

**Is Darwin Overbought? Evolutionary theory and human psychology**

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Throughout the 1980s and into the early 1990s, stock in evolutionary theory was highly undervalued in the cognitive and neurosciences. Behaviorism had been overthrown as the dominant theoretical framework by everyone from anthropologists to learning theorists, in part because the evidence for species-specific mechanisms of learning was so overwhelming (Garcia, Ervin, and Koelling, 1966; Garcia and Koelling, 1966). A major cornerstone of behaviorist metatheory had been the argument, first advanced by Edwin Thorndike (1899??), that evolutionary theory, by describing all animal life as sharing common descent, implies that all animals should share certain basic features in common, including those physiological systems that underwrite learning and the organization of behavior. This principle of evolutionary conservation of function motivated decades of laboratory research designed to uncover the basic laws that explain how all animals come to display the complex behavior patterns they do. Discovering that learning mechanisms seem to vary across species counted as a serious blow to the foundations of behaviorism, especially as an account of human behavior, and contributed significantly to its loss of place at the center of the behavioral sciences. The fact that the evidence suggested a result counter to what had been predicted from evolutionary theory may help to explain why there was no rush to embrace Darwinism as a replacement metatheory for behaviorism.

But there is almost certainly a deeper explanation for the low value placed on evolutionary theory, and it is related to the generally negative attitude among practitioners of the social sciences at the time toward the biological sciences generally. Biology might be fine for explaining why the stomach rumbles when one hasn't eaten, or the heart races when one is afraid, but it was part of the canon among social scientists of the time that explaining what satisfies one's hunger or causes one's anxieties is explainable only by appeal to the cultural context in which an individual's psychology is acquired. On this account, dubbed by Cosmides and Tooby (1992) the Standard Social Science Model (SSSM), there are determinate causes for the structure of mind and the patterns in a person's behavior, but they are to be found in the environment, especially the language-rich social environment, in which

an individual is reared and lives, not in his biology. There is no human nature on this account; we are born perfectly *tabula rasa*, and become human by living in human cultures. This process of acculturation may not be explainable by the behaviorist's species-general learning mechanisms, but this conclusion in no way compromises the view that learning in cultural context determines who and what we are. In fact, it makes the job of explanation easier in important ways, because seemingly unique human abilities, like language and creative problem solving, need no longer be made consistent with an impoverished stimulus-response theory of learning. The SSSM was actually strengthened by the demise of behaviorism, and stock in evolutionary theory became badly oversold.

What a difference a few decades makes. Today, the new interdisciplinary of *evolutionary psychology* is in the ascendant, riding the coattails of powerful new developments in the biological sciences. New technologies, and new findings, in genetics and the neurosciences have been particularly important in turning the attention of many scientists away from explanations of behavior based on complex environmental events and toward biological ones, a trend that seems clearly to have caught on in the popular culture as well. Evolutionary psychology has emerged as part of an attempt to bring this biological perspective to bear on the problems of explaining human thought and action. To their credit, thoughtful evolutionary psychologists seek to occupy the explanatory zone between narrowly biological or environmental determinism. From this perspective, interactions between genes and environments produce complex phenotypes, including many that account for a remarkable variety of mental and behavioral processes. It is possible to predict these phenotypes, or to explain them after the fact, as the products of neural processes that were designed over many generations by the process of natural selection. Such evolutionary explanations are offered for the poor performance of humans on many tasks of formal reasoning (Gigerenzer and Selten, 2001), for why human morality is fundamentally authoritarian (Geiger, 1993), for why and under what circumstances women have orgasms (Shackelford, Weekes-Shackelford, LeBlanc, Bleske, Euler, and Hoier, 2000), for why we

form stereotypes (Schaller and Conway, 2001), for why there are psychopaths (Lalumiere, Harris, and Rice, 2001), for why both men and women pay so much attention to women's hair (Hinsz, Matz, and Patience, 2001), for why there is music (Brown, 2000), and for why we are ticklish (Harris, 1999), to give just a few examples from the recent literature. In all of these cases, it is claimed that the behavioral patterns observed result from the operation of highly specialized brain modules that evolved to solve a particular class of problems in the Environment of Evolutionary Adaptedness (EEA). The claim that the mind is, "...likely to resemble a confederation of hundreds or thousands of functionally dedicated computers, designed to solve problems endemic to the Pleistocene," (Tooby and Cosmides, 2000, p. 1171), is at the core of both the theory and the research strategy of evolutionary psychology. The goal of this paper is to examine this claim with respect to certain basic cognitive processes, as traditionally conceived, and to suggest that just as evolutionary psychology was once undervalued in the marketplace of ideas, it has become overbought, with interesting implications not only for psychologists, but for epistemologists as well. This paper concludes with some thoughts about how a fairly valued evolutionary psychology might contribute to a better understanding of certain key features of human nature.

### **The argument for massively modular (human) minds**

Evolutionary psychology exists as the union of evolutionary biology, biological anthropology, and cognitive psychology, but its cornerstone is the theory of evolution of adaptations by natural selection. An adaptation is any biological structure or process that increases an individual organism's ability to survive and reproduce more successfully than other occupants of its ecological niche. Within a given niche, the resources available for supporting life are finite, and a competition ensues among occupants of the niche for access to those resources. Because individuals in the niche differ in the biological structures and

processes they possess for exploiting the resources of the niche, they will be differentially successful at solving the problems of obtaining the resources they need to survive and reproduce. To the extent that such differences in traits are heritable, those genes responsible for successful traits will become more frequent in the population -- they will be *selected for*. Those that are less successful will be *selected against*. This is the process of natural selection. Over time, i.e., across generations, the tendency will be for the emergence of more adaptive traits, and the disappearance of less adaptive ones, *ceteris paribus*.

This much of the story, told at this level of abstraction, is not controversial. No serious biologist, or psychologist for that matter, doubts the validity of this argument. Although very little of the data that anchor its premises come from true experiments, the weight of the evidence, which has been accumulating for nearly two centuries, is overwhelming, and the logic is sound. Nor is there much doubt about the extension of the argument to particular cases in biology. For example, the structure of the single-chambered eye seems to have been discovered by natural selection at least twice on distinct branches of the evolutionary tree (Bruce, Green, and Georgeson, 1996). This is not a random coincidence. It is a reflection of the fact that the same laws of optics apply everywhere near the Earth's surface, and so provide an opportunity for a suitably structured device to extract information contained in the optic array, for the benefit of the organism that possesses that device. A process of genetic mutation results in a quasi-random search of the space of possible genotype-phenotypes, some of which constitute improvements on existing systems for extracting information from the optic array. The single-chambered eye represents a very efficient solution to this problem, and so it gets invented more than once in the history of life on Earth.

The proponents of evolutionary psychology argue that we have every reason to expect the same processes to have shaped the structures of thought and action. Because thought and action are products of the brain, and because the brain is a biological organ whose design is coded in genes, phenotypic thought and action patterns are subject to

natural selection just as surely as the structures for responding to patterns in light or digesting food (e.g., Buss, 1999; Cosmides and Tooby, 1992; Tooby and Cosmides, 2000). Brains exist in the first place because there is a reproductive advantage to the specialization of some of an organism's cells for the purpose of recovering and then managing information available in the energy fluctuations in the organism's vicinity. Specifically, nervous systems evolve to coordinate the relationship between organs for movement and organs for information gathering. Over time, selection favors nervous systems that contribute to more successful solutions to the problems posed in a given environmental niche. Historically, this seems to have resulted in organisms of greater and greater complexity (as well as greater size, on balance; see Bonner, 1988), with the human brain representing the currently most complex device of its kind. Its complexity, the argument goes, is owing to a very diverse set of specialized brain modules for solving very specific problems confronted by human beings during their evolutionary history (Tooby and Cosmides, 2000).

A great deal of the evidence adduced in support of the argument for evolution of specialized modules comes from comparative studies of a wide range of animal species. For example, it counts in favor of the specialization argument that ants and bees solve the problem of navigation in highly species specific ways, even though both make use of sunlight in the process (Gallistel, 2000), and in fact different species of ant solve the navigation problem quite differently, as a function of the nature of the problem as it presents itself in the ant's local environment (Wilson, 1975). If we look still farther afield, to birds, fish, or mammals, we find an even more varied set of solutions to the problem of navigation. The same variety can be found across species in response to the problems of mate finding, feeding, and so forth. It seems obvious that there are multiple ways to solve a given problem, and the process of natural selection has found a wonderfully varied set of solutions.

As is the case for evolutionary theory more generally, I take it to be uncontroversial that a diverse set of solutions exists for any number of problems in survival and reproduction, as encountered in specific niches in the ecology. Nor is it controversial that many of these solutions manifest phenotypically as behaviors, and that it is therefore reasonable to conclude that natural selection can operate on behavior as well as on other kinds of processes. But what else follows from these conclusions?

Evolutionary psychologists want to add one more step to the argument, concluding that, because there are so many different neurocomputational procedures for solving the same set of problems, then it follows that, "There is no single algorithm or computational procedure that can solve every adaptive problem." (Tooby and Cosmides, 2000, p. 1168). We should therefore not expect to find the kinds of general-purpose, content-neutral cognitive procedures that the behaviorists, and more recently the cognitive psychologists, have sought. Instead, we should expect to find modules dedicated to solving just those problems that our ancestors encountered in the Environment of Evolutionary Adaptedness or EEA. Knowing something about that environment will help us to predict and explain otherwise odd-looking regularities in human behavior across time and cultures.

Before examining some specific proposals for the kinds of modules one might expect to make up the massively modular brain, it is worth being clear about what is meant by a module. This idea was introduced in something like its current form by Jerry Fodor in a very influential book entitled, *The Modularity of Mind*, published in 1983 (Fodor, 1983). Fodor's modularity was of a limited sort, confined largely to the systems for managing input to what he called the "central systems," of the mind, including the high order systems for remembering, conceptualizing, reasoning, and the like. Fodor proposed nine criteria all of which a system must possess to count as a module, but the modules proposed by evolutionary psychologists are less restrictive, and so more likely to be met. For a system to count as an evolved mental module, it must be linked to a specific neural architecture that is genetically specified and so heritable, it must be specific to a domain of content, and it must

be relatively encapsulated so that its operations are generally unaffected by and cannot affect information from outside the domain.

What kinds of modules does evolutionary psychology predict? Some of them can be quite domain specific indeed. Consider, for example, the problem of identifying women who are in good health, young enough to be highly fertile, and not currently involved in a relationship with a man. Evolutionary psychologists argue that this problem is universal for males in the EEA. Identifying such women narrows the search for a mate to those who are most likely to become pregnant, carry a fetus to term, and nurture it successfully. The ability to detect reliable clues to health, age, and availability, and to respond with appropriate feelings of attraction would give a reproductive advantage to men who have this ability. Hinsz, et al. (2001) offer data claiming to show (a) a correlation between certain properties of women's hair (fullness, etc.) and general health, and (b) a correlation between both hair length and age (younger women have longer hair), and hair length/quality and availability (unmarried women have longer, better quality hair). Men will be more attracted to and pursue younger, healthier women who are not already in a relationship if they want to maximize their reproductive success, and women want to attract the best possible mates from whom to choose, so, on an evolutionary psychological account, there will be a module for the evaluation of female hair quality that produces the appropriate level of attraction. It isn't too difficult to imagine how this module might be extended to include the propensity to spend time and resources on improving hair quality and monitoring hair length among women themselves.

A cognitive module need not be this narrowly focused. For example, Leda Cosmides and her colleagues have offered a great deal of evidence in support of the claim that there is a human cognitive module specialized for the detection of people who cheat on the accepted moral or conventional rules of the group (Cosmides, 1989; Fiddick, Cosmides, and Tooby, 2000). The argument is that cheaters tend to reduce one's reproductive fitness while enhancing their own, because cheating generally affects things like access to

resources. The ability to detect cheaters restores the balance by avoiding the cost of being cheated upon, and so a cognitive mechanism for rapid and reliable detection of cheaters should be selected for. Cosmides argues that this explains why people reason well and reliably on logical tasks whose content involves social exchange but reason poorly when the task has the same logical structure but is devoid of such content. Human reason, on this view, is not a single process, but a multitude of distinct processes specialized for solving the kinds of problems that affected reproductive success in the EEA.

Similarly, Philip Atran (1998) has argued that humans possess an evolved, special purpose module for the classification and conceptualization of living things. Because of the special role of other living things for human survival -- as sources of food and other resources, as predators, as the loci for various toxins or healing substances, and so forth -- it would be advantageous to any individual to have a dedicated module primed to discover the complex, hierarchical pattern of relationships among different kinds of organisms and the special place of interbreeding populations in the resulting taxonomy. By extension, one might imagine other conceptual systems, specialized for other kinds of content, like patterns of membership in social groups or rankings in social hierarchies.

In this way, evolutionary psychologists have tried to build the case that the mind is massively modular, with each module dedicated to solving a very specific computational problem. Hence the earlier reference to the, "confederation of hundreds or thousands of functionally dedicated computers," that make up the human mind/brain, each of them prepared by natural selection to handle some very specific problem type. No evolutionary psychologist claims to have a parts list that includes all of these modules, never mind an assembly guide for the brain that shows how they fit together. But they do point to specific examples of the kinds of specialized processes they are seeking, and argue that with guidance from evolutionary theory, and only within that framework, the full picture will eventually emerge.

## **How modular is "massively modular?"**

In one respect at least it is clear that the mind/brain does indeed have a modular structure, and that Karl Lashley's (1933) doctrine of equipotentiality, in which the cortex of the brain in particular was thought to be an undifferentiated mass, is clearly incorrect. The brain is organized from birth into distinct areas specialized for handling different kinds of perceptual inputs and for organizing actions. For example, those parts of the brain and nervous system that transduce variability in environmental energies into patterns of neural firing are specialized by energy domain (vision, hearing, olfaction, etc.) and even sometimes by energy range within a domain (two different transducer types detect high and low temperatures, for example). Other cortical regions manage planning for and coordination of movement, still others regulate mood and emotion, yet others regulate a variety of autonomic functions, from heart rate to sweating palms. This pattern is found throughout the animal kingdom, and reflects certain causal properties of the physical world of which we are a part. This much is uncontroversial, and entirely consistent with evolutionary theory. The question is, does this rather gross modularity really imply the existence of thousands of sub-modules for computing things like attraction based on hair quality or appropriate mode of reasoning and classification based on content of the domain?

Logically, the answer certainly seems to be that it does not, and the flaw in the argument involves two related ideas. Recall the observation that there are many different solutions to be found in the animal kingdom for the same kind of problem. This observation leads evolutionary psychologists to conclude that, "There is no single algorithm or computational procedure that can solve every adaptive problem." (Tooby and Cosmides, 2000, p. 1168). But this simply does not follow. The fact that a given problem can be solved in many different ways, or that there seem to be discrete processes in animals for solving different classes of problems does not at all imply that there is no single procedure

that might solve all, or at least a large subset, of those problems. The class of universal Turing machines, for example, seems to constitute an existence proof for such a computational device on at least one definition of computation.

Is the claim, then, that the process of natural selection could not have produced such a general purpose device? That still does not follow from the data showing a variety of computational devices in the animal kingdom. The argument, if P, then not Q, only follows if P and Q have a relationship of incommensurability, and there is nothing in the evidence thus far presented to support that conclusion. So long as there is no evidence ruling out the possibility of implementing a general purpose, domain independent device for classifying, or recognizing objects, or remembering facts about the world in networks of neurons, then it is entirely consistent with evolutionary theory that eventually this device might be found in a search of the space of possibilities. Human beings, and the nature of the human mind, could well be the successful result of just such a search.

Indeed, on the face of it, a small number of domain-general procedures for things like object and event recognition or classification of those objects could well give the creature that possesses them a powerful advantage in the competition for resources precisely *because* they are general purpose. The ability to learn to recognize and respond appropriately to objects never before encountered even by one's ancestors would give an organism remarkable freedom of movement across ecological niches. General purpose procedures for thinking about causal or implicative relationships are not defeated by changes in the workings of the local environment, or by movement to a new niche. The idea that there might be general purpose, domain and content independent mental procedures is in no way inconsistent with evolutionary theory. On the contrary, it is just as easy to construct an account of the pressures favoring emergence of general purpose mechanisms as it is to construct an account favoring specialization of function.

As thoughtful evolutionary psychologists themselves would be the first to admit, we are left with a fundamentally empirical question. Just how specialized are the modules of

the human mind/brain? On this point, the data remain equivocal, in my view. For example, many different explanations are readily found for the content-sensitive nature of reasoning tasks, none of which requires postulating an innate, special-purpose module (e.g., Cheng and Holyoak, 1989; Girotto and Gonzalez, 2001; Livingston, 1998; Sperber, Cara, and Girotto, 1995). Recent studies by Fiddick, et al. (2000), on the other hand, call into question at least some of the conclusions of the critics of domain specificity. Similarly, claims for a specialized module to classify living things are beset by a number of logical problems and the data can be explained in ways entirely consistent with a domain-general classification procedure (e.g., see Keil, 1995, and Livingston, 1998; Maffie, 1998; and Solomon, 1998). And as I have argued above, there is nothing incompatible about domain generality and evolutionary processes. One can see the value in evolutionary theory without committing to wholesale, massive modularity.

So we come to a theoretical impasse, with no obvious resolution in sight. As is often the case in such situations, progress seems unlikely without a fresh theoretical perspective on the problem. In the remainder of this paper I offer a preliminary sketch of such a new perspective, in the hope of suggesting new lines of empirical inquiry and the collection of new data that might break the impasse. The approach taken is consistent with a view of evolutionary theory as a valuable heuristic for guiding hypothesis making in the cognitive sciences, rather than as the ultimate explanation for all cognitive phenomena.

### **Evolution, specialization, and domain generality**

How could it be that the human mind is both a general purpose thinking machine and the source of so much apparent specialization of function? One plausible answer runs like this.

1. *The human brain is an evolved organ.* As noted earlier, this is an uncontroversial claim. It is worth noting, however, that the pressures on its evolution operate via the phenotype of the behaviors it organizes. Furthermore, the relevant pressures are those operating in the EEA, not necessarily those that characterize modern human environments.

2. *Evolution never does a clean-sheet design; new adaptations are added to and integrated with existing systems.* Another way to think of this principle is to imagine a multidimensional space containing all possible designs for an organic creature that can be coded in DNA. Many, probably most, of these designs will be non-viable in any of the known niches near the Earth's surface. Any given actual species occupies a bounded region of the space of viability. Note that a species occupies a region, not a point, because individual members of the species tend to vary on some of the dimensions that define the space of possibilities. This variation is crucial to the operation of natural selection. Now imagine a mutation outside the range of normal variation for the species. Whether this new gene sequence results in an organism that can survive and reproduce depends not only on whether the new structure or process for which it codes lies within the range of viability, but also on whether it can be integrated with the remainder of the genetic code for the individual without disrupting some other necessary structure or process. Thus, not all regions of the space of possible organisms can be reached with equal ease from a given starting point, and for some, it may literally be true that, to coin a phrase, you can't get there from here. Adding new functionality, even when it is superior to pre-existing functions, does not mean that the older design will be abandoned.

3. *The human brain contains a number of phylogenetically ancient structures with highly modular properties.* To further extend the argument from point 2, the design of the human brain contains a number of structures and processes that are phylogenetically quite old, some having originated many millions of years before even the most primitive mammals appeared on the scene. Among these are discrete modules for handling information about

sexual partners, possible threats from the environment, food, offspring and other kin, and other events of direct relevance to survival or reproduction. These modules persist, even as new structures and procedures are added to the system via a process of mutation and selection, and in fact there are good reasons that they should be conserved.

4. *Given a context of successful special purpose information processing modules, and only given that context, selection will favor the emergence of increasingly domain general information processing systems.* The laws of chemistry and biochemistry virtually guarantee that life will begin in small, relatively simple systems. Once life goes multi-cellular, the same principle applies to the emergence of new subsystems, including subsystems for handling information (nervous systems). Small neural networks simply lack the computational power to implement general-purpose algorithms. As a result, the earliest information processing modules to emerge will necessarily be dedicated, special-purpose devices. As noted above, the process of evolution will tend to preserve these special purpose subsystems. This occurs not only because evolution is not like clean-sheet engineering, but also because general-purpose mechanisms, *by their nature*, require tuning to the world they encounter. That is, in fact, the whole point of moving to domain general modules: They allow adaptation during the lifetime of the organism to highly variable events in the environment, thereby improving the ability to survive and reproduce relative to similar organisms that depend entirely on the slower process of phylogenetic adaptation.

But what guarantees the survival of the organism long enough to bring those general purpose devices on line? The answer is the phylogenetically older, special-purpose modules already in place. Truly domain general processes and structures will therefore not be found in simpler organisms. Furthermore, their appearance requires a period of developmental change not seen in simpler animals. During the early period of development of such organisms, there will be abundant evidence of the operation of specialized mental modules, but this fact does not count against the existence of domain-general processes.

5. *Domain generality vs. specialization is a graded dimension; there may be different levels of generality in the same brain.* Generality versus specialization is defined by the range or scope of the phenomena over which a system operates. There is, therefore, no reason why there might not be different levels of generality in modules that exist side-by-side within the same brain, given the previously described conservative nature of the evolutionary process. It could be the case, for example, that there is a classification module biased for the classification of living things, and also a general purpose module that operates across any domain. The former might be engaged early in development as part of one's normal encounters with animals and plants, and so characterizes the child's early concepts of living things (e.g., see Keil, 1995). The latter emerges later, perhaps with more directed training, and eventuates in the more sophisticated system of classification found in the biological sciences.

5. *Newer, domain general mechanisms and older, more specialized systems are part of an integrated brain.* Newly added, more domain general mechanisms are not isolated from older systems, but are integrated, more or less directly, into a common system. In part this is because they must share the same input and output systems. The senses provide information to both older, specialized and newer general systems, and both must activate the same common pathways to the muscles that generate action in the world. The rich set of anatomical interconnections between the newer cortical areas likely to be responsible for general purpose thinking and the older, more specialized parts of the brain certainly imply information exchange between them. These modules, in other words, may not be so encapsulated as modularity theory predicts.

This interconnection is especially important in the context of understanding the developmental history of a general purpose mechanism. Cummins and Cummins (1999) have recently suggested that what may be innate in the structuring of cognition is no more than a set of biases that canalize or channel learning in particular directions. But suppose these canalizing influences do not reside in cortical structures themselves. Cortical systems

may indeed be truly domain general. What produces seemingly specialized processing of faces, or living things, or certain kinds of social events like cheating is the disproportionate amount of attentional focus brought to bear on these events by the operation of specialized subcortical modules. These subcortical modules, for reasons already examined, do tend to operate on information much more directly relevant to issues of survival and reproduction, so, *ceteris paribus*, they tend to produce the kinds of results that lead evolutionary psychologists to propose that the mind is massively modular. For that same reason, however, development in an environment that tends not to engage those modules to the same degree leaves the domain general cortical modules free to canalize in other directions. For example, Wolff, Medin, and Pankratz (1999) present evidence for a dramatic decline in what people seem to know about living things during the 20<sup>th</sup> century as compared with the 16<sup>th</sup> through 19<sup>th</sup> centuries, at the same time that their knowledge of other, non-biological, categories (e.g., books, boats, furniture) has increased. Are we evolving new specialized modules for artifacts, or could it be that cultural changes have altered the relative salience and importance of these domains? On the argument offered here, this conceptual shift reflects a change in which object and event classes get tagged as significant by older parts of the brain, which canalizes the development of a domain-general conceptual system. Such a system is ideally suited to creatures like *homo sapiens sapiens*, who have the ability to so rapidly and dramatically alter by their own actions the very environments in which they grow and learn.

The bi-directional connections between older and newer brain systems are active in both directions, and this has important implications as well. If there are domain general systems, and if they exist precisely because of the advantages they confer in understanding and responding to the world, then those advantages will be realized only to the extent that these newer systems are capable of superceding the outputs of older ones. To do so requires being able to suppress or otherwise inhibit the outputs of those older systems. It may even be possible to reconfigure the procedures performed by those older systems by a

kind of top-down reprogramming, which may be exactly what happens in the course of certain kinds of cognitive therapy. The ability to understand these kinds of top-down effects is one reason for not giving up prematurely on the idea of domain general cognitive processes.

### **On not giving up on domain generality**

The proposal outlined above reconciles domain generalists with domain specialists in a way that respects evolutionary theory. It makes use of evolutionary theory as an organizing heuristic, without suggesting that evolutionary theory actually explains what a concept is, or how a face is recognized, or what processes count as valid reasoning. This is the true value of evolutionary theory: it helps to organize and constrain hypothesis generation by pruning the set of possibilities to those that are consistent with the theory, so saving valuable time and intellectual energy. In the end, though, whether the account given above stands or falls depends on the collection of the right kinds of empirical evidence.

What kind of evidence would count in favor of or against this proposal? There are many possibilities, but in the interest of space, let me suggest just one. One of the characteristics of a module, as typically defined, and one of the reasons for thinking that a module may exist, is that information in the domain served by the module is processed much more rapidly, and often even automatically, than it is when the processes are non-modular. If one can produce such fast-processing effects in arbitrarily chosen domains by contriving to load those domains affectively for some people but not for others, one would have *prima facie* evidence for the kind of canalization by older brain structures described above.

Another option is to examine different cultures and subcultures for evidence of apparent specialization outside the domains where it is predicted by evolutionary theory. The work claiming to find evidence for human universals in specialized processing has thus

far focused primarily on looking for that evidence where the theory predicts, but not looking for evidence of similar levels of specialization where it does not (e.g., in various artifact domains, or in more abstract conceptual domains characteristic of complex social systems).

Whatever the data eventually show, it is clear that these debates are of more than passing academic interest. Whether we decide that we are domain general thinkers or massively modular specialists will have a great deal to do with how we understand ourselves, and will certainly contribute to our sense of the possible in human affairs. . What really matters in the end, of course, is coming to a correct understanding of human cognition, and thus of what is at the heart of the matter when we discuss human nature, but it would be a mistake to rush too quickly to judgment on this matter, as I think many evolutionary psychologists have done.

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## Appendix

The following proposal is as yet too ill-formed to fit neatly into the body of this essay, but because I believe that it is a possible corollary of the views expressed here, I want to offer it for discussion and criticism.

*The question:* How does an organism track the various computational procedures it is performing at a given time for purposes of organizing action?

*A proposed answer:* When the nervous system is organized as a set of narrowly focused, specialized computational devices, each associated with a specific and well delineated neural substructure, the physical location of that substructure serves to mark or identify the computation being performed. One can therefore regulate which module gains control of the output or action system by a simple, winner-take-all arrangement in which the module that is most energetic gains control.

The emergence of general-purpose computational procedures makes this plan unworkable, however. The neural architecture of a domain-general piece of cortex is not specific to the content of its procedures, and it is therefore not possible to track relevant content in by place of activity. I propose that this produces the selection pressures in favor of the emergence of consciousness, where the primary function of consciousness is simply to track the content of general-purpose computational devices. Consciousness is a means of registering *to the organism* the contents of its general purpose machinery. I believe that this proposal is consistent with at least two observations from the cognitive science literature.

(a) A major current hypothesis about the physiological foundations of consciousness holds that consciousness emerges as the result of synchronized activity in a complex thalamocortical circuit that is found only in mammals and birds. These orders contain the only organisms for which general purpose cognitive systems are claimed, and

the behavior of many of these organisms, especially the larger, more complex mammals, is consistent with the view that they possess at least some first-order awareness of the world.

(b) The major problem that continues to bedevil attempts to build an artificial intelligence to rival the human mind (even the lowliest mammal remains out of reach at the moment) is the problem of content. Computers are general purpose processing systems *par excellence*, but computer scientists have not been able to solve the problem of how to register *to the computer* the contents of its computations. It may be that there are ways to do this other than via consciousness, but this further example of a correlation between the presence/absence of consciousness and the ability or lack thereof to track computations by their content is at least intriguing.