Bounded Rationality

The Adaptive Toolbox

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19

Group Report: What Is the Role of Culture in Bounded Rationality?

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As a research program, "bounded rationality" aims to understand the actual cognitive processes that humans use to arrive at their behavioral repertoire. The assumptions of bounded rationality depart from the traditional assumptions of omniscient, "Laplacean Demons" with unlimited information, time and processing ability, and instead assume that individuals possess fast, frugal algorithms which allow individuals to solve a variety of difficult problems under ecologically realistic circumstances without incurring substantial information-gathering or processing costs. In this chapter, we explore three ways in which sociocultural processes produce adaptive (or boundedly rational) algorithms. First, simple imitation or social learning heuristics allow individuals to save the costs of individual learning, experimentation, and search by exploiting the information available in the minds of other individuals. Second, over cultural-evolutionary time scales,[1] these algorithms give rise to complex sets of motivations, decision processes, rules, cues, and procedures that are adaptive in particular socio-ecologies (yet quite maladaptive in others). Third, cultural and socio-interactional processes can combine to give rise to adaptive group processes that distribute cognition, knowledge, skill, and labor (institutions, governing processes, markets, etc.). We argue that these three types of processes form the essential elements in a wide range of human decision-making and

[1] Cultural–evolutionary time scales are, on average, longer than individual-level adaptive learning processes, but shorter than genetic–evolutionary time scales.

behavioral patterns. Consequently, any effort to understand the patterns requires an exploration of how each of these sociocultural processes works.

WHAT ARE CULTURE, CULTURAL TRANSMISSION MECHANISMS, AND SOCIAL DECISION MECHANISMS?

"Culture" is information, stored in people's heads, that can be transmitted among individuals. This information can be thought of as the ideas, values, beliefs, behavioral strategies, perceptual models, and organizational structures that reside in individual brains, which can be learned by other individuals through imitation, observation (plus inference), interaction, discussion, and/or teaching. Culture is not institutions, technology, or social structure but is inextricably related to the evolution and functioning of each.

Technology, for example, is often considered a part of culture; however, this interpretation fails to understand that the essential part of technology (its function, use, and design) resides in people's heads and is not embodied in the artifacts themselves. The glass coke bottle was originally designed to store Coca-Cola, but people unfamiliar with carbonated beverages find that it's an excellent musical instrument, portable mini-club, water container, nut grinder, or even a fire starter. What it is (meaning its function or what it's "good for") depends on what is in the mind of the user, and is only constrained by the physical form of the object itself.

People often have the sense that culture must, by definition, be shared among some group of individuals. This intuition arises because individuals within social groups tend to believe similar things and behave in similar ways, and thus they share a large amount of culture. However, populations may share certain components of culture more or less: there may be subcultures within the population that share some things, but not others; there may be clines of cultural traits carving out regions through populations, etc. In each case, we want to be able to ask why a certain distributional pattern exists. One cannot ask why individuals share certain traits, and not others, if "shared" is part of the definition of culture.

Cultural transmission mechanisms are cognitive information processors that allow individuals to acquire information (or infer information) in some fashion from other individuals, often via observation, imitation, and interaction (Cavalli-Sforza and Feldman 1981; Durham 1991; Boyd and Richerson 1985; Sperber 1996). Many researchers think of these as species-specific, mental mechanisms constructed by natural selection to search, select, and acquire information from the distribution of different behaviors available in the social world. Cultural transmission capacities allow individuals to shortcut the costs of search, experimentation, and data processing algorithms, and instead benefit from the cumulative experience stored in the minds (and observed in the behavior) of others.

CULTURAL TRANSMISSION MECHANISMS AND THEIR CULTURAL-EVOLUTIONARY PRODUCTS ARE FAST AND FRUGAL HEURISTICS THAT HAVE ALLOWED HUMANS TO ADAPT TO AN INCREDIBLY WIDE RANGE OF DIFFERENT HABITATS

Taken as a whole, human populations display three interesting patterns: (a) humans have the largest variety of habitats and adaptations of any animal; (b) humans belonging to the same group tend to behave in similar ways, while members of different groups often behave quite differently (i.e., most studied behavioral variation occurs *between* human groups)[2]; and (c) even in identical and overlapping environments, human groups display *quite* different behavioral patterns. In an effort to explain these three facts about human behavior, researchers have suggested that individuals rely heavily on certain forms of imitation and/or cultural transmission mechanisms. Here we will briefly describe the operation of two such cognitive algorithms: prestige-biased transmission and conformist transmission (see Boesch and Tomasello 1998; Gil-White and Henrich 1999; Cavalli-Sforza and Feldman 1981; Boyd and Richerson 1985; Henrich and Boyd 1998; Sperber 1996; Boyer 1994 for more detail on other mechanisms).

A substantial amount of cross-cultural ethnography (e.g., Dove 1993; Hammel 1964; Rogers 1995; Moore 1957) and laboratory psychology (for a summary, see Gil-White and Henrich 1999) suggests that humans everywhere possess a tendency to copy prestigious individuals, i.e., those who receive the most displays of respect/deference from others. This mechanism embodies two shortcut heuristics. First, by preferentially copying a "bundle" of cultural traits from prestigious individuals (prestige correlates with skill/knowledge and often wealth) copiers can rapidly acquire a repertoire of fitness-enhancing or success-oriented traits (i.e., better-than-average solutions to the problems of life). Second, rather than gradually learning via individual experience who the most successful, knowledgeable, or skillful individuals are, copiers rely on honest ethological and sociolinguistic signals of respect that other individuals display toward such high status individuals. Ethologically, lower status individuals unintentionally indicate who are the high status individuals by watching them, paying attention, maintaining proximity to them, and by their diminutive body position relative to the prestigious individual. Sociolinguistically, high prestige individuals can also be recognized by how rarely they are interrupted, how often it's their "turn" to speak, how lower status individuals ask questions, and by the ingratiating compliments that prestigious individuals receive. These signals cue

2 A "group" is composed of individuals who frequently interact socially, but not necessarily by individuals who share similar cultural beliefs/behaviors (not by definition). Baboons, for example, live in social groups, yet they do not have any cultural capacities.

copiers as to who they should begin imitating, i.e., who, for example, is likely to be the most highly skilled hunter. Lower status individuals interested in acquiring information from high status hunters must provide these signals and deferential displays — both because these copiers want to improve their learning (by watching and listening closely), and because they need to supply a kind of payment to the high status individuals for allowing them to hang around, interact, and learn. Failure to show such signals causes high status individuals to avoid interactions with such disrespectful imitators. Because copiers continually update their initial assessments of who is prestigious (i.e., worthy of respect) with information that can be gradually accumulated through life experiences (which may cause them to switch among potential models), the aforementioned correlation between prestige and skill/knowledge is maintained (for a detailed discussion, see Gil-White and Henrich 1999).

Unlike prestige-biased transmission, conformist transmission causes individuals to preferentially copy the most common behaviors in a population. Under conformist transmission, individuals use the frequency of a behavior as an indirect measure (or cue) of the behavior's quality. Theoretical evolutionary modeling suggests that individuals should rely heavily on this heuristic (and a little bit on individual learning) under a wide variety of circumstances, even when environments vary both spatially and temporally, but especially when circumstances provide ambiguous or uncertain cues about the environment (Henrich and Boyd 1998).

Both laboratory and field data provide some confirmation of the predictions generated by these models. Laboratory work by psychologists studying conformism confirms that, as the uncertainty of environmental information rises, individuals rely more heavily on socially transmitted information (Baron et al. 1996). Further, the fact that individuals within social groups tend to behave in similar ways, even when these behavioral patterns cannot be enforced by social sanctions or punishments, suggests that some kind of conformist mechanism is at work.

Both ethnographic data and computer modeling suggest that innate, individually adaptive processes, such as prestige-biased transmission and conformist transmission, will accumulate and stabilize cultural-evolutionary products that act as effective decision-making algorithms, without the individual participants understanding how or why the particular system works. Systems of divination provide interesting examples of how culture provides adaptive solutions. Among the Kantu of Kalimantan (Indonesian Borneo) swidden farmers rely religiously on a complex system of bird omens that effectively randomizes their selection of garden sites (Dove 1993). Each Kantu farmer selects a new garden location based both on the type of bird observed there, and the type of call the bird makes after it is first observed. This prevents individuals from committing the "gambler's fallacy," which would increase their chances of crop failure from periodic floods, and diversifies the types of gardens across community members, which spreads risk among households. As a quick and thrifty heuristic, this cultural system suppresses errors that farmers make in judging the chances of a flood, and substitutes an operationally simple means for individuals to randomize their garden site selection. In addition, by randomizing each farmer's decision independently, this belief system also reduces the chance of catastrophic failures across the entire group — it decreases the probability that many farmers will fail at the same time. All this only works because the Kantu believe that birds actually supply supernatural information that foretells the future and that they would be punished for not listening to it.

Theoretical work by Hutchins and Hazlehurst (1991) suggests that gradual cultural evolutionary processes can accumulate effective mental models of complex problems — that is, sufficiently difficult problems that no single individual could solve on her own. In the past, these inland-living, native Californians evidently visited the coast to harvest nutritionally important shellfish. To facilitate this, these people acquired an effective cultural model of the relationship between lunar phases and tides. Hutchins and Hazlehurst's simulation shows how, with a small bit of individual learning and observation, and the ability to transmit this information across individuals and through the generations, populations would eventually produce an accurate, effective lunar-tide model. From the bounded rationality perspective, such processes can generate simple rules that are quite hard for individuals to figure out — like when to travel to the ocean to harvest shellfish.

Perhaps as a consequence of the interaction of cultural evolution and social processes that occur among individuals and groups, humans are also affected by higher-level processes which produce things like institutions, political systems, firms, markets etc. These things allow groups to aggregate information, skill, and processing power (each of which may be distributed among group members) in adaptive ways (e.g., group decision making, democratic structures, a division of labor, Micronesian navigation) without individual participants necessarily understanding how or why the total system works. One theory suggests that cultural transmission mechanism, like conformist transmission can give rise to a higher-level selective process called *cultural group selection*. This process can build increasingly adaptive, more accurate, and more efficient systems at the group level, which involve both distributed cognition and complex divisions of labor (Boyd and Richerson, this volume, 1990; Soltis et. al. 1995). This process is the sociocultural analog to the genetic group-selective processes which have been suggested to explain the evolution of the highly effective "new nest" search algorithms among bees (Seeley, this volume).

HOW DOES CULTURE INFLUENCE IMPORTANT HUMAN DECISIONS?

In an effort to explore how culture influences human behavior and decision making, we will examine empirical data from three different cases: reciprocity and cooperation, mate selection, and food choice. We use these concrete cases to: (a) demonstrate that many important human decisions cannot be understood as products of built-in cognitive algorithms, devoid of cultural input; (b) delineate the debates about how to approach such issues; and (c) suggest lines of future research.

Does Culture Influence Decision-making Related to Reciprocity and Cooperation?

Evidence from cross-cultural experimental economics strongly suggests that cultural differences can substantially affect the patterns of reciprocity and cooperation found in different social groups. In recent experimental work from the Peruvian Amazon, Henrich (2000) has shown that Machiguenga horticulturalists greatly deviate from the behavior of typical western subjects in both the ultimatum and a common pool resources game. In the ultimatum game, Machiguenga proposers yielded an average offer of 26% of the total pot, and a modal offer of 15%, while typical ultimatum proposers (those found in urban, industrial societies) produce a mean around 44% and a mode of 50%. Similarly, in the common pool resources game, Smith and Henrich found that Machiguenga players yielded a mean contribution of only 23% to the common pool and a modal contribution of 0% (complete defection) as compared to typical U.S. mean contributions of between 40% and 60%. Henrich also found quite different results (as compared to westerners) among the Mapuche, an indigenous group of small-scale peasant farmers in the agricultural plains of central Chile (Henrich and Smith 1999).

Even in places as culturally similar as East and West Germany or Israel and Pittsburgh, we find more similar, but still significantly different, results in these games. In a study of solidarity and cooperation experiments conducted in eastern and western Germany, it was observed that eastern subjects behave in a significantly more selfish manner than do western subjects. The solidarity game, which was invented by Selten and Ockenfels (1998), is a three-person game in which each player independently wins DM 10 with probability 2/3. Before the random decisions are made, each player has to decide how much he or she is willing to give to the losers in the group in the case of winning. Ockenfels and Weinmann (1999) observe that the conditional gifts made in anonymous experiments in eastern Germany are dramatically smaller than the corresponding gifts in western Germany. Moreover, average expectations about the conditional gifts of the other group members match average gifts within each population (but, of course, not across populations). Analogous effects are observed in standard public goods games. The authors conclude that cooperation and solidarity behavior depend on different culture-specific norms resulting from opposing economic social and economic histories in the two parts of Germany. Ultimatum game experiments performed by Roth et. al. (1991) have also demonstrated that

significant cultural differences exist between Israeli students from Hebrew University (with a mean proposer of 0.36) and American students from Pittsburgh (with a mean proposer offer of 0.44).

In these cases, simple heuristics like "give half" or "take almost everything" operate quite well, given that others in your group possess similar and complementary rules. Such rules allow people to make pretty good decisions without any computation and without knowing much about how others will behave. In general, people's heuristics seem well calibrated with other members of *their* group.

A variety of approaches may account for these data. There seem to be two basic starting points. Starting point 1: people come into the world with a propensity to reciprocate and behave "fairly" with anyone (kin, friend, or anonymous person), but they are sensitive to socio-environmental cues, which allow them to adjust or calibrate their degree of trust and trustworthiness and their expectations of fairness and punishment in adaptive ways (ways that fit with the current pattern of social interaction so they avoid being exploited). Such cues may be social interaction or cultural. Social interaction cues mean that either individuals rapidly learn from small samples of failed or successful interactions, or they use some ethological signal (e.g., narrow eyes, hunched shoulder, downturned head) to update or adjust the relevant parameters (like degree of trustworthiness). Culture users would ignore ethological cues (at least innate ones) and save the costs of failed interactions by copying the dispositions, degree of trust, or behavioral patterns of others. From an evolutionary perspective, however, it remains unclear how this tendency toward generalized reciprocity could have evolved, although Richerson and Boyd (1998) have suggested one coevolutionary possibility.

Starting point 2 maintains that humans come predisposed to cooperate/reciprocate with *only* kin and "close friends" (i.e., "reciprocal altruism" or repeated interaction with known individuals).[3] This assumption derives from empirical work in simple horticultural and forager societies. In these places, people do not interact with, trust, or expect anything from anonymous individuals who are not friends or relatives. Even when governments, missionaries, and locally inspired leaders attempt to conduct group projects that would surely benefit the entire community, individuals do not cooperate or fail to reciprocate. Even imposed sanctioning methods fail to maintain cooperation and reciprocity in many cases.

From an evolutionary perspective, interacting and cooperating with anonymous individuals is probably a recent problem (last 10,000 years). Thus the development of anonymous exchange and cooperation results from cultural evolutionary processes, and requires that each individual acquire an entire behavioral model about how to deal with specific types of situations. This has three implications: (a) humans are probably heavily reliant on cultural transmission

3 Both cooperation with kin and reciprocal altruism are also found among other primates, although the data on reciprocal altruism remains sparse.

(so reliant that cultural input can fundamentally structure one's basic economic-interactional behavior); (b) behavioral rules and mental models will be specific to certain cultural domains, and will not translate across all cooperative/exchange possibilities; and (c) people who achieve effective cooperation in different societies may possess entirely different decision-making algorithms or heuristic models. Both allow their possessor to navigate effectively, but each embodies entirely different assumptions about the world.

One line of evidence that bears on this debate comes from recent work by experimental economists on signaling in exchange interactions. Ockenfels and Selten (1998) examined involuntary truth-signaling with the help of a simple two-person bargaining game with face-to-face interaction. Players bargain about the division of a fixed sum of money. Each bargainer could either have costs subtracted from his or her bargaining agreement payoff or not. The cost situations were neither known by the opponents nor by onlookers who observed the bargaining. It is shown that the cost guesses of the onlookers are somewhat more accurate than chance. However, this effect is entirely explicable by the onlookers' information about "objective features" of the bargaining process and not due to involuntary physical cues. Also, onlookers were not able to discriminate between liars and truth-tellers among those bargainers who explicitly asserted to have costs. The authors conclude that there is no evidence for involuntary truth-signaling in their bargaining experiments. Psychological studies suggest that the hypothesis of involuntary truth-signaling may have some merits in different contexts. However, people's ability to detect lies is quite modest (Zuckerman et al. 1981; Gilovich et al. 1998).

If these researchers are correct, and this result can be generalized, then we can eliminate ethological signaling as one of the potential cues that might calibrate an individual in the generalized reciprocity model (starting point 1). This leaves us with two potential cues: individual experimental samples or direct cultural transmission of behaviors and/or dispositions.

How Are Cooperation, Reciprocity, and Fair Exchange Maintained within Groups?

This is a large topic so we'll just sketch the debate and make a few comments. Cooperation among anonymous, unrelated individuals is notoriously difficult to explain. Most researchers believe that cooperation is maintained by an appropriately sized threat of punishment, such that deviations from cooperative behavior incur sufficiently large penalties that defections "don't pay." However, invoking punishment creates a new problem: how to explain punishment. Punishers can be exploited by nonpunishing cooperators (NPCs) when punishing has a cost. NPCs always cooperate, but cheat when it comes time to punish noncooperators, and therefore get higher payoffs than punishers do (Boyd and Richerson 1992).

Theorists have attempted to solve this problem in three ways:

1. Some ignore it by assuming that a State or some other overarching institution does the punishing.
2. Others incorporate a recursive punishing method in which punishers punish noncooperaters and other punishers who fail to punisher any nonpunishers, etc., in an infinite regresss.
3. Still others assume punishing is costless.

Solution 1 just moves the problem back to why we have States and institutions, and in answering this question one gets hung back up on the horns of the same old dilemma. The second solution seems entirely unrealistic to many people. Do people really punish people who fail to punish other nonpunishers? Solution 3 seems unrealistic too. Any attempt to inflict costs on another must be accompanied by at least some tiny incremental cost.

Cultural transmission mechanisms, however, may provide a fourth means to solve the problem of cooperation and punishment. A mechanism like conformist transmission, which creates a directional force that maintains common behaviors, can act to maintain cooperative behaviors in populations — when they are common — by reducing the appeal of rare noncooperative and nonpunishing behaviors. Because second- and third-order defections (not punishing rare nonpunishers) have such small differential payoff advantages, conformist transmission can act to eliminate the replicatory viability or advantage of such strategies effectively, as long as they remain rare. This makes cooperation possible and reduces the cost or frequency of the punishment required to maintain cooperation.

Some empirical evidence supports this argument by suggesting that cooperation levels are too high, given the potential for and cost of punishment. The legal system, for example, often ends up to be more costly than simply ignoring the transgression. Courts recognize this, e.g., small claims, etc., but individual opportunity costs are not taken into account. In this sense, courts are a threat that are not used very often — low frequency of use keeps costs down. However, if the threat were credible so that large numbers of law-breakers went to court, then the system would be too costly and would fail. Similarly, tax compliance in the U.S. is too high, given the probability of being caught for cheating and the size of the penalty — particularly in comparison to other nations where people cheat more, get caught more, and receive stiffer penalties.

Our discussion suggests several lines of future work. First, the relative importance of specific culturally evolved models of exchange/cooperation vs. a genetically evolved generalized reciprocity can be tested by performing experimental games with different, culturally appropriate mediums of exchange. If foragers, for example, were to behave the same when the stakes are paid with meat (or honey) instead of money, then a generalized reciprocity would seem likely. If people behave differently (and predictively) with different mediums, then this suggests that people have special sets of rules for exchanging different mediums — which supports the cultural models line of reasoning.

Second, the "protection game" should be further incorporated into our arsenal of experimental games, so we can differentiate behavioral orientations or decision algorithms related to exchange from those consistent with other social contexts (and establish if and how context matters). In general, testing people's behavior under different contexts will allow researchers to identify the cues that individuals use to select among different rules or strategies.

Third, experimentalists should team up with geneticists to figure out what proportion of the variation within experimental game samples can be explained by genes, common-family environments, and other factors, like the cultural milieu. Experimentalists could administer economic games to subsamples from the existing data bases that geneticists use to sort out the genetic and environmental components of personality, behavior, and preferences.

Fourth, experimentalists need to incorporate further study of their subjects' behavior and decisions outside the laboratory — in the real world — to determine how performance in these games maps onto actual behaviors. Perhaps experimental economists should team up with anthropologists and sociologists who can observe and interview experimental subjects in real-life socioeconomic interactions — in their jobs, homes, volunteer work, and economic dealings.

Mate Selection

Mate selection is a very old problem. One might think that, given the evolutionary importance of this problem and the amount of time natural selection has had to work on it, humans would have innate, highly refined cognitive algorithms for picking mates. It turns out, however, that while there are some regularities like women's preferences for wealthy, powerful men, and men's preferences for some physical features in women, people living in different groups select mates in an extraordinarily wide variety of ways. Among the Kipsigis (e.g., Borgerhoff Mulder 1988), for example, brides are sold for cows in a marriage market. Brides are priced just as one would guess: the fattest ones fetch the most. This contrasts with our own societies where most things are openly sold on the market, except of course wives. In other places, parents select marriage partners for their children and, depending on the place, the children may or may not be able to decline. Among many Amazonian groups, the ideal partner is someone who does not speak your native language (Jackson 1983), or someone who is your mother's brother's daughter (i.e., your first "cross-cousin"; Johnson 1986). To understand how someone in a particular place picks a mate, one needs to understand the cultural models acquired by individuals from those around them.

How Does Culture Influence Food Choice Decisions?

Selecting a food, like selecting a mate, is an important evolutionary problem that natural selection has had a long time to perfect. However, unlike mate selection, which most do only a few times per life, food choices are amenable to repeated trials and small improvements, which — one might think — make it more likely to be solved through some individual sampling algorithm that would allow humans to find food fast in any environment. However, with the exception of innate preferences for the taste of salt, sugar, and fat, and certain food avoidance learning responses, humans possess an incredibly diverse culinary repertoire that is highly dependent on cultural input.

Some comparative examples of food preferences will illustrate the diversity of human food choice. Many people in the Midwest of the U.S. will not eat lamb, ostensibly because they have some vague notion that it causes disease. Meanwhile, people elsewhere in the U.S., with access to the same sheep, love to eat lamb. In the U.S. most people would not think of eating horse, despite the fact that it's lower in cholesterol and fat than most other red meats, favorable characteristics for many Americans. Meanwhile, the Mapuche of Chile, who rely on horses as their primary mode of transportation, frequently eat horse meat, although they prefer pig because it has more fat (horse is way too lean for them). Many Germans believe that drinking water after eating cherries is deadly; they also believe that putting ice in soft drinks is unhealthy. The English, however, rather enjoy a cool drink of water after some cherries, and Americans love icy refreshments.

In Peru we find an interesting comparative case. Among the Machiguenga of the Peruvian Amazon, nobody ever eats snake meat. If you ask people what happens if you eat snake, they say that you will throw up blood and die. Nobody admits to ever having eaten snake, and they say that they do not know anyone who has ever eaten it. Meanwhile, just down river from this Machiguenga village is a Mestizo village inhabited by immigrants from the Andean highlands who have retreated into the tropical forest in search of arable land. These Mestizos, who have periodic contact with the Machiguenga, believe snake meat is fine to eat, and do consume it, when the occasion presents itself — although they do not hunt snakes or raise them, like the Chinese do.

The Machiguenga have another curious dietary preference (besides stopping along the trail to snack on the fat-rich larva found under decaying logs). The recent sedentization of Machiguenga families into communities has depleted the availability of wild foods, which have traditionally supplied the Machiguenga with critical sources of vitamin A and C. Recognizing the rising problem, protestant missionaries planted lemon and grapefruit trees throughout the community, and these trees have subsequently multiplied. Presently, despite their ongoing deficiencies in vitamins A and C, few Machiguenga have adopted the practice of consuming these abundant fruits. When asked, Machiguenga will explain that they do not consider the fruits a food and find it strange that outsiders seem to like them so much.

Except in its ritual form during Christian ceremonies, consuming human meat, blood, or bone marrow is rare among Westerners, but many peoples consume these for symbolic and perhaps even for nutritional reasons. The Foré people of New Guinea, for example, consume the brains of dead relatives (Durham 1991). In Mexico, Aztecs distributed the choice limbs and organs of sacrificial prisoners-of-war to valorous warriors for ritual consumption (Price and Feinman 1993). In the Amazon, the Yanomana consume the bone marrow of deceased relatives in a rite of ancestor worship (Chagnon 1992).

Few mammals ever eat their own kind, presumably because this meat may carry harmful microorganisms that are well adapted to the consumer. Despite this strong aversion to cannibalism in most mammals, humans, because of their immense reliance on culture transmission, may acquire a taste for their own kind, and cultural evolutionary processes may maintain these preferences through time under certain socio-environmental conditions.

Culturally transmitted preferences are so powerful that they can overcome physiological aversion. For example, capsicums (e.g., chili peppers) possess the chemical equivalent of pain. When anyone eats them for the first time, it's an unpleasant experience. Yet, under certain ecological conditions, particularly in tropical regions, the habit of eating capsicums, often with every meal, is widespread. Evidence suggests that eating capsicums, storing food in their marinades, and applying capsicum sauces to foods generates a number of adaptive results. In places where food cannot be stored and bacteria infestation is likely, capsicums supply vitamins (especially vitamin C) in a form that can be stored for long periods. Actually eating capsicum probably helps control parasite loads, which are a primary cause of death among children throughout the developing world. Food stored in, or "treated" with, a capsicum sauce lasts longer and is much less likely to spoil. Here we find an adaptive behavior using what should be an aversive food, yet most of these people think they just like to eat chilies.

Human children do not arrive in the world being disgusted by any particular foods or classes of foods, although they will react negatively to very bitter things (Rozin and Fallon 1986). Children will happily eat bloodworms or solidified chunks of bacon fat. It seems that children connect the emotional reaction of disgust to particular foods by observing the disgust reaction of other individuals. Often, as we all probably know well, no amount of nutritional information or well-meaning recommendations can change these emotional connections once they are solidly in place.

As a learning heuristic, cultural information channeled by social learning algorithms acts to limit choices and direct attention to certain reliable dietary options. It solves the otherwise difficult and costly problem of figuring out what to eat in widely varying environments that range from the Arctic tundra and the Amazon. Cross-cultural evidence clearly indicates that human tastes are incredibly flexible, and people seem to rely enormously on imitating the taste preferences of those around them.

ARE CULTURAL PREFERENCES, CUES, AND DECISION PROCESSES ADAPTIVE?

A survey of the cross-cultural data yields a large number of cases in which human cultural practices seem well adapted to their environments, yet we still find a substantial number of clearly maladaptive cases (Edgerton 1992). We will begin with two illustrations.

Favism, a genetically transmitted disorder, provides a good example of how culture can be both adaptive and maladaptive. Fava beans are an important food in many parts of Europe that border the Mediterranean compared to other areas in Europe. According to Katz and Schall (1986), fava bean use coincides with the areas in which malaria was prevalent during historical times, an intriguing result in light of the fact that fava beans contain a chemical which acts as a malarial prophylactic. It also turns out that an X-linked genetic condition called G6PD deficiency is also common in the same areas in which malaria was endemic. Women who are heterozygous for the G6PD allele are also resistant to malaria. Thus it is plausible that fava bean consumption and G6PD deficiency both represent evolved responses to malaria: one cultural and the other genetic. However, there is an interesting interaction between these practices that shows how culture can be maladaptive as well. Men who carry the G6PD-deficient gene get sick when they eat fava beans because, in effect, they overdose on their malaria medicine. This disease, called favism, is a significant health problem in places like Sardinia in which fava beans are an important part of the cuisine, and in which G6PD deficiency is common. Thus, the cultural heuristic "fava beans are good to eat — include a lot in your diet" causes many people to avoid malaria, but at the same time causes the G6PD deficient to suffer serious health consequences.

It's also interesting that people living in these areas believe malaria is caused by "bad air" (and thus the name "mal" [bad] aria [air]). One locally prescribed measure that helps to prevent this "bad air" condition is to keep all the windows shut, especially at night. This preventive scheme has the fortunate side effect of also keeping mosquitoes out.

Among the Foré people of New Guinea, the practice of eating the brains of dead relatives has maladaptive and dire consequences, especially for women. While preparing the raw brains of a deceased relative for cooking, a woman sometimes contracts Kuru (a human version of Mad Cow Disease) from contact with brains.[4] Months later, this disease eventually produces a horrible death, as the victim gradually goes violently insane. Then, while her female relatives repeat the ritual in preparing her brains, they too may contract the disease and

[4] Eating the brains may be a secondary means of disease transmission, as this virus is particularly resistant to heat and may sometimes survive the cooking process.

continue the cycle. Women were also forced to eat the brains more often, because men believed that human flesh diminished their combat prowess, and thus they preferred to eat pork (Durham 1991). Interestingly, southern Foré women apparently came to prefer to eat Kuru victims and found them particularly tasty, as they were more tender and fatty than other recently deceased individuals (Glasse 1963, p. 13).

When complex cultural practices and preferences spread incompletely or too rapidly from one place to another, we often find quite maladaptive cultural practices. Amazonian Indians have long cultivated bitter manioc in the infertile, acidic soils of the Amazon basin where sweet manioc cannot grow. To remove the cyanide from this long root crop, indigenous Amazonian groups have a routinized preparation, which involves grating, boiling, and repeatedly rinsing the manioc. Eventually Europeans brought bitter manioc to Africa, where it spread rapidly into regions where agriculture had previously been impossible. Unfortunately, the processing model was transmitted incompletely or, in some cases, not at all. The sad result is that many African cultivators of manioc die quite young — once the cyanide has accumulated beyond toxic levels (Frechione 1998).

When are cultural products (i.e., fast, frugal algorithms) adaptive and when are they maladaptive? This question will go largely unanswered; however, four things are relatively clear. First, cultural products can rapidly become maladaptive when environments change too quickly, or when individuals migrate into environments that are too different from their previous environments. Second, groups vary immensely in their concern for and punishment of norm violations, which affects the operation of within-group cultural evolutionary processes. Sometimes cultural groups adopt very high levels of norm enforcement that severely suppress the individual variations, innovations, and "errors" that innate cultural transmission mechanisms require to generate adaptive evolutionary processes within groups — although slower between-group selection processes may eventually sort this out (e.g., the Foré are gradually disappearing).

Third, historical and archaeological evidence indicates that group size (population size) and degree of interconnectedness or contact with surrounding groups strongly affect cultural evolutionary rates. For example, eight thousand years ago a technologically sophisticated, stone-age group of Australian aborigines settled on the island of Tasmania, where they were subsequently isolated for thousands of years. When the Europeans arrived in 1835, they found the most technologically simple people on earth. The Tasmanians had lost a vast repertoire of complex technologies including fishhooks, canoes, nets, and even the knowledge of how to make fire (Diamond 1978). This is certainly not an isolated story.[5] The ethnographic, historical, and archaeological record is full of cases in

[5] It is probably also no coincidence that the most technologically sophisticated and complex societies on earth have all arisen from the world's largest and most interconnected continent, Eurasia (see Diamond 1997).

which small, isolated groups began to lose the cultural knowledge that allowed them to adapt. Large, interconnected populations, if nothing else, allow populations to resist the long-term effects of random cultural drift by storing many copies of the relevant information throughout a dispersed metapopulation (through several populations)

Fourth, social structure, together with innate biases about who to imitate, and certain cultural beliefs may eliminate valuable innovators, experimenters, and error-makers from being viewed as people to copy. For example, in the case of food choice, innovation is suppressed because "innovators" and "experimenters" are usually young children, or because "novel" food choices are observed only among individuals from ethnically or social disenfranchised groups.

FURTHER RESEARCH

Understanding how and why cultures change requires understanding the details of why certain ideas or practices spread, and why others do not. Understanding and analyzing the factors that influence how rapidly novel beliefs, preferences, cues, decision models, and values diffuse through populations, demands detailed laboratory and field research in which individual ideas, decision methods, or preferences are tracked as they spread through populations.

We close by briefly summarizing the decision-making challenges confronted by cultural transmission mechanisms, cultural-evolutionary products, and social decision mechanisms, and how this is accomplished.

1. Cultural transmission mechanisms speed up learning by skipping costly individual experimentation, sampling, and data processing.
2. Cultural-evolutionary products limit choice sets. For example, norms of fairness in ultimatum games (when played in industrial societies) provide players with a quick, easily-calculated method of getting a pretty good answer. Yet, similar norms would perform poorly among the Machiguenga.
3. Cultural-evolutionary products limit choices in explicit decision making by providing simple mental models, built upon our most basic cognitive abilities (e.g., spatial and temporal representation), which may effectively exploit features of the environment to simplify processing and improve accuracy. The medieval tidal computer is one such example.
4. Social decision mechanisms solve adaptive problems that individuals could not by distributing memory, computations, and skills among individuals. Micronesian navigation (Hutchins 1980) is one example; others include decision-making institutions and governance structures.

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