the massive modularity of mind hypothesis is an empirical and existential statement and, as such, its truth should be ultimately decided in an empirical way, not a priori or by means of armchair arguments (Sperber, 1994, 2001). Nonetheless, much of the debate over massive modularity has taken place on theoretical grounds. This is due to an alleged underdetermination of the hypotheses regarding the modularity of central systems by data (Rich, Blokpoel, de Haan, & van Rooij, 2020). In such conditions, the remaining open option has been to advance theoretical considerations in favour of the plausibility—and not directly in favour of the empirical truth—of the massive modularity of mind generally, and of the modularity of central systems in particular. These theoretical considerations are mostly based on an adaptationist view of evolution cum a classical computationalist approach to mind. They include arguments about the nature and evolution of hierarchically ordered complex systems, a presumption of (local) optimality (or sub optimality) expressed in the apparent design of phenotypic traits shaped by natural selection and dismissing non-modular mental architectures as computationally intractable.

Is the massive modularity of mind hypothesis a cogent view about the ontological nature of human mind or is it, rather, an effective/ineffective adaptationist discovery heuristic for generating predictively successful hypothesis about both heretofore unknown psychological traits and unknown properties of already identified psychological traits? Considering the inadequacies of the theoretical arguments in favour of massive modularity as an ontological hypothesis, I suggest approaching and valuing massive modularity as an adaptationist discovery heuristic.

Since the term 'module' has been used in many different ways in the debate, section 2 elaborates on what I argue are the most relevant and productive senses of cognitive modularity: computational modules (which include informationally narrow-encapsulated modules and informationally wide-encapsulated modules) and intentional modules. In doing so, my aim is to shed light on the controversy as well as to pave the way for developing a more straightforward discussion. It is far from my intentions to interpret the modularity debate as one purely semantical and originated in a sort of ambiguity or lack of precision in the definition of terms (Pietraszewski & Wertz, 2022).

Section 3 articulates the massive modularity of mind hypothesis putting it into the context of the research programme of evolutionary psychology and the work of other evolutionarily oriented theorists and philosophers. In section 4, I present and analyze the main theoretical considerations that is customary to offer in favour of the massive modularity of mind hypothesis. Specifically, I assess the feasibility of three theoretical arguments that give (non-demonstrative) support to this hypothesis: the evolvability of complexity argument, the task-specificity argument, and the tractability argument. In section 5, I highlight the pitfalls of the three theoretical arguments in favour of the massive modularity of mind hypothesis presented in section 4. Finally, in section 6, taking into account that, apart from being a hypothesis underdetermined by the data, the plausibility of the mind being massively modular is grounded on questionable theoretical assumptions, I suggest approaching and valuing massive modularity as an adaptationist discovery heuristic.

2. Why Invoke Modules?

For most of us, adult human beings, perceiving the world and thinking in general feels like a seamless experience. There are neither abrupt switches between unrelated mental states nor random discontinuities and intrusions in the execution of everyday life tasks. The phenomenal experience that corresponds to the succession of the mental events we have is so smooth—and prima facie also logical—that it causes the proposition that the mind is a unity to appear not just true but also commonsensical. The mind feels like a relentless and continuous causal flow of perceptions, emotions, beliefs, desires, moods, and actions, not like a fragmented collection of discrete mechanical processes and unconscious rule-following activities. Certainly, the hypothesis that the human mind is partitioned into numerous and relatively independent or semiautonomous especially dedicated information-processing mechanisms results far from intuitive.

Modules are invoked under the principle of 'divide-and-conquer' (Marr, 1976) as means for explaining in a cognitively suitable fashion the strikingly diverse facts mental life is composed of. Considering this rationale, and following a suggestion by Samuels (2000), I distinguish two classes of cognitive modules: computational modules and intentional modules. The former are information-processing internal mechanisms, while the latter are domain-specific bodies of mental representations akin to theories. The massive modularity of mind hypothesis is formulated in terms of computational modules: it states that the mind is largely or entirely comprised of informationprocessing internal mechanisms. Peripheral modularity is formulated in terms of computational modules too—this position states that modules are involved in processes typical of input and output systems. Among computational modules, and following a suggestion by Carruthers (2006a, 2006b), I further distinguish between two species: informationally narrow-encapsulated modules (Fodor's sense of modules) and informationally wideencapsulated modules (Carruthers' sense of modules). Some comments are in order.

On the one hand, informational narrow encapsulation is informational encapsulation in a strong sense: a module is understood as a system that, once activated, cannot be affected by information that is stored outside its proprietary database even when such information is relevant to the task performed by the module. On the other hand, the concept of informational wide encapsulation does not rest on a stark distinction between an extensionally determined subset of information held in the mind that can affect a module in the course of its processing (i.e. its proprietary database) and an extensionally determined subset of information held in the mind that cannot affect or penetrate it (i.e. the information stored outside the module). It just happens that most of the information (not an extensionally determined subset) held in the mind does not affect the wide-encapsulated module in the course of its processing because the algorithms it has—some frugal search heuristics and stopping rules—are such that only a partial amount of the total available information held in the mind is consulted before completing or aborting a task.

Now, in analytical terms, informationally narrow-encapsulated modules and informationally wide-encapsulated modules do not exhaust the notion of computational module. They are biologically based computational mechanisms that have a characteristic ontogeny or a reliable pattern of development. It is worth emphasising that to be biologically based—to be biologically 'incarnated'—is not a necessary condition for a mechanism to fulfil in order to be computational in nature. Indeed, the distinctive feature of a classic computational mechanism is manipulating representations, not having certain strong nativist (Fodor's sense of modules) or interactionist (Carruthers' sense of modules) pattern of development. By this criterion, I do not preclude the possibility of implementing an artificially designed—and hence not a phenotypic character that is expression of an organism's genotype—computational module in a human brain. An example of this implementation is the external hardware's sensory system that allows the artist Neil Harbisson[2] to infer from sound signals the chromatic colours standard humans attribute to physical objects. This hardware (the 'cyborg antenna') is implanted permanently in Harbisson's head (Harbisson, 2012).

Granted, it is difficult to single out a common essential property of all the above-mentioned kinds of modules. Domain specificity seems to be a good candidate, though (Coltheart, 1999). This is because the raison d'être behind positing modules in order to make sense of cognition is to refer to how freely or how limitedly different items of information flow in the architecture of mind. Yet it is imperative to stress some nuances when making use of the concept of domain-specificity since not all cognitive modules are said to be domain-specific in the same manner.

Computational modules can be called domain-specific in two senses. First, they can be called domain-specific in case they are only turned on or triggered by a particular and highly restricted class of representations or inputs, that is, if they are input-specific; and, second, they can be called domain-specific in case they are specialised in the solution of a particular class of problems or, what amounts to same, in case they are specialised in performing a specific task, that is, if they are task-specific (sometimes evolutionary psychologists refer to this sense of domain-specificity in modules, mostly, when they defend the massive modularity of mind hypothesis by means of the task-specificity argument).

On the other hand, intentional modules are domain-specific in relation to the content of a task, that is, they are bodies of knowledge about a particular subject matter, like (folk) physics, (folk) psychology, (folk) biology, (folk) arithmetic, and so forth. They are content-specific.

To sum up, domain-specificity can be understood as input-specificity, task-specificity, and content-specificity. In order to avoid potential misunderstandings, I would like to stress that when I talk about modules in the context of this paper, I refer to human cognitive modules (i.e. internal mental/informational structures that underlie human cognitive competences). That said, however, I must admit that the sense of modularity closest to the cognitive use is the biological/developmental sense.[3]

3. Massive Modularity of Mind Hypothesis

The massive modularity of mind hypothesis reveals itself as a bold and ambitious depiction of the human cognitive architecture. It states that our mind is a system largely— though not necessarily exclusively—composed from numerous modular cognitive mechanisms shaped opportunistically by natural selection in order to tackle information-processing problems and regulate the behaviour of our hunter-gatherer forebears in an adaptive manner.

This view of cognitive modularity as massive and pervasive to the peripheral and the central mental systems alike is commonly associated with the proponents of evolutionary psychology (Barrett, 2005, 2015a; Barrett & Kurzban, 2006; Tooby & Cosmides, 1992). Tooby and Cosmides (1995a) state the massive modularity of mind hypothesis in the following metaphorical terms: 'our cognitive architecture resembles a confederation of hundreds or thousands of functionally dedicated computers (often called modules) designed to solve adaptive problems endemic to our hunter-gatherer ancestors' (p. xiii-xiv).

The massive modularity of mind hypothesis receives additional theoretical and conceptual support and justification by authors and philosophers somewhat sympathetic to the research programme of evolutionary psychology such as Carruthers (2006a, 2006b) and Sperber (1994, 2001). Importantly, as Carruthers (2006b, 2008) makes explicit, the massive modularity of mind hypothesis entails that the mind is modular all the way down. That is to say, the mind is a hierarchic system of modules, in which 'all but the bottom layer of modules will be construed out of other modules as parts' (Carruthers, 2008, p. 294). This means that modules have embedded modules as components, and the embedded modules are, in turn, composed of further embedded modules, and so forth. Routinely, modules are complexes of modules unless they are modules at the bottom layer of the cognitive hierarchy.

Now, we should take into account that endorsing the modularity of the central systems of mind in addition to the seemingly uncontroversial modularity of the peripheral systems of mind goes logically hand in hand with the defenestration of some of the properties deployed by Fodor (1983) to characterise the concept of cognitive module. Mainstream evolutionary psychologists—and, by extension, mainstream massive modularists —reduce the concept of module to the sole property of functional specialisation (Barrett & Kurzban, 2006). In any case, the most obvious candidates to be toppled from the characterisation given by Fodor (1983) are informational encapsulation, swiftness of processing, and shallow outputs.

The massive modularity of mind hypothesis entails that almost all modules are domain-specific (input-specific), that most modules are innate (that is, that most modules have a reliable development), and that some modules are narrow-encapsulated (Fodor's sense of informational encapsulation) (Carruthers, 2008, p. 295).

4. Theoretical Considerations in Favor of Massive Modularity

4.1. The Evolvability of Complexity Argument

The evolvability of complexity argument draws the conclusion that modularity—insofar as understood in the seemingly uncontroversial and generic sense of dissociable and quasi-independent subsystems without any necessary reference to whether or not these subsystems are information-processing—constitutes a foreseeable outcome when it comes to the evolution of complex systems like the human mind (Pinker, 1997). Carruthers (2006b) presents the argument as follows:

1. Biological systems are designed systems, constructed incrementally.
2. Such systems, when complex, need to have massively modular organisation.
3. The human mind is a biological system, and is complex.
4. So the human mind will be massively modular in its organisation.

This reasoning is grounded on the idea that modularity is a necessary condition for the evolution of complex systems by natural selection. This is because modularity warrants the evolutionary stability of complex systems and allows selection to target single traits. Hence, if we accept the thesis that the mind is a complex system—i.e. the thesis that the mind has components organised in certain functional and non-random manner—in conjunction with the prima facie uncontroversial thesis that its organisation evolved by natural selection as long as the behaviours the mind contributes to produce impinge on individual organisms' fitness, then we are allegedly entitled to predict that the organisation of the human mind is probably massively modular.

4.2. The Task-Specificity Argument

The slogan of the task-specificity argument is 'a jack of all trades is necessarily a master of none' (Cosmides & Tooby, 1994, p. 89). Like the evolvability of complexity argument, this new case in favour of the massive modularity of mind hypothesis is based on a series of conceptual considerations borrowed from an adaptationist understanding of evolutionary theory.

As advanced by Cosmides and Tooby (1994), the argument runs as follows:

1. When two adaptive problems have solutions that are incompatible or simply different, a single general solution will be inferior to two specialised solutions.
2. Our Pleistocene ancestor had to be good at solving an enormously broad array ofadaptive problems ... These different adaptive problems are frequently incommensurate: they cannot, in principle, be solved by the same mechanism.
3. Therefore, the human mind can be expected to include a number of functionally distinct cognitive adaptive specialisations.

Here, the core idea is that numerous functionally specialised information-processing mechanisms perform more efficiently—and so produce a higher fitness payoff—than a reduced number of general (and hence not specialised) information-processing mechanisms. Arguably, this is why natural selection is likely to have favoured the evolution of a massively modular mind in humans and other animals, and not of a domain-general intelligence packed with a set of rules for solving a large array of unconnected adaptive information-processing problems.

4.3. The Tractability Argument

The tractability argument is based on two ideas. The first one is that the computational theory of mind is true. The second idea is that non-modular mental architectures are computationally intractable and this counts as a reason against their existence because human cognitive capacities are constrained by computational tractability[4] insofar as humans are finite systems and have limited computational resources. The alleged reason for the intractability of non-modular mental architectures is that the processes they would execute demand much more time, memory, information, and computational power than those possessed by a standard modern human mind (Ermer, Cosmides, & Tooby, 2007).

As schematised by Peter Carruthers (2006c), the argument is the following:

1. The mind is realised in processes that are computational in character.
2. If cognitive processes are to be realised computationally, then those computationsmust be tractable ones.
3. In order to be tractable, computations need to be encapsulated.
4. Therefore, the mind must consist wholly or largely of modular systems.

Together, the evolvability of complexity argument, the task-specificity argument, and the tractability argument, aim to show by means of parallel inferences to the best explanation the plausibility of the massive modularity of mind hypothesis and that evolution by natural selection and software engineering converge on the same solution when faced to similar problems: a massively modular cognitive architecture.

5. Theoretical Arguments' Pitfalls

5.1. Problems of the Evolvability of Complexity Argument

The evolvability of complexity argument is an adapted version of an argument originally developed by Simon (1962) in favour of the mechanistic idea that evolved complex systems are usually hierarchically assembled and near decomposable into subcomponents.
As Simon put it, 'we could expect complex systems to be hierarchies in a world in which complexity had to evolve from simplicity' (p. 482).

Surely, this statement, which emphasises that hierarchies and near decomposability give stability to evolved complex systems does not equate to say that evolved complex systems are modular in the cognitive sense that underlies the massive modularity of mind hypothesis. The reason is straightforward: hierarchy is not a concept equivalent to modularity in a cognitive sense. It's true that a complex system is evolvable because its subcomponents can be single targets of natural selection, which means that they are both functionally decomposable and developmentally decoupled. But pure decomposition is far from being a sufficient condition of cognitive modularity.

Now, in which way, if any, hierarchical near decomposability amounts to modularity? Presumably, cognitive modules are not just decomposable mechanisms. They are decomposable informationally encapsulated mechanisms (whether informationally narrowscope encapsulated or informationally wide-scope encapsulated). Furthermore, it is not clear how to extract the concept of informational encapsulation or domain specificity from an analysis of the concept of hierarchy in order to make Simon's argument a genuine argument in favour of the massive modularity of mind hypothesis. A further premise is needed.

Anyhow, it seems that Simon's argument works nicely for massive modularists in case they are willing to portrait cognitive modularity only in terms of dissociable and quasiindependent functionally specialised information-processing mechanisms. Precisely, this is the argumentative strategy chosen by Barrett and Kurzban (2006) to tackle the criticisms addressed against the massive modularity of mind hypothesis. In similar spirit, this more 'workable' characterisation of module that allows an accommodation with Simon's original argument excludes ipso facto informational encapsulation as a property essentially attached to the concept of cognitive module. Ultimately, cognitive modules would be conceived as dissociable and quasi-independent functional specialised information-processing mechanisms regardless of whether or not they are informationally encapsulated.

Yet removing informational encapsulation as a necessary condition for cognitive modularity is a bold move and constitutes a radical departure from the conventional understanding of modules in a cognitive sense. In fact, it is not just a departure from the classical characterisation of Fodor (1983), but also a departure from the view of authors sympathetic to evolutionary psychology such as Sperber (2005) and Carruthers (2006a, 2006b), who are skeptical of a complete conceptual divorce or disconnection between modularity and informational encapsulation.

Furthermore, conceiving modules only in terms of functionally specialised information-processing mechanisms invites us to draw the conclusion that all cognitive mechanisms are probably modular. This is because there are good reasons to think that all cognitive mechanisms are to some extent specialised mechanisms and probably also functional.

5.2. Problems of the Task-specificity Argument

First, it is not obvious that we must expect our central cognitive systems to be architecturally modular just because an a priori task analysis informs us that, from the point of view of engineering (that is, according to an optimisation approach), modular designs are more efficient than non-modular designs when it comes to solve adaptive informationprocessing problems. Here, the engineering supposition is that one specialised solution to certain problem beats a general solution applied to the self-same problem and some other problems—in other words, the optimality adaptive mantra ‘specialisation beats generality.’

Adaptive values should be measured in terms of differential reproduction (relative fitness) and not in terms of elegant, minimalistic or globally optimal designs. That is, the effect of natural selection is fitness maximisation; and in order to achieve such a result it is not necessary for this process to engineer the best possible solution to a specific adaptive problem—and, definitely, not even the second or the third best possible solutions either. This process just ‘picks up’ the available phenotypic variant that boost the relative fitness of its bearer the better.

Natural selection is a discrimination process whose ultimate effect is increasing functional specialisation. The expression ‘increasing functional specialisation’ may be translated accurately as more efficiency to outreproduce conspecifics—which on balance means increasing fitness maximisation. It should be clear by now that fitness maximisation does not require global optimality.

Less obviously, it is not even clear that massive modularity is a locally optimal solution and, as such, the one solution historically picked up and tinkered gradually by natural selection among the different evolvable mental strategies that could develop in our hunter-gatherer forebears. This is because there are no reasons for thinking that the only alternatives in the ‘strategy set’ of the optimisation model are, on the one hand, massive modularity and, on the other hand, a single general-purpose cognitive device. To present those two alternatives as the only evolvable mental strategies and choosing massive modularity as the better available solution (i.e. as the locally optimal solution) for the numerous adaptive information-processing problems faced by our ancestors amounts to falling into the trap of a false dilemma.

Consider a second line of criticism in relation to the task-specificity argument. Functionality (the enhancement of fitness) does not amount to specialisation (task-specificity of a phenotypic trait). They are two different concepts and, as such, not necessarily coextensive. This means that there are functional phenotypic traits that are not specialised (i.e. exaptations), as well as specialised phenotypic traits that are not functional (for example, vestigial organs). The primary effect of selection is functionality (ability to enhance fitness) rather than specialisation (task-specificity).

Certainly, a new functional (fitness-enhancing) and ingenious co-option of a phenotypic trait evolved for facing some past—and probably currently nonexistent—selection pressure is also an open path for evolution to take and for the opportunistic tinkering typical of natural selection to benefit from. If a new adaptive problem could be solved relatively efficiently by the form of an already existing phenotypic trait, why not coopt it instead of shaping a new trait from simpler elements, which requires a slow process that might take hundreds of generations? Natural selection will tinker the coopted trait for the new task gradually, causing it to gain more and more relative efficiency and structural specialisation generation after generation.

A third line of criticism against the task-specificity argument (and also against the optimisation approach to evolution in general) could be found in the theoretical specifics and research practical implications of what is known as the 'grain problem' (Sterelny & Griffiths, 1999).

Start considering that the task-specificity argument and the language used by its proponents suppose that there were fine-grained adaptive problems in the environment characteristic of our hunter-gatherer forebears, that is, that there were very specific and potentially identifiable individual adaptive problems or evolutionary challenges. Here the questions are puzzling: how to define the boundaries of an adaptive problem? Is there any principle of individuation we can use as a tool to 'carve' the environment in discrete, specific, and numerically distinct adaptive problems? Are adaptive problems fine-grained or coarse-grained?

For example, it results misleading and even fallacious to think about mate choice as a single fine-grained problem in response to which natural selection shaped a domainspecific (task-specific) especially dedicated cognitive module. In fact, we can divide the problem of mate choice into many other problems and these newly found problems, in turn, may be broken down into many further problems, and so on. It is not clear when to end this division or analysis and whether or not there are objectively individual fine-grained problems 'out there.'

5.3. Problems of the Tractability Argument

Massive modularists hold that the source of intractability in non-modular architectures is what Fodor (1987) calls the 'frame problem.' Fodor's frame problem suggests that the processes typical of central cognition lack a frame for determining in a computationally tractable manner which items of information are relevant every time they perform a task and, as a result, they are forced to conduct a search of everything the individual organism knows. This exhaustive memory search is computationally intractable for systems holding the amount of information a standard human mind typically stores. Such intractability is a consequence of the globality proper to processes typical of central cognition, which means that any item of information stored in the mind, and not just those included in a module's proprietary database, could be relevant to the tasks these processes perform.

But in which way, if any, do the features of modularity (domain-specificity and informational encapsulation) solve the frame problem and avoid computational intractability? Carruthers (2006a) suggestion is that modularity avoid intractability in the mind's central systems because the modules proper to these systems are informationally widescope encapsulated: they have heuristics and stopping rules that reduce the information search, and make them frugal. For the sake of the argument, we might accept that modularity (encapsulation) is a sufficient condition for frugality and tractability. Here the important question is whether or not modularity (encapsulation) is also a necessary condition for tractability.

Why affirm that the mind is massively modular if informational encapsulation is not the only way to attain frugality and tractability? Why make the strong claim that ‘all mental processes need to be computationally tractable, and therefore realised in encapsulated modular mechanisms’ (Carruthers, 2003, p. 504)? As Samuels (2005) says ‘it is one thing to claim that modularity is an important way to engender tractability and quite another to claim that it is the only plausible way’ (p. 114).

Massive modularists hold that non-modular architectures cannot tackle the frame problem. The argument is that they lack the domain-specific information and the domain-specific procedures that could help central systems to reach a solution to its cognitive tasks in real-time. This is what causes them to evaluate all the items of information it can retrieve from the individual’s background belief as possible solutions to the tasks they perform. Samuels (2005) notes well that ‘the need for informationally rich cognitive mechanisms’ is not equivalent to the need for modularity. Even granting that modularity brings specialised knowledge to a system, this would not show that it is the only way to do it. ‘Another is for nonmodular devices to have access to bodies of specialised knowledge’ (Samuels, 2005, p. 114).

6. Massive Modularity as a Heuristic

After the consideration of the main theoretical arguments, several doubts about the plausibility—and ultimately about the truth—of the massive modularity of mind hypothesis naturally arise. This is because the plausibility of the mind being massively modular is grounded on questionable theoretical assumptions. In this light, the present section contends that the valuable aspect of the idea of massive mental modularity is not its truth as an ontological statement but its usage as an adaptationist discovery heuristic, that is, the heuristic guided by the notion that numerous information-processing mechanisms evolved by natural selection for solving specific adaptive problems faced by our hunter-gatherer ancestors.[5]

The term 'heuristic' comes from the Greek expression heuriskein, which literally means 'to discover.' Heuristics are strategies to generate novel hypotheses. They allow us 'to investigate possible patterns that those without the heuristics are blind to and to articulate these unique insights to the point of testability' (Goldfinch, 2015, p. 85). Here, I refer to methodological heuristics consciously followed by researchers, and not to the inferential heuristics (and biases or mental shortcuts) individual humans reason in accordance with not necessarily in a conscious and deliberate manner (Kahneman, Slovic, & Tversky, 1982).

On this basis, if understood as an adaptationist discovery heuristic, massive modularity might inform research in a fruitful way.[6] The actual practice shows that it helps to generate hypotheses that lead to successful empirical predictions regarding either unknown psychological mechanisms or novel properties of already identified psychological mechanisms. I interpret successful prediction as successful 'improbable' prediction. That is, a prediction that does not make much sense in absence of the hypothesis generated due to the heuristic (Al-Shawaf, 2019). For example, the successful prediction that people will be less angry when those who harm them benefited greatly (Sell et al., 2017) that you can extract from the hypothesis that anger is produced by a module evolved to bargain for better treatment (Sell, 2011), the prediction that commitment-skepticism (a bias toward underperception of men's commitment intentions) does not occur in postmenopausal women (Cyrus, Schwarz, & Hasserbracuk, 2011) from the hypothesis that there are evolved psychological mechanisms that lead to systematic cognitive errors whenever costs of false-positive and false-negative decisions have been asymmetrical over evolutionary history (Haselton & Buss, 2000), the prediction that autistic individuals tend not to be religious that you can extract from the hypothesis that religion is a byproduct of the 'hyperactive agency detection module' ('hyperactive agency detection device' [HADD], Barrett [2004]), etc.

As an adaptationist heuristic, massive modularity constrains the hypotheses in terms of functionality, that is, in terms of whether or not—as well as to what extent—the psychological traits eventually hypothesised by a researcher enhanced the fitness of our hunter-gatherer forebears.

One follows the heuristic by starting with a definition of an adaptive information-processing problem probably faced by our hunter-gatherer ancestors, then one hypothesises an information-processing mechanism (a computational module) likely to have evolved as a result of that selection pressure, finally one extracts critical predictions from this hypothesis (that is, improbable or counterintuitive novel statements and not platitudes). Importantly, as a heuristic, the usage of this routine is not free of risks.

First, the massive modularity heuristic does not entail that just one and the same module (that is, one and the same form) is going to be ultimately hypothesised as a response to the same adaptive information-processing problem by all the researchers working on the same topic. Indeed, many evolvable forms can have the same function (many evolvable modules can tackle satisfactorily the same adaptive information-processing problem).

Second, and given the foregoing, hypotheses generated from the massive modularity heuristic in response to the same research problem might be incompatible with each other and, logically, at the very least some of them will lead to unsuccessful predictions. Worse still, it might also happen that all the competing and incompatible hypotheses lead to unsuccessful predictions. Surely, heuristics in general produce occasional errors.

Nonetheless, a heuristic that systematically fails to lead us to successful predictions is ultimately not a heuristic at all.

Also, against massive modularity as a heuristic that generates hypothesis about especially dedicated modules, not all adaptations are task-specific. As a matter of fact, some adaptations are multi-task (multi-functional), and this detail inevitably causes many predictions extracted from hypotheses we generate thanks to the massive modularity heuristic to fail. Still, numerous adaptations are task-specific and, hence, numerous predictions generated due to the usage of massive modularity as a heuristic will be successful (Machery, Forthcoming).

In sum, as a heuristic, massive modularity does not guarantee that every researcher using it will come to the same answer—as an example of competing hypotheses generated by means of the heuristic that the mind is comprised of adapted psychological mechanisms (modules) consider the hypothesis of Daly and Wilson (1988) that takes homicide as a byproduct and the hypothesis of Duntley and Buss (2005, 2011) that takes homicide as an adaptation. Surely, this claim does not entail that the heuristic leads us systematically to a myriad of competing hypotheses. If such were the case, what we depict as a heuristic would not be a proper heuristic, but just a chaotic and misguided trial and error. The heuristic is useful insofar as the number of competing hypotheses it might help to generate is manageable.

The heuristic imposes constraints. In fact, a heuristic can be characterised in terms of the constraints it imposes. It helps insofar as it reduces to a manageable number the range of hypotheses that might be offered as plausible answers to a problem. Competing hypotheses (logically incompatible hypotheses) that are generated from the same heuristic are in principle equally plausible since they don't violate the constraints imposed by the heuristic. That said, however, not violating the constraints of the heuristic is not the only criterion one has for assessing how good a hypothesis is. We should extract empirical predictions from the competing hypotheses. One could say that we are 'dealing with hypotheses that are just as good as any other' if, apart from being logically incompatible, they are also empirically equivalent (that is, in case their empirical consequences do not make any difference). If so happens, they are underdetermined by the data. It is not the case that all competing hypotheses are empirically equivalent. I do not mean that all competing hypotheses are empirically equivalent when I say that there are examples of competing hypotheses being generated by massive modularity as a heuristic—it is not the case that the heuristic generates systematically competing hypotheses either.

For example, one can explain the fact that we detect cheaters (non-reciprocators) in terms of two competing hypotheses: there is a module for detecting the violation of deontic conditionals and there is a module for detecting cheaters. Now, since cheating might be interpreted as the violation of a deontic conditional (the social contract 'if you accept a benefit, then you must pay a cost'), then detecting cheaters could be seen as detecting the violation of a deontic conditional. But if such is the case the hypothesis that there is a cheaters-detecting module cannot be empirically disentangled from the hypothesis that there is a module for detecting the violation of deontic conditionals— detecting cheaters could be just interpreted as a by-product of detecting the violation of deontic conditionals. The challenge for those who hypothesise the existence of a cheaters-detecting module is to extract an empirical prediction that does not involve the detection of any conditional at all: to show that the module is concerned with the detection of cheaters and not necessarily with the detection of the violation of a deontic conditional (some people might violate the social contract 'if you accept a benefit, then you must pay a cost' by mistake or accident and hence they are not cheaters). That is precisely what the 'switched social contract' (if you pay a cost, then you must accept a benefit) experiments try to show (Cosmides, 1989).

Importantly, the fact that massive modularity used as a heuristic ultimately helps to the generation of successful empirical predictions does not count as an evidence of the truth of massive modularity as an ontological hypothesis. We are not testing the truth of massive modularity if a prediction succeeds or fails; we are testing the truth of the specific hypothesis generated thanks to massive modularity understood as a heuristic. (In a similar vein, we do not test the truth of evolutionary theory when we test a hypothesis we generate from it since, as a matter of fact, we can generate competing hypotheses from it.)

The point and motivation behind the above entire discussion is that the idea of massive modularity constitutes a useful heuristic because it provides a reliable and not entirely subjective way to generate hypotheses about psychological traits and to extract potential successful predictions from them. One does not need to appeal just to intuitions or wait for a brilliant idea to arrive in one's mind. In this sense, massive modularity gives us a 'method.'

Notes

1. Recent research argues that visual perception, which is part of the peripheral systems ofhuman mind, is top-down influenced and thus not informationally encapsulated. (For an exhaustive review of the literature, see Collins & Olson, 2014.) According to the data this research presents, visual perception is influenced by beliefs, desires, emotions, motivations, and so on (Siegel, 2012). If such is the case, then visual perception is cognitively penetrable and not modular. This recent research could be used as empirical evidence against the distinction between perception and cognition (Clark, 2013). In opposition to this view, Firestone and Scholl (2016) contend that 'there is in fact no evidence for such top-down effects of cognition on visual perception' (p. 3).
2. Neil Harbisson is an individual born with achromatopsia (a rare condition also known as'color blindness'), who claims to be the first 'officially recognised' cyborg of the world

since the United Kingdom Passport Office accepted the inclusion of the electronic hardware attached to his head in his passport picture. Harbisson claims that the antenna is an organ, and not a device.

3. There is not a univocal definition of modularity in biology (Wagner, Mezey & Calabretta, 2005). Yet this lack of analytical precision does not undermine the relevance of the concept of modularity for understanding biological phenomena. The concept of biological modularity is connected to properties such as dissociability (Needham, 1933) and quasiindependence (Lewontin, 1978). The reading of these properties—and hence the reading of biological modularity—is purely in terms of functional specialisation (Barrett, 2015b). This means that living complex organisms must be functionally dissociable into specialised traits that can be semi-independently modified by natural selection without affecting other specialised traits of the organism. In which case, 'modularity allows the adaptation of different functions with little or no interference with other functions' (Wagner, 1996, p. 38). Thus, the concept of modularity articulates a 'building block hypothesis:' new improvements do not compromise past achievements (Wagner & Altenberg, 1996). This is a key idea in evolutionary developmental biology or 'evodevo.' Modules are not innate in the sense of being 'preformed.' They are results of evolved developmental systems and gene-environment interactions. It is worth emphasising that the proximity between the notions of cognitive and biological modularity explains why there are some important attempts to understand cognitive modularity just as a special case of biological modularity. In this respect, according to Sperber (2005), 'if cognitive modules are real components of the cognitive system and not mere boxes in a nominalist flow-chart model, then they're a subtype of biological modules' (p. 55).

4. That 'human cognitive capacities are constrained by computational tractability' is what van Rooij (2008) calls 'the tractable cognition thesis.'
5. This idea can interpreted as a kind of instrumentalism (for more about this point, see thenext footnote). It's beyond the limited ambitions of this paper to discuss the arguments in favour and against instrumentalism in the philosophy of science. For more about instrumentalism, see Rowbottom (2019).
6. There has been an intense debate over adaptationism in the last four decades. Taking intoaccount the distinction between empirical adaptationism, explanatory adaptationism, and methodological adaptationism proposed by Godfrey-Smith (1999, 2001), the adaptationism referred to by means of the expression 'adaptationist heuristic' in this paper is neither empirical adaptationism—because it does not require to endorse the thesis that natural selection is the key to predict and explain most of the outcomes of evolutionary processes, as most mutations are not adaptive but neutral or nearly neutral—nor explanatory adaptationism—because it does not require to endorse the thesis that the problem of apparent design is the most important in biology. The adaptationism referred to by the expression 'adaptationist heuristic' is methodological adaptationism. This version of adaptationism recommends studying biological systems looking for features of adaptation and design. Here adaptationism is seen as a research strategy or working starting point. There are no underlying empirical claims about how the world is. There is not a philosophical valuation of the role of natural selection either. 'There is nothing particularly new in this logic, which is also the basis of functional anatomy, and indeed of much physiology and molecular biology' (Maynard Smith, 1978, p. 31). In the realm of psychology, the task is not trying to make sense of already known psychological traits in terms of ingenious—and sometimes outlandish—hypotheses that present them as adaptations (post hoc storytelling) but trying to discover either actual

psychological adaptations that are heretofore unknown or unknown properties of already known psychological adaptations. Pace Gould (1997a, 1997b), this appeal to adaptationism is not a matter of parochial and dogmatic fundamentalism. Adaptationism qua heuristic yields testable hypotheses about potential adaptations and the specific selection pressures (adaptive problems) that shaped them.

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