THE TROUBLE WITH MEMES
Inference versus Imitation in Cultural Creation

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Memes are hypothetical cultural units passed on by imitation; although nonbiological, they undergo Darwinian selection like genes. Cognitive study of multimodular human minds undermines memetics: unlike in genetic replication, high-fidelity transmission of cultural information is the exception, not the rule. Constant, rapid "mutation" of information during communication generates endlessly varied creations that nevertheless adhere to modular input conditions. The sort of cultural information most susceptible to modular processing is that most readily acquired by children, most easily transmitted across individuals, most apt to survive within a culture, most likely to recur in different cultures, and most disposed to cultural variation and elaboration.

KEY WORDS: **Cognition; Culture; Imitation; Inference; Meme; Modularity**

INTRODUCTION: MEMES ARE NONBIOLOGICAL BUT STRICTLY DARWINIAN

The concept of *meme*, introduced by Richard Dawkins in 1976 in *The Selfish Gene*, is now defined in the Oxford English Dictionary as "an element of culture that may be considered to be passed on by non-genetic means, esp. imitation." Candidate memes include a word, a sentence, a thought, a

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belief, a melody, a scientific theory, an equation, a philosophical puzzle, a religious ritual, a political ideology, an agricultural practice, a fashion, a dance, a poem, a recipe for a meal, table manners, court etiquette, or plans for cars, computers, and cellphones. Derived from the Greek root *mimeme,* with allusions to memory and mime (and the French word *même,* or "same"), a meme is supposed to replicate from mind to mind in ways analogous to the ways a gene replicates from body to body.

Memes undergo natural selection in a Darwinian sense. The process of natural selection requires only that elements of selection be units of hereditary information that control the matter that encodes the information, and for which there is a bias to selection over time that greatly exceeds the rate of endogenous change: "Information can proliferate and be edited by natural selection only if the selection affects the information at a greater rate than competing processes such as mutation and drift" (Williams 1992:12). The matter that encodes the information selected can be DNA or RNA, as with genes and proteins, electro-chemical neural networks or written languages, as with memes, or nonbiological electric circuits, as with computer viruses.

The units of selection must have fecundity. They or their carriers must "be fruitful and multiply"; otherwise, there is little morphological or behavioral variation among units from which to select because of lack of abundance of different elements. The heritable variants must be copied with high fidelity so that they resemble one another more than they do unrelated forms. Only then can they be repeatedly chosen as favorable or eliminated as unfavorable by selection. The replicating variants must be relatively long-lived. They must survive at least long enough to produce more copies than do other forms in order to contribute to differential fitness or reproductive success. Finally, the elements of selection must be in competition for survival over scarce resources that sustain them in a given environment (e.g., cell, body soma, ecological niche, mind, computer memory), or else there would be no pressure for selection.

A general theory of the evolution of replicators under natural selection requires *fecundity* and *variation, heredity* and *high-fidelity, longevity* and *fitness,* and *competition for survival-enhancing resources.* Whenever all such interrelated factors are present, in whatever possible nomological world where laws of cause-and-effect and thermodynamics hold, different lineages of self-replicating forms should evolve from one or a few original forms. As new forms evolve, so must the environments to which the forms are constantly added and adapted. The cultural evolution of ideas (memes), including changes wrought by ideas on the cognitive and social environments that ideas adapt to, seems to fit the bill.

Although the relation of memes to genes is one of analogy, the relation is no more intended as a metaphor than was the Rutherford-Bohr analogy of the atom to the solar system at the beginning of the past century. The meme-gene analogy itself is meant to function as a research program that will hopefully lead to a science of "memetics," much as the atom–solar system analogy was briefly viewed by some scientists as a research program to help unify physical processes at the microscopic (e.g., electromagnetism) and macroscopic (e.g., gravity) levels. The initial stage of memetics, then, is to specify whether and how the analogy between meme and gene holds up under testable scrutiny. If the analogy can be informatively sustained, then it must be able to reliably predict significant and surprising scientific discoveries about specific causal structures. If the analogy cannot be informatively sustained, as with the atom–solar system analogy, then it must be eventually discarded as a scientific endeavor. In this latter eventuality, the analogy might still be maintained as a pedagogic device, which could introduce novices into a field that has developed, in part, by failed efforts to make the analogy informative.

I lean to the latter eventuality. Nevertheless, I recognize the likelihood that such an original and enticing idea as the "meme" will endure with significantly altered content, or as an expedient trope that orients attention, like the etiological notion of "germ." In any event, if the meme-concept were eventually to work for science, I think that it could not be as a replicator that copies information to the mind. It might work as an elicitor that draws out inferences and information from the mind.

WHAT IS UNIQUE ABOUT MEMES?

Other Darwinian approaches, such as coevolution models of genes and cultural traits or social norms, offer similar perspectives on cultural life (Boyd and Richerson 1985; Cavalli-Sforza and Feldman 1981; Durham 1991; Sober and Wilson 1998). But Dawkins's proposal has an original response to the key evolutionary question: *Cui bono,* "Who benefits?" (Dennett 1995). The answer: not brains, individuals, or societies but memes themselves. Just as genes or viruses seek serial immortality by successively using, then discarding the individual organisms that host them, so memes seek to perpetuate themselves by nesting and nurturing in mind after mind. In the mind, a meme associates itself with other memes in a package, or "memeplex" (Blackmore 1999). Together, memes in a memeplex act to restructure the mind's computational architecture.

Restructuring includes instructions that cause the mind to transmit the memeplex to other minds. Take the evangelist's dictum: "Spread, but dare not alter, The Word of God." The underlying message, but not its surface form, appears replicated in a review of The Bible that was originally posted at Amazon.com and then reprinted in newspapers: "Nonbelievers need to read this in any form. I don't want to spoil the end, but let's just say YOU NEED TO READ THIS BOOK AS SOON AS POSSIBLE" (*International Herald Tribune*, July 18, 2000, p. 22). Colonization by a memeplex also further renders the mind susceptible to invasion and transformation by a memeplex, like increasing devotion to dependence upon religion or science, or addiction to dialogue on the Internet.

Like genes, memes can pass supposedly "vertically" from parent to child: for example, in the religious practice of circumcision. Memes can also copy themselves "horizontally" from person to person—between peers or from leaders to followers—as with the concept of meme itself. In our hominid past, when sustainable transmission was largely vertical, and horizontal transmission was restricted to a few cultural artifacts, the fitness of memes depended almost exclusively on the fitness of the population that hosted them. With language, the computational possibilities of horizontal transmission exploded.

Once the newer, faster-paced memetic evolution took off, it was no longer subservient to the older, slow-moving pace of genetic evolution, or necessarily bound to it at all. Memes could even afford to kill off their hosts if given the time and the medium to broadcast themselves to new victims before the hosts' demise, as with well-publicized cases of religious or political martyrdom. With Internet and globalization of information transmission, the evolutionary rate of memetic change appears to be once again on the verge of exponential takeoff, with unforeseeable evolutionary consequences. Now there is even less pressure on memes to guarantee the physical survival of brains, as more and more memetic activity shifts from biospace to cyberspace.

In fact, as David Hull points out (personal communication, 2000), the memetic distinction between vertical and horizontal transmission makes little sense in the case of ideas. In gene-based biological evolution, "vertical" is defined as the way genes go. Genes usually go the way organisms go. A mother passes on half her genes to her children. In "horizontal" transmission, a virus might pick up a gene and transfer it to a non-family member. From a genetic perspective, the difference between parents teaching something to their children and anyone else teaching them is irrelevant. The process by which memes move is the same in both cases. Moreover, information "explosions" are not restricted to ideas. For example, millions of T cells are manufactured every day in the thymus gland, 97% of which are reabsorbed before they ever leave the thymus gland. Of those that do, 99.99% never meet an antigen they recognize. Biological selective processes often require massive waste (e.g., sperm) for remarkably little creation and innovation. Finally, at least some processes of genetic evolution are as fast, or faster, than any memetic change. The immune system was designed to cope with rapid change of viruses and bacteria. No conceptual change in a population has ever surpassed the speed of some viral infections, not even cell phones. Rapid, horizontal spread is thus not unique to memes.

BRAIN- AND MIND-BUILDING

For psychologist Susan Blackmore (1999), the human brain, language, and the self evolved because they primarily gave advantage to memes, not genes. The brain grew large in order to function as a better and better copying machine for memes. The brain evolved as a genetic fax built for and run by memes. Similarly, language was selected for meme transmission. Language evolved as a genetic telephone line built for memes to call upon one another. The self, too, was created by and for the replication of memes. The "I," with its illusion of free will, is in reality a meme-stronghold for defense against displacement by masses of fearless competitors invading from the surrounding social environment.

There is also a novel account of altruism and friendliness. Nice guys who are available and helpful to others have more chances to influence others. They are "meme-fountains." People who keep to themselves are "meme-sinks" that other memes and their supporting folk would do better to avoid. Meme-fountains spread "altruism memes" and other good memes (e.g., tolerance) and bad memes (e.g., faith) that ride piggyback on the altruism meme. Bad memes that hitch onto the altruism meme are said to use "the altruism trick" to insinuate their way into unsuspecting minds. Bad religion memes co-opt the altruism meme and insinuate themselves into minds to form an infectious memeplex of co-memes (Dawkins 1993; Dennett 1997; Lynch 1996).[1]

Blackmore's account, like nearly all other stories of the evolution of the big brain and language, provides neither empirical evidence nor substantive proposals for how one might go about gathering and testing evidence. No insight is provided into any specific brain structure or neural organization: for example, concerning the structure of the late-evolving prefrontal cortices and their relationship to language comprehension and production centers in the temporal and parietal lobes of the dominant hemisphere. Neither is there a hint about specific semantic or syntactic structures, such as *wh-* movement, case assignment, anaphora, and so on. The operative analogy, of course, is that minds are built for memes as bodies are built for genes. As masterly work by Hamilton (1964), Williams (1966), and Dawkins (1976) demonstrates, grudging acceptance of the gene's-eye view of body-building in biology, which is still hotly debated, required considerable detailed biological groundwork. The meme's-eye view of mind-building requires no detailed knowledge or evidence concerning the computational architecture of the human brain/mind, and provides no specifiable structural constraints on allowable cultural forms.

MINDBLIND MEMETICS

In *The Extended Phenotype*, Dawkins appeared to backtrack from forceful advocacy of a memetic science of mind and culture: "its main value lies not so much in helping us understand human culture as in sharpening our perception of genetic natural selection. . . . I do not know enough about the existing literature on human culture to make an authoritative contribution to it" (1982:112). By then, two major objections had arisen. First, there was no ready way of deciding what counts as a meme. There was no set of criteria for determining whether or not the chosen units or "chunks" of information actually cut up culture at its natural joints. No compelling psychological evidence emerged for memes as bundles of learned information, stored as discrete units in memory, aggregated into higher-order knowledge structures, and expressed in identifiable bits of behavior. Even if memes could be operationally isolated, they still might not constitute a theoretical expedient. Without definable or at least agreed upon operational units, little by way of cumulative scientific argument could advance.

For genes, there is a rather straightforward operational definition: those DNA-encoded units of information that dependably survive reproductive division, that is, meiosis (although crossover can occur anywhere along a strand of DNA, whether at the divisions of functionally defined genes or within them). "Definable units" may be fairly discrete traits, such as sex, or fairly continuous traits, such as height. Continuous traits, in turn, may be "blended" (e.g., height and skin color) and evolve if there are high enough rates of mutation to maintain sufficient variation for selection to produce reliable differences in survival and production of organisms. Nevertheless, even continuous and blended traits must survive transmission with reliably measurable frequency and fidelity to produce "selectable" differences in survival and productions of organisms (or ideas and behaviors). Whether discontinuous and digital or continuous and analog, selectable traits must in themselves be cohesive in definite and coherent proportions, and not because someone wishes or decides to attach numbers to "operational units" that have no fixed contents or boundaries.[2]

The second objection poses a more serious challenge to the possibility of memetics. Unlike genes, ideas rarely copy with anything close to absolute fidelity. In the overwhelming majority of cases, an idea undergoes some sort of modification during communication (Atran 1996; Sperber 1996). For example, arbitrarily select any news item and see how the different news media present it. The real mystery is how any group of people manages an effective degree of common understanding given that transformation of ideas during transmission is the rule rather than the exception. If transformation (mutation or drift) affects the information at a greater rate than high-fidelity replication, then a favorable or unfavorable selection bias cannot develop for the replicated (hereditary) information. In such cases, Darwinian selection becomes impossible. Moreover, unlike genetic lines, descendent ideas cross and merge so quickly and thoroughly that there can be no identification of "species" or "lineages" of memes, only variably defined "influences": for example, the influence of black African and classical European rhythms on American blues, and the further looping of these three strains of music on rock and roll. Although eminent biologists and philosophers of biology have continued to view culturally persistent or widespread ideas as true replicators (Hull 1988; Williams 1992), these objections greatly threaten to undermine the nascent memetics movement.

In a recent essay, Dawkins (1999:xvi) gives Dennett (1995) and Blackmore (1999) much of the credit for his renewed faith in "the possibility that the meme might one day be developed into a proper hypothesis of the human mind"—a possibility that now appears at hand. According to Dennett (1995:356), what *Romeo and Juliet* and *West Side Story* memetically share is not text and "syntactic structure" (phenotype), but the underlying story and "semantic structure" (genotype). In this case, there are historical records indicating that the authors of *West Side Story* got the thematic idea from *Romeo and Juliet*, and so one can claim them to be instances of the same underlying meme or descendent memes in the same memetic lineage. Of course, in the absence of historical records it may be impossible to distinguish independently evolved analogies from genealogically related homologies: "consider the fact that two widely separated cultures both used boats; this is no evidence at all of a shared cultural heritage" (Dennett 1995:357), unless the boats of both cultures shared some arbitrary design, such as blue hexagons on their bows.

One potentially serious obstacle to this account is anthropologist Dan Sperber's (1985) insight that the key to understanding how ideas become cultural representations lies not with their formal (semantic) structure, but with their *causal* relationship to multimodular minds. Dennett (1995:379) is well aware of recent advances in cognitive and developmental psychology with respect to domain-specific, modular structures. He allows that prior mental structures facilitate the nesting of memes in the brain (much as certain trees or building structures may facilitate specific kinds of bird nesting), and that memes sometimes "enhance and shape preexisting structures, rather than generating entirely new structures." Nevertheless, Dennett (1995:358–359) dismisses the role of the biologically evolved mind with a hand wave: "The peculiarities of human psychology (and human digestion, for that matter. . .) are important *eventually*, but they don't stand in the way of a scientific analysis of the phenomena. . . . You can finesse your ignorance of the gory mechanical details of how the information got from A to B, at least temporarily, and just concentrate on the fact that it *did* get there."

This seems a reasonable strategy only if the mind—or at least higher-order cognition—is in effect a huge parallel machine, or "central processor," which gets reprogrammed by memes via language and culture. In such a mind, whatever cognitive modules there may be function primarily at lower levels of perceptual processing (cf. Fodor 1983). At higher levels modular processes have little presence, except perhaps as anchors for memes to harbor in and work over the mind. Dawkins (1976) also acknowledges that the mind has prior cognitive structure, but he considers those who concentrate on the role of evolved cognitive faculties in generating and selecting cultural ideas as "begging just as many questions as I am." Coming from an evolutionary biologist, this is a curious position. To explain how genes function and adapt, Dawkins describes rich adaptive landscapes—conglomerations of fitness-relevant environmental factors from conspecifics to predators to sunlight. For memes, he merely alludes to the cognitive architecture of the mind as part of the adaptive landscape under which memes evolve, and then dismisses concern with the adaptive landscape as "question begging."

I suspect that Dawkins and colleagues tend to disregard or underplay the role of evolved cognitive architecture in constituting culture for many of the same reasons that motivate Stephen Gould (1980) and colleagues to take a similar stance: as an answer to vulgar sociobiology (i.e., identifiable classes of genes directly cause identifiable classes of cultural behavior). The central message of memetics is that human beings can still be purely Darwinian creatures and yet possess a significant measure of independence from their selfish genes and from the blind processes of natural selection that ruthlessly govern biological evolution. But sociobiology is not the only Darwinian alternative to memetics.

The multimodular mind, too, allows for obvious human creativity and much free play in thought. Unlike memetic hand waving, it does so by attempting to actually specify the cognitive tools available and the recurrent rules of their use in building cultures. Imagine if you were to build a city. Would you have more creative possibilities with some simple or general-purpose tools, or with a richly endowed tool kit that could be used to build further complex building tools (e.g., cranes) (Pinker 1997; Tooby and Cosmides 1992)? Imagine also a game plan with few or no rules, and instructions to keep it that way. How could increased skills and ever more refined strategies take hold and evolve? They might, if time was unlimited and randomly produced patterns could stabilize and surreptitiously pass for new rules. In general, though, the more specific and multiple the rules, as with chess versus checkers, the greater the possibilities for increased skill, choice, and complexity in play.

NATURAL DOMAINS OF THE MULTIMODULAR MIND

The recent evolutionary approach to cognitive and cultural phenomena focuses on what functional arguments from sociobiology and so-called materialist anthropology generally ignore, namely, the mental mechanisms that cause behavior. Research into these mental mechanisms stems from a convergence of several late-twentieth-century theoretical developments in cognitive and developmental psychology, psycholinguistics, evolutionary biology, and cognitive and cultural anthropology: (1) computational thinking (the mind is a computer; Marr 1982), (2) domain specificity (the mind is a multimodular computer; Hirschfeld and Gelman 1994), (3) nativism (different mental modules are innate; Fodor 1983), (4) adaptationism (modules were functionally designed under natural selection to solve vital problems in ancestral environments; Barkow et al. 1992), and (5) cultural epidemiology (beliefs and practices spread, develop, and survive under cultural selection to the extent they are susceptible to modular processing; Sperber 1996). Each modular faculty, or "mental organ," is presumably governed by a specific set of (genetically prescribed) core principles that interpret and generalize the behavior and properties of entities in the world belonging to (falling under) the faculty's domain (Chomsky 2000).

A naturally selected, modular structure is functionally specialized to process, as input, a specific domain of recurrent stimuli in the world that was particularly relevant to hominid survival. The module spontaneously produces, as output, groupings of stimuli into categories as well as inferences about the conceptual relationships between these categories. The innately constrained cognitive structure of this output was presumably designed under natural selection. It allowed humans to adaptively navigate ancestral environments by responding rapidly and economically to important, statistically repetitive task demands, such as distinguishing predator from prey or friend from foe.

Within the current approach of domain specificity, there are roughly two classes of evolved cognitive modules: first-order perceptual modules and second-order conceptual modules. A first-order *perceptual module* has automatic and exclusive access to a specific range of sensory inputs. It has its own proprietary database and does not draw on information produced by other conceptual modules or processes. A perceptual module is usually associated with fairly fixed neural architecture, and fast processing that is not accessible to conscious awareness. Examples are modules for facial recognition, color perception, identification of object boundaries, and morphosyntax (Fodor 1983). A second-order *conceptual module* works on a privileged, rather than strictly proprietary, database that is provided by other parts of the nervous system (e.g., sensory receptors or other modules), and which pertains to some specific cognitive domain (Atran 1990:285). Examples include folkmechanics, folkbiology, and folkpsychology.

Folkmechanics: Human neonates detect a solid object as a solid object when they infer that the bounded surface they see is a three-dimensional body that maintains its connectedness and boundaries when in motion (unlike water or shifting sand), that cannot simultaneously occupy the same space as another such object (unlike shadows) or occupy two different places at once (unlike a fire), and so forth (Baillargeon 1987; Spelke 1990).

Folkbiology: Humans in all cultures appear to have a concept of (folk) species, as well as taxonomic rankings of relations between species (Atran 1990; Berlin et al. 1973). This implies conceptual realization that, say, apple trees and turkeys belong to the same fundamental level of (folk)biological reality, and that this level of reality differs from the subordinate level that includes winesap apple trees and wild turkeys as well as from the superordinate level that includes trees and birds. This taxonomic framework also supports indefinitely many systematic and graded inferences with respect to the distribution of known or unknown properties among species (Atran 1998; Coley et al. 1997). Folkbiology harbors non-obvious and unobservable constructs, such as attributions of underlying causal essences to animal and plant species (e.g., a cat that never meows in fact is still expected to produce meowing kittens by nature). Essentialism is manifest in children across cultures by four years of age (Atran et al. 2001).

Much as mountain rain will converge to the same mountain-valley river basin no matter where the rain falls, so each person's knowledge will converge on the same cognitive "drainage basin" (Kauffman 1993; Sperber 1996; Waddington 1959). This is because (1) inputs naturally cluster in causally redundant ways inasmuch as that's the way the world is (e.g., where there are wings there are beaks or bills, where there are predators there are prey, where there are fruit-eating birds there are fruit-bearing trees, etc.) and (2) dedicated mental modules selectively target these inputs for processing by domain-specific inferential structures (e.g., to produce natural taxonomies). In this way, the mind is able to take fragmentary instances of a person's experience (relative to the richness and complexity of the whole data set) and spontaneously predict (project, generalize) the extension of those scattered cases to an indefinitely large class of intricately related cases (of larger relevance to our species and cultures). Thus, many different people, observing many different exemplars of dog under varying conditions of exposure to those exemplars, all still generate more or less the same general concept of *dog*.

Folkpsychology: People, and perhaps other animated objects, are *intentional agents* who act, and cause others to act, because of *internal motivations*. This allows people to understand how they and others can react to and act upon objects and events at a distance, that is, without immediate physical contact. Intentional causal mental states, such as beliefs and desires, cannot be directly perceived. Mental states are inferred from poor and fragmentary triggering experiences that indicate only physical movement or expression, such as interruptible movement towards a goal (Csibra et al. 1999), self-propulsion and coordinated movements between subjects (Premack and Premack 1995), pointing (Leslie 1991), eye gaze and facial expression (Baron-Cohen 1995), or interactive gesture or signaling (Johnson et al. 1998). By age four, children across cultures attribute to others internal motivations that include false beliefs and deception (Avis and Harris 1991; Wimmer and Perner 1983).

Each module has a *natural domain*, which includes a proper domain and a (possibly empty) actual domain (Sperber 1996). A *proper domain* is information that it is the module's naturally selected function to process. The module's naturally selected function is a set of outcomes that causally contribute to making it a stable species trait. Thus, stimuli that track behaviors of animals, including people, fall under the proper domain of a folkpsychology module. Identifying animals as agents, with goals and internal motivations, would allow our ancestors to anticipate goal-directed actions of predator, prey, friend, and foe, and to profit in survival-enhancing ways.

The *actual domain* of a module is any information in the organism's environment that satisfies the module's input conditions, whether or not the information is functionally relevant to ancestral task demands (whether or not it also belongs to its proper domain). For example, cloud formations and unexpected noises from inanimate sources (e.g., a sudden, howling gush of wind) readily trigger inferences to agency among people everywhere (Guthrie 1993; Hume 1957). Although clouds and wind were present in ancestral environments, they occupied no task-specific role. Experiments show that adults and children spontaneously interpret contingent movements of geometrical forms and dots on a screen as interacting agents that have distinct goals and internal motivations for reaching goals (Bloom and Veres 1999; Heider and Simmel 1944; Premack and Premack 1995). Moving dots on a screen do not belong to folkpsychology's proper domain because they could not have been involved with ancestral task demands. Like clouds and wind, moving dots on computer screens can belong to folkpsychology's actual domain.

Food-catching behavior in frogs provides an analogy. When a flying insect moves across the frog's field of vision, bug-detector cells are activated in the frog's brain. Once activated, these cells in turn massively fire others in a chain reaction that usually results in the frog shooting out its tongue to catch the insect. The bug detector is primed to respond to any small dark object that suddenly enters the visual field: "Every time it moves, with even the faintest jerk, there is a burst of impulses that dies down to a mutter that continues as long as the object is visible. If the object is kept moving, the burst signal discontinues in the movement, such as the turning of corners, reversals, and so forth, and these bursts occur against a continuous background mutter that tells us the object is visible to the cell" (Lettvin et al. 1961). If flying insects belong to the proper domain of frog's food-catching module, wads of paper dangling on a string belong to the actual domain.

CULTURAL DOMAINS

Humans *conceptually create* actual-domain entities and information to mimic and manipulate the natural input conditions of evolutionarily proper-domain entities and information (Sperber 1996). That is, they create *cultural domains* that are parasitic on mental modules. Masks, makeup, Mickey Mouse, geometry, governments, gods, and so on are made by and for human beings. Because the created phenomena readily activate modular processes, they are more likely to survive transmission from mind to mind under a wide range of different environments and learning conditions than entities and information that are harder to process. As a result, they are more likely to become enduring aspects of human cultures.

Another example from ethology offers an analogy. Many bird species have nests parasitized by members of other species. Thus, the cuckoo deposits its eggs in passerine nests, tricking the foster parents into incubating and feeding the cuckoo's young. Nestling European cuckoos often dwarf their host parents: "Consider the ludicrous site of a Garden Warbler . . . standing atop a cuckoo to reach the mouth of the gaping parasite? . . . The most rudimentary eyesight should suffice to show that something has gone seriously wrong with the normal parental process" (Hamilton and Orians 1965). How does the cuckoo manage to fool its otherwise visually acute host? According to Lack (1968): "The young cuckoo, with its huge gape and loud begging call, has evidently evolved in exaggerated form the stimuli which elicit the feeding response of parent passerine birds. . . . This, like lipstick in the courtship of mankind, demonstrates successful exploitation by means of a 'super-stimulus'." Nestling cuckoos have evolved perceptible signals to *manipulate* the passerine nervous system by initiating and then arresting or interrupting normal processing. In this way, cuckoos are able to subvert and co-opt the passerine's modularized survival mechanisms.

Similarly, people can be aroused by pornographic pictures or scared by masks. People create pornography and masks in order to initiate and manipulate modular processing for parasitic ends (e.g., instilling desire to make money, or incurring fear of predatory agents to enforce social submission). Indeed, people may be sexually aroused or frightened by quite abstract or unrealistic representations. Nevertheless, the visual stimuli have sufficiently enough in common with the real things (human sexual or facial recognition modules) to trigger similar physiological reactions (together with allied cognitive inferences).

Within our species' evolutionary landscape of medium-sized objects and actors that are snapshot in a single lifespan of geological time, biologically poised mental structures channel cognitive development but do not determine it. Cultural life, including science, can selectively target and modify parts of this landscape but cannot simply ignore it or completely replace it. For example, modern systematics emerged from folkbiology's cultural domain. Consider three corresponding ways in which ordinary folk and biologists think of plants and animals as special (Atran 1998). First, people in all cultures classify plants and animals into species-like groups that biologists generally recognize as populations of interbreeding individuals adapted to an ecological niche. Second, there is a commonsense assumption that each generic species has an underlying causal nature, or essence, that maintains the organism's integrity even as it causes the organism to grow, change form, and reproduce. For example, a tadpole and a frog are in a crucial sense the same animals although they look and behave very differently, and live in different places. Evolutionary biologists reject the notion of essence as some sort of metaphysical reality. Nevertheless, biologists have traditionally interpreted this conservation of identity under change as due to organisms having separate genotypes and phenotypes.

Third, in addition to the spontaneous division of local flora and fauna into essence-based species, such groups have "from the remotest period in . . . history . . . been classed in groups under groups. This classification [of generic species into higher- and lower-order groups] is not arbitrary like the grouping of stars in constellations" (Darwin 1859:431). Such taxonomies not only organize and summarize biological information; they also provide a powerful inductive framework for making systematic inferences about the likely distribution of organic and ecological properties among organisms. In scientific taxonomy, this strategy receives its strongest expression in "the fundamental principle of systematic induction" (Warburton 1967).

Folkbiological species and groups of folkspecies are inherently well-structured, attention-arresting, memorable, and readily transmissible across minds. As a result, they readily provide effective pegs on which to attach knowledge and behavior of less-intrinsically-well-determined social groups. In this way totemic groups can also become memorable, attention-arresting, and transmissible across minds. These are the conditions for any "meme" (elicitor) to become culturally viable. A main feature of totemism that makes it "good to think" is that it enhances both memorability and capacity to grab attention by pointedly violating the general behavior of biological species (Lévi-Strauss 1962). Members of a totem, unlike species members, don't interbreed; they only mate with members of other totems to create a system of social exchange. Notice that this violation of core knowledge is far from arbitrary. It is such a pointed violation of human intuitive ontology that it readily mobilizes most of the assumptions people ordinarily make about biology in order to help build societies around the world (Atran and Sperber 1991).

Supernatural agents, which are banished from science but enthroned in religion, lie within folkpsychology's cultural domain. Supernatural agent concepts are culturally derived from modular cognitive schema for recognition and interpretation of agents, such as people and animals. By "culturally derived," I mean that people acting together causally manipulate modular processes in contingent ways—much as makeup and masks involve collective, contingent, causal manipulation of innate sensibilities to secondary sexual characteristics and human facial cues. In normal circumstances, for instance, a sudden wind movement might activate cognitive processing for agents, but it would soon deactivate on further analysis ("it's only the wind"). By conscientiously manipulating and violating innate, modularity-induced ontological commitments (e.g., endowing spirits with movement and feelings but no body), processing can never be brought to factual closure, and indeterminately many interpretations can be generated for indefinitely many newly arising situations (Atran in press; Atran and Sperber 1991; Boyer 1994).

In brief, these enduring aspects of human cultures need not be, and often are not, fixed in terms of perceptual or conceptual content. Unlike genetic transmission and replication, high-fidelity transmission of cultural information is the exception rather than the rule. Constant and rapid "mutation" of information during cultural transmission results in endlessly varied proliferation of information that nevertheless continues to meet modular input conditions. The sort of cultural information that is most susceptible to modular processing is the sort of information most readily acquired by children, most easily transmitted from individual to individual, most apt to survive within a culture over time, most likely to recur independently in different cultures and at different times, and most disposed to variation and elaboration.

NO REPLICATION WITHOUT IMITATION; THEREFORE, NO REPLICATION

We are increasingly witness to a rapid and global spread of anonymous electronic messages that many of us would prefer to do without yet cannot seem to avoid. This adds much to the sentiment that these messages are authorless, active, aggressive, and alive. I believe this sentiment is an illusion. Ideas do not reproduce or replicate in minds. They do not nest in and colonize minds, and they do not generally spread from mind to mind by imitation. It is minds that produce and generate ideas. Minds structure certain communicable aspects of the ideas produced, and these communicable aspects generally trigger or elicit ideas in other minds through *inference and not imitation.* Consider:

When millions of Chinese in a rally hold up Mao's *Little Red Book* and cite the statement, "Let a thousand flowers bloom," you can bet most do not have the same flowers in mind, or any flowers at all, or even a medium-fidelity version of what others have in mind. What the crowd has in common is a context: for example, a rally against "western influence." The shared context mobilizes background knowledge in people's minds: for example, that western ideas, practices, preferences, and so on have heretofore dominated in China. This background knowledge is then used to infer the statement's "real" or "true" underlying message: for example, that autochthonous ideas, practice, preferences should be adopted. This presumptively true message may be interpreted in widely varying ways by different people: for example, that a single-party political system is better than a multi-party system, that acupuncture and herbal medicine should be exclusively or also used in the local hospital, that peasants should determine the priorities of scientific research, that violins should be banned, or that every village should have a politically correct dance company, and so on.

To test this speculation, I presented the expression "Let a thousand flowers bloom" to East Asian and American students at the University of Michigan. Students were asked to write down the meaning of the expression on a piece of paper. The responses of one group of East Asian students were as follows: "Many good things will happen"; "Let all in your group be able to express their inner thoughts"; "May there be much crop growth and productivity"; "Make the world a beautiful place, use your talents to help others"; "Allow the flowers to bloom"; "Help your environment, don't pollute"; "Allow life to try to reproduce"; "Let things go on their own and see how things turn out"; "Let us enjoy the beauty and serenity of meadows"; "Grow and flourish"; "Let things be in peace and good things will happen"; "Prosperity, health and happiness." American responses were, if anything, even more wide-ranging.

True, this is a rather extreme example of successful low-fidelity communication via inference instead of imitation. But it is by no means uncommon. Communication involving religious beliefs is often of this sort. For example, in another set of classroom experiments, I asked students to write down on a piece of paper the meanings of three of the Ten Commandments: (1) Thou Shall Not Bow Down Before False Idols; (2) Remember the Sabbath; (3) Honor Thy Father and Thy Mother. Despite the students' own expectations of consensus, little was apparent. One class of 10 students interpreted (1) as: "Only worship the Christian God"; "Don't follow anyone else's rules but God's"; "Only believe in what is good or you go to Hell"; "Be careful not to pay too much attention to wealth and material things"; "Be true to yourself and don't compromise your ideals just to satisfy short-term goals"; "Believe in the system your parents inflicted on you"; "Why not believe in celebrities?" "Don't follow bad examples"; "You should not worship objects, persons or gods outside your religion"; "It means that person who is false—a person who does not show cooperation should not be someone I follow." These responses, in turn, were presented to another class, and students were again asked to give the meaning of the expressions read. Not one produced a recognizable version of the first commandment (1). Interpretations of the other commandments showed similar ranges of variation.

One student project aimed to show that at least members of the same church have some normative notion of the Ten Commandments, that is, some minimal stability of content that could serve for memetic selection. Twenty-three members of a Bible class at a local Pentecostal church participated in the study, including the church pastor. They were given identical pieces of paper, and pens, and asked to define seven expressions, including the three commandments listed above as well as: "Thou shalt not kill"; "The Golden Rule"; "Lamb of God"; and "Why did Jesus die?" Only the last two elicited consensus (such that the meaning expressed elicited something close to the original on a different occasion). I suspect that similar results would obtain for almost any congregation, despite widespread claims that the Ten Commandments and the Golden Rule are among the most constant norms of contemporary America (Frank 1988), with meanings that have changed little since Biblical times (Schlesinger 1999).

By contrast, instances of successful high-fidelity transmission strictly or mainly by imitation are often frequent but minimally informative. Examples include formal salutations (handshakes, wolf-whistles, "Dear X, . . . Sincerely Y," etc.), standing in line or marching in formation, public applause, driving on the right side of the street rather than the left or vice versa, setting a table, copying addresses and telephone numbers, mimicking another person's mannerisms, humming a tune you heard somewhere and would rather forget, dancing the Twist or the Macarena, reciting a prayer in Latin or Hebrew without understanding a word, ear-piercing. Other examples include emulation learning of minimal but sometimes important skills: lighting a fire, artificial respiration, putting babies in baby carriages, cutting paper with a scissors, opening cans with a can opener, the Heimlich maneuver (a recently acquired technique that helps to offset our evolutionary susceptibility to choke on food). Only occasionally does imitated behavior carry information that explicitly includes instructions for replicating that information, as with chain letters, computer viruses, or messages such as: "please forward," "tell a friend," "do someone else this favor." But the rarity of information with active instructions for its own propagation is not a significant objection to the meme perspective. It is enough that the cognitive environment *reacts* to memes in reliably productive ways.

Nevertheless, most high-fidelity communication is overwhelmingly inferred rather than imitated. Consider the simple proposition expressed by the statement, "Cats chase birds." When you read the statement you do not have the proposition replicate in your mind. This is so even if the context in which the statement is expressed is as poor as can be (e.g., receiving only this statement in a letter with no indication of who sent it or why). Decoding the expression's syntactic structure is not the end of an ordinary communication process, but only the beginning. Once syntactically decoded, semantic elements of the proposition are recovered in ways that "automatically" activate a rich set of conceptual structures. These structures are partly innate and partly enhanced through personal experience and previous testimony from others.

For example, because of the universal character of folkbiological taxonomy, you infer that members of a familiar biological species likely have it in their nature to prey upon a wide variety of known and unknown biological species, although this underlying biological disposition may not be actually realized for various reasons (some cats are too sick to chase birds, others may be trained to not chase birds, some large raptors are probably too big for cats to handle, etc.). You further infer that all of these species whose members a cat might chase, if circumstances were right, belong to a taxonomic level superordinate to the level of the species, on a par with the category *fish* or even the category *tree*. Innumerable further inferences could be easily generated from just this entry into your folkbiological taxonomy, if the context of the utterance or statement warranted it. In addition to automatic taxonomic inferencing, various aspects of learned encyclopedic knowledge might be mobilized about cat and bird behaviors, predator-prey relationships, and so on. Episodic memories associated with personal recollection could also be stimulated, as when a particular cat chased a certain bird on a given occasion, or when a cat chased a mouse (maybe you've never seen a cat chase a bird), and so on. Further inference and interpretation can vary from person to person, depending on differences in extent of encyclopedic knowledge and content of personal memory (for fuller discussion, see Atran 1998).

Unless the context warrants further interpretation and inference, though, most people's inferential processing of a statement is remarkably rapid and economical (Gigerenzer and Todd 1999; Sperber and Wilson 1986). It *stops* as just as soon *enough sense* is made of a statement to be *relevant* (e.g., by providing for new knowledge or rejection of old knowledge). In the present example, this "stopping-rule" can apply only after activation of taxonomic knowledge that is shared among minds in the population by virtue of their innate, modular structure.[3]

IMITATION VERSUS INFERENCE

Coevolution theories examine cultural traits from the standpoint of a number of different learning processes: observational experience, imprinting, classical and operant conditioning, formal and informal teaching, and imitation. For memeticists, imitation is often all that is necessary (and sufficient) for replication of information. Only because of imitation can replicated information subsequently undergo natural selection. Imitation occurs when an individual copies a new skill or behavior by observing the behavior of someone else. This allows an individual to benefit directly from the efforts of others without having to pay the original cost of seeking out and testing the behavior. What is copied is not the rote sequence of motor movements, but structure-dependent behaviors. This involves simultaneous awareness of distal as well as proximate causal relationships between behavioral elements, and anticipation of behavioral consequences that transcend the actual learning context.

Clear examples of imitation among other animals are scarce (Heyes and Galef 1996). In some instances of social learning, one individual may reproduce the novel behavior of another individual without copying it. This is one interpretation of the celebrated case of sweet-potato washing by Japanese macaques (Kawai 1965). After a young female found that she could wash sand off her sweet potatoes, others in the group eventually adopted the practice, beginning with relatives and close associates of the inventor. Arguably, however, the initiator's actions simply drew the attention of others to a context consisting of sweet potatoes, sand, and water. The other macaques would recognize the context and begin to manipulate its elements. Eventually, after two years on average, some of the other macaques would stumble on the same discovery, in effect "reinventing the wheel" (Heyes and Galef 1996).

The case for imitation is stronger among chimpanzees and bonobos (Boesch 1991). For example, some groups of wild chimpanzees (at Bossou and Kibale) crack nuts, using selected sticks as "hammers" and other objects as "anvils" on which to break the hard casing. Mothers monitor and routinely intervene in attempts by their young to crack nuts. On occasion they take the youngster's club and slowly rotate it (for up to a minute) until the right striking position is attained, and then back away as the youngster practices. Even with apes, however, emulation is rare enough so that there are too few novel behaviors and too few behavioral differences for cumulative combinations of new behaviors to evolve (Tomasello 1994).

On the memeticist view there is no true imitation without replication, and no true replication without imitation. The key point about imitation is not that it triggers or elicits or produces or reproduces information. Rather, it both *causes replication* as well as *provides the information to be replicated.* The process of imitation causes replication by including, as part of the information it provides, instructions for copying the information. This entails that the information carried by a replicator will always contain instructions for copying the instructions. The building plan incorporates the builder.

For Dawkins (1999:xi–xii), who follows Blackmore in this regard, considerations associated with copying-the-instructions (replicating the genotype), rather than copying-the-product (reproducing the phenotype), "greatly reduce, and probably remove altogether, the objection that memes are copied with insufficient fidelity to be compared with genes." To illustrate the point, Dawkins offers a thought experiment that compares two games involving representation of a Chinese junk. In the first game, a child is shown a picture of a Chinese junk and asked to draw it. A second child is then shown the drawing but not the original picture, and is asked to make her own drawing of it. A third child is asked to make a drawing from the second drawing, and so on down the line. By the time several unskilled drawings are completed, the last drawing in the series will probably differ so much from the first that it would be unrecognizable as a Chinese junk. There is too much "mutation and drift" to sustain the design.

In the second game, the first child is taught by (wordless) demonstration to make a model of Chinese junk with origami, the art of paper folding. The first child then demonstrates to a second child how to make an origami junk. As the skill passes down the line, it's a good bet that an independent judge will recognize later productions as more or less faithful versions of the original model. If, in the first game, the child also learned by demonstration to draw the junk, later productions might be as recognizable as in the second game. And if, in the second game, the child were given no demonstration of the art of paper folding but simply shown a finished product, then later productions would likely be as unrecognizable as in the first game.

A critical difference between the two games is that only the second has a demonstration that allows the observer to induce the instructions: for example, "take a square sheet of paper and fold all four corners exactly into the middle." Although actual productions rarely involve perfect squares or folding to the exact middle, such surface (phenotypic) imperfections tend to cancel out in the long run because the underlying (genotypic) code is "self-normalizing": "what passes down the line is the ideal essence of junk, of which each actual junk is an imperfect approximation." Plato would be grinning. "For me," opines Dawkins, " the quasi-genetic inheritance of language, and of religious and traditional customs, teaches the same lesson."

Either I have misunderstood the memetic program or there is an insurmountable inductive barrier of the kind Hume and Nelson Goodman described—a logical barrier akin to the physical barrier that disallows mass from exceeding the speed of light and arriving at a destination before it starts out. How in the world is a person ever going to induce a unique rule from any given display of behavior? Rules of grammar, principles of origami, or techniques of drawing are always underdetermined by the behaviors they produce. Any such behavior can be logically associated with indefinitely many alternate interpretations (rules, principles, instructions, techniques, etc.). The only way a person understands one of indefinitely many fragmentary instances of experience as an example of a general rule is by being able to project that instance to an indefinitely large set of complexly related instances (e.g., there are infinitely many imperfect squares or middle lines that satisfactorily instantiate the concepts "square" and "middle" in the origami instruction) (Sperber in press). But to do *that*, either you must already have the rule in mind or you must be able to *infer* the rule from other premises available in your mind.

Notice that for language you obviously need a very rich prior inferential structure, including much built-in information content, to be able to infer the same rule from strikingly different behaviors, or different rules from remarkably similar behaviors. For example, (1) "John kissed Mary" has nearly the same underlying syntactic structure as (2) "The dog bit the cat." Both are transitive sentences with practically identical phrase structure. By contrast, (3) "John appeared to Peter to do the job" has a very different underlying syntactic structure than (4) "John appealed to Peter to do the job." Sentence (3) involves a recursive structure of two embedded sentences with subject-control (John appeared to Peter → John does the job), whereas sentence (4) involves a recursive structure of two embedded sentences with object-control (John appealed to Peter → Peter does the job). What "self-normalizing" instruction could possibly be read off these "phenotypic" surface forms that would justify including (1) and (2) under the same "genotypic" rule but (3) and (4) under different types? The language learner's task is not to imitate and induce; it is to use the surface form of sentences to test the applicability of preexisting and observationally "invisible" syntactic structures, such as transitive phrase structure and subject-controlled versus object-controlled embeddings (Chomsky 1986).

Like considerations apply to "traditional customs." In the United States, the same experimentally controlled physical or verbal behavior can lead to radically different interpretations and responses depending on whether or not the person grew up in the South or the North (Nisbett and Cohen

1996). For example, southerners tend to justify violent responses to a perceived insult, whereas northerners are more likely to let it pass. Identical observations may produce very different interpretations depending on the observer's cultural background, and quite different observations can lead to similar interpretations in one culture but not another (for a review, see Nisbett et al. 2001). For example, when shown an animated cartoon of a school of fish swimming in unison and a lone fish swimming on the outside, Americans interpret the outlier as a leader who is more intelligent and daring than the others, whereas Chinese interpret the outlier as an outcast, lacking in promise and ignorant of responsibility. Americans tend to interpret mass murders as caused by the inherent mental instability of the murderer. Chinese tend to interpret the same events as caused by situational and social factors such as the prior rejection of the murderer by colleagues at work (Morris et al. 1995). Given triads of items (man/woman/child, chair/table/bowl), Americans tend to isolate the nonfunctional, categorical dyad (man + woman = adult, chair + table = furniture); Chinese tend to factor out the functional, thematic dyad (mother + child = nurturing, table + bowl = meal) (Chiu 1972).

Don't such robust and systematic cultural differences actually reinforce the memeticist's claim instead of refuting it? Dennett (1995:365) suggests that the structure of Chinese or Korean minds is "dramatically different" from that of American or French minds because of differences in prior meme activity. Yet, the experiments cited, and others (Norenzayan 1999), also show that Americans and East Asians have little trouble making sense of one another's preferences. The preferences of one cultural group are also latent alternatives in the other cultural group, and can be readily elicited. Notice, for example, that members of neither cultural group interpret the animated cartoon simply as changing patterns of illumination, as a lifeless screen, as a moving cluster and point, as a temporal sequence of clusters and points, as a school of fish and a singular object, as a clustered object and a single fish, or any of the infinitely many other logically possible interpretations of the scene observed. This implies operation of richly textured, built-in computational structures that severely constrain the space of logically possible interpretations of experience to a much narrower range of spontaneously accessible, or "natural," interpretations.

To drive the point home consider a set of three somewhat informal experiments, which I gave to students in two different classes at the University of Michigan (one co-taught with Richard Nisbett). In the first experiment, I flashed a piece of paper for ten seconds and asked the students to copy what was written on it: "Through the air underground as they fly marry bachelors." None of the students got it perfect, but most captured a few chunks, like "through the air" and "as they fly," and there was also a case of "merry bachelors." Then I showed the following to the students in one class: "Bachelors the through marry fly they underground as." Most got as far as "Bachelors" and then muddled the rest. To the students in the other class I showed: "Bachelors marry underground as they fly through the air." Although the last string of words is as meaningless as the other two strings, all of the students copied it right. The reason that students got this string right is not because they induced some self-normalizing instruction, but because they were readily able to process it syntactically.

Humans everywhere automatically seek to process word strings as meaningful sentences. To be meaningful a sentence must, first of all, be a sentence: that is, a morpho-syntactic structure that fits a set of grammatical rules. The first two strings fail to meet this preestablished cognitive threshold. The first string, however, contains syntactic fragments that, if passed on serially as in the origami experiment, might bias students down the line to alter syntactic structure and lexical combinations in ways that ultimately stabilize into a grammatically correct and meaningful pattern. Such a pattern, if it arises, would not likely be predictable from the original. Chances are more remote that the second string would stabilize because the lack of initial structure allows too much leeway for mutation in every copying episode.

Only the third string is readily inferred to be grammatically well-structured. This stable structure would be initially more resistant to change in a serial transmission than a less well structured string. Possibly, it would succumb to selective pressures to be *both* grammatically well-formed *and* meaningful, so that it would eventually transform into a meaningful expression as well as a grammatical one. Perhaps the string would stabilize down the line as a statement about "merry bachelors," or a proposition about bachelors who like airplanes rather than subways. Selective pressures leading to both grammatical well-formedness and meaningfulness owe to the mind's modular landscape: in this case, the innate language faculty (Pinker 1994) in conjunction with universal pragmatic constraints on semantic relevance (Sperber and Wilson 1986).

In a second experiment I asked students in two classes to copy a row of nine circles flashed on a piece of paper for ten seconds. Going from left to right: the last circle in line was smallest, the first circle was the next smallest; the second, third and fourth circles where all medium size; the fifth circle was largest, and the other circles were all a shade smaller than the fifth. In one class, few students copied the correct number of circles, and no students correctly reproduced their relative sizes, except for the last circle. In the other class, I prefaced the copying instruction with the statement: "These are the planets." Nearly all students got the number and relative sizes of the circles right. What happened in the second case was that the students brought to bear a rich repository of background knowledge that enabled them to *infer* the number and relative size of the objects observed, and to at least partially verify what they inferred from what they observed. They did not copy what was presented to them, but used what was visually and verbally presented as inferential stepping-stones towards a more complete representation.

The third experiment is a variation on a thought task that Dan Sperber suggested to me (cf. Sperber in press). In one class, I asked students to copy a drawing of a square outlined by eight broken lines, two on each side. All students more or less faithfully reproduced the square, although the overall size of the figure and the lengths of broken lines varied from person to person. Some of the representations were more rectangular than square, and some representations connected all of the broken lines. In the other class, I asked students to copy a drawing that preserved significant features of the square, such as the number and length of broken lines, four right angles, and contiguity among the four right angles (separated only by the length of the gap between the original broken lines). Few students could reproduce the original figure, although most figures produced contained only right angles and one student produced a swastika (with no underlying intent, I'm sure). Logically speaking, there was no difference in the quantity and complexity of information presented to the two classes for copying. Students in the first class, however, all spontaneously inferred that the object of the task was to copy a *square* or *rectangle.*

The information pertinent to being a square or a rectangle was not wholly or even mostly carried in the drawing itself, and the drawing together with the copying instruction did not produce a replication of the drawing. Rather, the drawing triggered a chain of inferences in each person's mind that resulted in the production of a representation that selectively shared particularly significant aspects of the original drawing. The selection of significant shared elements came entirely from the cognitive architecture of the mind—in particular, computational structures that determine the well-formedness of geometrical shapes—and not from the broken figure itself. Indeed, the broken lines and angles *could* have been interpreted in indefinitely many other ways. Possible interpretations include a rotated diamond, a digital "L" together with an inverted "L," a digital "C" and a digital "I," a digital "D," eight separate lines, one figure consisting of one right angle and three lines conjoined with another figure consisting of two right angles and five lines, a window, the outline for cutting a hole in a piece of paper, pairs of birds flying off in opposite directions, and so forth ad infinitum.

If one objects that many of these logically possible interpretations violate expectations of symmetry or require additional cognitive effort beyond considerations of geometrical form, such objections prove the point: Broken lines don't make a square. To make a square requires inferences from broken lines to preexisting computational structures. This specific piece of human cognitive architecture selectively reduces the set of all possible relations between stimuli to only those that fit prior determinations of what counts as geometrical well-formedness.

Another factor that militates against memes as cognitive replicators transmitted via imitation concerns the role of the emotions in cognitive preference. Religious ideas, for example, are loaded with emotional valence. In fact, without passionate commitment to religious ideas and practice they would be indistinguishable from Mickey Mouse cartoons or a high school football game and parade. Emotional behaviors do not imitate well or at all (Ekman 1992). True, actors can learn to control some outward manifestations of emotional signaling, such as crying, but even the best actor cannot, by imitation, fall in love, become honest or hateful, be truly vengeful or remorseful, fair or faithful (Frank 1988). And crying itself isn't imitated, but elicited.

Emotional preference may also depend on congruence with, or violation of, modular structures. Good geometrical forms are "pleasing," deities and demons that violate ontological assumptions (e.g., sentient but bodiless, able to pass through solid objects) are surprising, and attention-arresting and hence memorable, and so on (Atran and Sperber 1991; Boyer 1994). Iambic pentameter and couplets that rhyme are culturally specific; but though culturally specific, their pleasingness has to do with innate preference for rhythmic structures in humans (perhaps alone of animal species, humans spontaneously and creatively use rhythmic cadencing of affective body states—song, chant, dance, sway, etc.—to coordinate communication emotionally).

Memeticists might grant all this and argue that, somehow, memes insinuate themselves into minds to activate the emotions that sustain them, much as a virus can insinuate itself into cells to stimulate certain cell processes that facilitate viral spread and transmission. Nevertheless, relations between emotions and cognitions may also depend upon universal structures that cannot be learned simply by imitation or association. Thus, experimental studies of emotion indicate that people cognitively appraise situations in terms of elements such as pleasantness, certainty, anticipated effort, control, legitimacy, or perceived obstacle (Ellsworth 1991). Distinct emotions tend to be associated with different combinations of appraisals. A perceived obstacle (barrier to a goal) thought to be caused by an external agent is associated with anger, a perceived obstacle that is a person's own responsibility is associated with guilt, a perceived obstacle that has no apparent source is associated with sadness, and a perceived obstacle characterized by uncertainty is associated with fear and anxiety (Keltner et al. 1993). Like the idea of "good form," the concept of "perceived obstacle" comes from the mind itself and is not implanted by memes.

CONCLUSION: COGNITIVE CONSTRAINTS ON CULTURE

Cultures are causally distributive assemblages of mental representations and resultant behaviors. Representations that are stable over time within a culture, like those that recur across cultures, are those that are readily produced, remembered, and communicated. The most memorable and transmissible ideas are those most congenial to people's evolved, modular habits of mind. These habits of mind evolved to capture recurrent features of hominid environments relevant to species survival. Once emitted in a cultural environment, such core-compatible ideas will spread "contagiously" through a population of minds (Sperber 1985). They will be little affected by subsequent changes in a culture's history or institutional ecology. They are learned without formal or informal teaching and, once learned, cannot be easily or wholly unlearned. They remain inordinately stable within a culture and are by and large structurally isomorphic across cultures. An example is the categorization and reasoning schema in folkbiological taxonomy.

"Prosthetic devices," like bibles and bombs, and natural or constructed ecological features, like colleges and churches, further constrain and extend the distributions of thoughts and actions that humans evolved to produce. By further channeling and sequencing thoughts and actions, these aspects of institutional ecology allow harder-to-learn representations and behaviors to develop and endure, like the science of biology or totemic religion.

One positive message that memetics brings is that evolutionary psychology might profit from a source barely tapped: the study of cultural transmission. Some bodies of knowledge have a stability of their own, only marginally affected by social change (e.g., intuitive mechanics, basic color classification, folkbiological taxonomies); others depend for their transmission, and thus for their existence, on specific institutions (e.g., totemism, creationism, evolutionary biology). This suggests culture is not an integrated whole, relying for its transmission on undifferentiated cognitive abilities. But the message is also one of "charity" about mutual understanding of cultures (Davidson 1984): anthropology is possible because underlying the variety of cultures are diverse but universal commonalities. This message also applies to the diversity and comprehensibility of the various sciences (Atran 1990) and religions (Atran in press).

Would-be "memeplexes," like beliefs in natural causes and supernatural agents, are universally constrained by specific structures of the multimodular human mind. The computational architecture of the human brain strongly and specifically determines reception, modification, and tendency to send any "meme" on its way again to elicit similar responses from other minds. Even harder-to-learn cultural ideas—like science, theology, or politics—are subject to modular constraints, at least in their initial stages and conception. Indeed, it is only by pointedly attempting to transcend, violate, or enrich modular expectations about folkmechanics, folkbiology, folkpsychology and other universal, species-specific cognitive domains that more varied and elaborate cultural ideas acquire life.[4]

I thank Dan Sperber, Douglas Medin, David Hull, Joe Henrich, Francisco Gil-White, Michael Baran, and the reviewers for comments. Sperber's ideas are evident throughout. Hull informs me that Richard Semon (1904 / 1921) coined the term "Mneme" in 1904 for an entity that functions much like the meme: "In the evolution of language, 'meme' and 'mneme' are homoplasies [analogies], not homologies."

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NOTES

1. Boyd and Richerson (1985:11) allow that successful cultural traits, such as social norms, do not always enhance the chances of an individual who follows the norms to maximize transmission of his or her genes to the next generation. But it is the group as a whole, not the idea of altruism per se, that benefits. Memes break links to biology, making their own way in the world.
2. A possible response is that the basic unit of cultural information more properly analogous to the gene is the "word"/morpheme, that is, the smallest unit of consistent sound/meaning correspondence (or its semantic referent). A memeplex, then, is a complex "word-plex," such as a proposition. Rather than "replicate," word-plexes "recombine" into more intricate forms of inference and predication. I fail to see how this maneuver gains anything. Take the command, "Eat cake!" The actual intent and inferred meaning of the command, and the informational content that is transmitted over time, may have very little to do with the command's explicit propositional content (e.g., when uttered to a starving person begging for bread).
3. Economy is not always good. Gigerenzer and Todd (1999) argue "fast and frugal" cognitive heuristics often "make us smart." But they may often be as likely to make us stupid. Thus, racial stereotypes are culturally widespread and cognitively economical, but biologically incoherent and often socially dysfunctional. Perhaps intellectual innovation is difficult because of economy.
4. Arguably, my claim that there are no "species" or "lineages" of memes is belied by multivariate analysis of linguistic and cultural traits (cf. Romney and Moore 2001). One issue is whether there are scientifically identifiable "traits" or "norms" at all, or whether such "cultural units" are simply commonsense summaries of complex and variable behaviors (cf. Atran et al. in press).

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