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by

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The evolution of costly displays, cooperation, and religion. Inferentially potent displays and their implications for cultural evolution

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Abstract

This paper lays out an evolutionary theory for the cognitive foundations and cultural emergence of the extravagant displays (e.g., ritual mutilation, animal sacrifice, and martyrdom) that have so often tantalized social scientists, as well as more mundane actions that influence cultural learning and historical processes. In Part I, I use the logic of natural selection to build a theory for how and why seemingly costly displays influence the cognitive processes associated with cultural learning—why do "actions speak louder than words." The core idea is that cultural learners can avoid being manipulated by their potential models (those they are inclined to learn from) if they are biased toward models whose actions/displays would seem costly to the model if he held beliefs different from those he expresses verbally. I call these actions *inferentially potent displays*. Predictions are tested with experimental work from psychology. In Part II, I examine the implications for cultural evolution of this evolved bias in human cultural learning. The formal analytical model shows that this learning bias creates evolutionarily stable sets of interlocking beliefs and individually-costly practices. Part III explores how cultural evolution, driven by competition among groups or institutions stabilized at alternative sets of these interlocking belief-practice combinations, has led to the association of costly acts, often in the form of rituals, with deeper commitments to group beneficial ideologies, higher levels of cooperation within groups, and greater success in competition with other groups or institutions. Predictions are explored with existing cross-cultural, ethnographic, ethnohistorical and sociological data. I close by briefly sketching some further implications of these ideas for the study of religion and ritual.

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Researchers from across the social and biological sciences have long proposed a connection between seemingly costly displays, often in various ritualized forms—such as firewalking, ritual scarification, animal sacrifice, and subincision[1]—with deep levels of commitment to group ideologies, religious beliefs, and shared values that promote solidarity and in-group cooperation (Atran and Norenzayan, 2004; Cronk, 1994; Durkheim, 1995; Irons, 1996; Radcliffe-Brown, 1952; Rappaport, 1999; Sosis and Alcorta, 2003a). This paper provides a novel approach to understanding these observations by considering how natural selection might have shaped our cognitive processes for cultural learning so as to give salience to certain kinds of displays or actions, and what the implications of such cognitive processes are for cultural evolution. Since the goal of this paper is merely to get this approach on the table, where it can properly compete with alternatives, I aim to provide a *prima facie* case for considering these ideas, and not a set of conclusive tests.

The argument proceeds in three parts. Part I lays out a theory for the evolution of one particular component in the suite of cognitive adaptations that make up the human capacity for cultural learning. The core idea is that, with the evolution of substantial communicative capacities in the human lineage, cultural learners are potentially exploitable by manipulators who can convey one mental representation but actually believe something else. To contend with this adaptive challenge, I propose that learners have evolved to attend to, alongside the linguistic expressions of those individuals whom they are learning from (their models), *inferentially potent displays* by these models. Such displays or actions provide the learner with reliable cues that the model is actually committed to (i.e., believes in) the representations that he has expressed symbolically (e.g., verbally) and cheaply. Learners should use such displays in determining *how much* to commit to a particular culturally-acquired mental representation (an ideology, value, belief, strategy, preference or practices). After laying out this idea, I summarize supporting experimental evidence from psychology.

Building on the existence of this aspect of our evolved cultural learning capacities, Part II explores whether such a bias could create interlocking sets of beliefs and costly practices that are self-stabilizing. That is, can this adaptive learning bias lead to the emergence of stable

[1] Subincision, a common traditional ritual practiced in many societies, involves slitting the penis lengthwise along the urethra. As part of rites of passage, it is done to boys without anesthetic.

combinations of widespread beliefs and costly practices (displays) in a social group, which could not otherwise persist (remain stable). My formal model reveals the conditions under which we expect to find interlocking sets of costly practices and beliefs. Such stable cultural evolutionary states are interesting because they show how particular displays or acts, which appear costly to one who does not hold the relevant corresponding belief, are sustained.

Part III considers the possibility that if this evolved bias for using inferentially potent displays can stabilize interlocking sets of beliefs and costly practices, it can also sustain costly practices that elevate the commitment of group members toward beliefs and practices that promote group benefits, larger-scale cooperation and solidarity, and in particular, favor success in competition with other social groups or institutions. This competition among stable culturally-evolved states favors social groups or institutions that are increasingly constituted by combinations of beliefs, that favor in-group cooperation/harmony and out-group competition, and practices (e.g. rituals) that maximize participants' commitment to those beliefs.

To explore the plausibility of these ideas, I summarize evidence from sociology, psychology, and anthropology confirming three predictions from the model: (1) participation in costly rituals is associated with prosocial in-group behavior, *because* costly rituals transmit commitment to group-beneficial beliefs/goals to participants, (2) institutions requiring costly displays are favored by cultural evolution because costly displays by members transmit higher levels of belief-commitment and thereby promote cooperation and success in inter-group or inter-institution competition, and (3) costly rituals spread via social learning from less successful groups to more successful groups because costly rituals affect groups' success by increasing members' commitment to the group and galvanizing greater cooperation.

In the concluding Discussion, I consider some further implications of this line of reasoning, with a focus on religion, by explaining how such cultural evolutionary processes might help explain why (1) religions are often associated with prestigious paragons of virtue who make (or made) costly sacrifices, (2) martyrdom is persuasive (i.e. inferentially potent), (3) religions and rituals are loaded with sacrifices of various kinds, (4) counter-intuitive agents (e.g., gods or ancestors) want costly acts, (5) religious leaders take vows involving sex, fasting, and wealth, and (6) counter-intuitive agents like Mickey Mouse are not gods. I hope these preliminary suggestions may eventually complement the important ongoing work at the interface

of religion, cognitive science, and evolution (Atran and Norenzayan, 2004; Barrett and Nyhof, 2001; Boyer, 2001; McCauley and Lawson, 2002; Sosis and Alcorta, 2003b; Whitehouse, 2000).

The Evolution of our Cultural Capacities

In the last three decades the application of the logic of natural selection to the evolution of social learning, and in particular to the evolution of our species' capacity for cultural transmission, has produced an array of novel theoretical insights, hypotheses, and empirical findings (for reviews see: Henrich and McElreath, 2006; Henrich and McElreath, 2003; Richerson and Boyd, 2005). One of the central lines of inquiry arising from this research program has focused on how our cultural learning processes can more effectively and efficiently acquire adaptive ideas, beliefs, values, preferences and practices from the others in our social world. The set of related hypotheses about these cognitive-operational details can be partitioned into two categories, those based on contextual cues (e.g., based on the frequency of a belief or practice, or on model-based cues like prestige, success, ethnicity, or sex) and those derived from content cues (e.g., the details of the mental representations themselves that make them more memorable, more desirable, etc.). Below, I briefly review work in this area in preparation for laying out the *inferentially potent displays hypothesis*, the central evolutionary idea in this paper.

Context biases

Contextual learning mechanisms use cues to allow learners to more effectively extract and integrate information from the range of individuals available to them in their social milieu (Henrich and McElreath, 2003). Two specific cognitive mechanisms have been proposed, formally modeled, and empirically substantiated. The first, often glossed as *prestige-biased transmission* (Henrich and Gil-White, 2001), proposes that cultural learners use model-based cues to figure out who, among their potential *models* (those from whom they could learn), is most likely to posses adaptive information (i.e., mental representations) suitable to the learner's current situation (e.g., his/her role in the social group). Theory suggests, and a wide range of empirical findings have confirmed, that both children and adults preferentially pay attention to and learn from prestigious/successful models, especially when they match the learner on ethnicity (marked by dialect, dress, etc.) and sex (Henrich and McElreath, 2006; Henrich and

Gil-White, 2001; Henrich and Henrich, 2007: Chapter 2). These effects influence cultural transmission across a wide range of representations, including opinions, economic decisions, food preferences, strategies, beliefs, technological adoptions and dialect. Moreover, these biases appear to operate across domains of expertise, as experts or stars in one field or endeavor (e.g., basketball) are granted influences in other arenas (e.g., clothing choice or politics). Given this learning bias, and anticipating what is to come below, a highly prestigious individual motivated by self-interest could express an opinion, belief or preference different from her own, that—once adopted by others—could yield benefits to her and costs to the learners.

The second cognitive mechanism, termed *conformist transmission*, focuses on how learners can best weigh and integrate observations from multiple models (Boyd and Richerson, 1985: Chapter 7; Henrich and Boyd, 1998). Learning mechanisms that 'copy the majority', 'average what most prestigious individuals are doing' or otherwise blend information from different models (e.g., apply a robust estimator) allow learners to effectively aggregate information across models and reduce transmission noise (i.e., errors introduced during the process of observation and inference in learning). Such processes allow learners to extract mental representations that are more adaptive, on-average, than anything learners could acquire from a single model (Henrich and Boyd, 2002), or figure out on their own. As with the prestige-biased transmission, substantial amounts of empirical work from across the social sciences confirm the predictions derived from formal models of conformist transmission (see summaries in Henrich and McElreath, 2006; Henrich and Henrich, 2007: Chapter 2).

Content biases

Evolutionary approaches to cultural transmission also provide a rich set of cognitively-informed hypotheses regarding how the content of representations influences their transmission (Boyd and Richerson, 1985: Chapter 5; Sperber, 1996). The general insight here is that learners should pay particular attention to and remember representations likely to contain adaptively useful information. Specifically, cultural learners should be more likely to pay attention to and store representations when these are judged, *ceteris paribus*, more (1) potentially actionable, (2) emotionally evocative and (3) plausible or compatible:

1) *Potentially actionable* means that the content of a representation leads to inferences that can readily influence subsequent actions, including additional inferences (Inferential Potential: Boyer, 2001). Representations, for example, in which the causes of unpleasant circumstances (e.g., storms or illnesses) are random with respect to the actions of those afflicted don't lead to useful or helpful inferences or actions, and thus are not easy to maintain. Evolutionarily non-actionable representations need not be stored because they can't help you even if you do remember them. Instead, representations that involve believing that illnesses are caused by the jealously of others (e.g., the "evil eye") can lead to inferences about who might be causing a particular illness and how one can avoid such illnesses in the future.

2) *Emotionally evocative* responses to representational content yield a measure of potential fitness-relevance, at least in ancestral environments. Representational content that sparks more positive or negative emotional responses should be biased in storage, recall, and potentially in subsequent transmission. Some research suggests that when representations are initially encountered they are spontaneously analyzed via simulation "as true" resulting in immediate emotional responses (Gilbert, 2007). If such simulations readily deliver affective reactions such as disgust, fear, etc. more cognitive resources are devoted to analyzing and storing the relevant information, leading to biases in cultural evolution. Evolutionary approaches regarding the origins of emotional or affective reactions to particular stimuli or content lead to a wide range of more specific hypotheses. Some examples below help clarify this.

3) *Plausible or Compatible* involves a variety of expectations that a learner might have about how the world works and, consequently, what is more and less likely to be true. Some expectations rely heavily on our reliably developing intuitions, including cognitive processes related to such domains as mechanics and biology. For example, representations from modern physics, which involve objects (e.g. electrons) that exist only probabilistically at any point in space, violate our intuitive expectations from folkmechanics and thus don't readily transmit. Such plausible or compatible content biases can also be culturally acquired, such that the possession of one mental representation biases the acquisition of others. That is, having acquired a particular idea via cultural transmission, a learner may be more likely to acquire another idea, because the two "fit together" in some cognitive or

psychological sense. For example, believing that performing a certain ritual in the spring will increase the crop harvest in the summer might favor the acquisition of a belief that a similar ritual will increase a woman's odds of conception, a healthy pregnancy, and the successful delivery of a robust infant.

Hypotheses generated by an evolutionary approach to representational content biases are finding a wide range of empirical support. For example, Barrett (2007) has shown that children from both the Ecuadorian Amazon and Los Angeles recall experimentally-transmitted information about the dangerousness of novel animals better than name-labels (e.g., peccary) or diet information (e.g., herbivore). Information about danger is emotionally evocative (fear), actionable (one can avoid these animals) and plausible (actual images of these animals were used so teeth, size, etc. cues would not violate plausibility). Similarly, Fessler (2003) has proposed that since meat is more likely to carry pathogens dangerous to humans than other foods, taboos directed at meat ought to be more prevalent than for other kinds of foods. Consistent with this, analyses of cross-cultural data have shown that meat is by far the most tabooed category of foods. Within the above framework, this argument suggests that humans are biased to be emotionally evoked by meat (disgusted) compared to other foods. Taboos on meat are also potentially actionable (e.g., avoid those foods) and plausible (e.g., some animals should not be eaten).

Research on how the content of stories (e.g., rumors and urban legends) influence their differential cultural transmission shows that successful stories are both more plausible and more emotionally evocative than less successful variants. Heath and colleagues (2001) show how the differential success of urban legends is influenced by both their judged plausibility and their emotional evocativeness (principally focusing on their disgustingness). Similarly, older lines of research on rumor demonstrate that content related to the three C's—crisis, conflict and catastrophe (which presumably evoke negative emotions)—favors more successful transmission (Rosnow, 1980).

Exploring a content-bias hypothesis related to religious concepts, research has demonstrated how the presence of counter-intuitive content in concepts or narratives can biases memory (Barrett and Nyhof, 2001) in a manner that would favor such concepts or narrative in cultural evolution. Counter-intuitive concepts or events violate our core assumption about the

nature of things in the world, usually about intentional beings, animals, inanimate objects, or events (expectations often associated with the cognition domains of folkphysics, folkpsychology, and folkbiology). Examples of counter-intuitive concepts from this literature are "a person who can be in two places at once" (Boyer and Ramble, 2001) and a "thirsty door" (Norenzayan et al., 2006). The presence of a few counter-intuitive concepts in a narrative, even within a list of otherwise ordinary concepts, improves for the entire narrative or list.

From the perspective just presented, many counter-intuitive concepts probably create complex mixtures of *plausibility*, *applicability*, and *emotional evocativeness*. Many religious beliefs, for example, would appear to be less plausible, more applicable, and more emotionally evocative than alternative non-religious concepts or explanations. Counter-intuitive concepts, by their very nature, make stories or beings seem *less plausible* (less believable) which is likely why the optimal number of such violations is small. In an analysis comparing a sampling of successful and unsuccessful Grimm's fairy tales, successful (widely known) fairly tales had 2 or 3 counter-intuitive violations (Norenzayan et al., 2006). Successful counter-intuitive representations are also likely to generate emotional responses, like fear or interest (see Fredrickson, 1998 for a discussion of positive emotions like interest), as well as actionable options and additional inferences. From this evolutionary account, it may be that people come to believe in, and commit to, counter-intuitive agents (e.g., God) despite—not because of—their counter-intuitiveness. Other elements of human cultural learning need to be brought to bear on this counter-intuitiveness, to overcome it and favor widespread transmission. The existing empirical work is consistent with this view. Counter-intuitive concepts ought to be better remembered—but not committed to or believed in—because, if true, they are important adaptively-relevant information. Accepting them as true, however, will require additional learning cues not derived from representational content. Below, I argue that the inferential potent displays are one such cue.

An increasing amount of work is indeed suggesting that children may be more inclined to believe in—as opposed to recall—intuitive concepts over counter-intuitive concepts (Bloom and Weisberg, 2007; Harris and Koenig, 2006; Harris et al., 2006). Harris and colleagues have compared children's beliefs in scientific concepts that defy first-hand experience but do not produce counter-intuitive violations (e.g., germs and oxygen) with counter-intuitive concepts endorsed by adults (Santa Claus, Tooth Fairy and God) and counter-intuitive concepts not

endorsed by adults (mermaids, ghosts, and monsters). Their findings show that children believe more in endorsed scientific concepts than in endorsed counter-intuitive concepts, suggesting that counter-intuitiveness does not appear to boost degree of belief (or confidence) in such concepts when facing off against intuitive but still undetectable entities, such as germs. This work also shows that counter-intuitive cultural concepts, like mermaids, which are prominent but do not motivate the actions and causal explanations of models (like adults), are not believed in by young children. In fact, young children seem biased against accepting the existence of such counter-intuitive entities. I will return to this work in the next section. Consistent with this work, Mead's (1932) classic study of animism on the island of Manus in New Guinea suggests that children do not readily commit to, or readily believe in, the counter-intuitive concepts they hear expressed by adults. In fact, they seem somewhat resistant to adopting such concepts.[2]

We will return to this work as it relates to religious representations in the Discussion, where I will address what is one of the central challenges to this approach to religion: the Mickey Mouse Problem. The Mickey Mouse Problem is the idea that while many counter-intuitive concepts, like God or Mickey Mouse, are highly successful in that they inhabit the minds and memories of millions, there is an important difference: people, at least some, are deeply committed to God, organize their lives around him/her/it, and might even die for their God. Mickey does not engender such commitments, despite Disney's best efforts. So, the question is: Why is God different from Mickey Mouse?

Part I: The emergence of an adaptive challenge

The evolution of high fidelity cultural learning, with all its adaptive benefits (Boyd and Richerson, 1995), increases the potential for exploitation by other members of one's group

[2] These findings may seem at odds with other recent work in developmental psychology demonstrating a willingness to accept certain kinds of counter-intuitiveness (e.g., Bering and Parker, 2006). To my knowledge, however, none of this recent work has been done with children in a socio-cultural environment like Manus, so it may result from growing up the in a very unnatural human environment. That is, it seems plausible that the industrialized world where this much of this work has been done, which is filled with talking animals (cartoons), flying men and machines (superheroes and planes), disembodied voices (phones), talking boxes (TV), etc. (designed to attract children's attention), may lead children to be more accepting of counter-intuitive representations then they might otherwise be. While this need not be the case, currents research seem concerned with this explanatory gap.

because cultural learners are open to modifying their behavior (and underlying mental representations) in response to others' behavior. Potential models can manipulate learners by displaying behaviors inconsistent with their true underlying mental representations. Tom Sawyer famously did this when he manipulated his mates in believing that they actually *liked* painting the fence.[3] However, prior to the evolution of sophisticated forms of symbolic communication, of which language is the most relevant example, this potential was minimal since learners had to actually observe their models "in action" to acquire his or her practices, preferences, beliefs, or strategies. For example, in acquiring a particular tool making practice, learners had to watch their chosen models actually making the tools, and the final product testified, at least in part, to the effectiveness of the observed manufacturing practices. A model who wanted to deceive others about his favored technique could demonstrate a less effective technique in front of the learners, but this would be costly in time and effort, and the learner may not be fooled because in the end a less effective tool would result. Similarly, in acquiring food preferences (diet choice), pre-linguistic cultural learners presumably watched what foods others actually consumed, and how this food was found, extracted, and prepared. Manipulation in this case would require consuming a non-preferred food, with all of its associated costs.

With the evolution of symbolic communication, in which mental representations (e.g., beliefs) can transmit at low cost, the opportunities for Machiavellian manipulators to exploit learners would have dramatically increased. These manipulators hold one mental representation but express another (e.g., state it verbally) in an effort to cause others to do things that will increase the manipulators' relative fitness. For example, a Sawyeresque manipulator might believe that 'blue mushrooms will make you sick in the long run' and therefore he won't eat them, but he verbally announces with enthusiasm that "blue mushrooms are quite tasty." An unwitting cultural learner who has selected this prestigious Machiavellian as a model might then acquire the mental representation that 'blue mushrooms are tasty' and start eating them.

Since we know from both theory and evidence that prestigious individuals can influence the beliefs (and other mental representations) of many learners, a prestigious Machiavellian could dramatically increase his relative fitness with well-designed culturally-transmitted mind-

[3] Thanks to Bob McCauley for pointing out Tom Sawyer.

viruses. With language at his disposal, this Machiavellian could manipulate existing beliefs. For example, people in many places believe "the wishes of our dead ancestors must be obeyed". A manipulator might transmit the belief—not held by him—that he is "the mouthpiece for the ancestors, and they will talk through him; their first command is to pay the mouthpiece for his service to the ancestors with 1 pig from each house in the village." Below, I show experimental evidence that learners are cognitively immunized—at least partially—against such persuasions.

I hypothesize that natural selection addressed the emergent problem of Machiavellian manipulators, not by suppressing any use of symbolic communication in cultural learning, but by constructing a kind of cultural immune system. This immune system is designed to assess a potential model's 'degree of belief or commitment' to a symbolically communicated belief using the model's displays or actions. Cultural learners should look for displays that are most consistent with the expressed representation(s) and, more importantly, look for actions that would not be performed by a model believing something different from what the model expressed symbolically. Such diagnostic actions are evidence of commitment to their expressed belief. A model, for example, might express the view that donating to charity is important, but not donate when given the opportunity. Such an action, failing to donate, should indicate to a learner that while the model may believe in some sense that giving to charity is a good idea, he's probably not deeply committed to it. As we'll see, cultural learners under such conditions would simply acquire the practice of talking about how good it is to give to charity, without actually giving. Learners imitate the model, in both actions (talking about how important charitable giving is) and in degree of commitment (not much). Conversely, when a model actually gives to charity at a cost to himself, learners more readily acquire both the representation that giving to charity is good, and a deeper commitment or belief in, that mental representation. Such diagnostic actions are *inferentially potent displays*.

Inferentially potent displays will often *appear* costly to a person holding one particular belief about the world, but appear substantially less costly, neutral, or even beneficial to a person holding an alternative belief about the state of the world. In our mushroom example, the act of simply eating the blue mushroom would seem costly, and unlikely, if the model believed that blue mushrooms were in fact poisonous. However, eating the mushroom would not seem costly to a model who believed that blue mushrooms are tasty and not poisonous. The action of actually eating the blue mushroom is an inferentially potent display for the verbal expression of the

underlying mental representation that blue mushrooms are tasty and non-poisonous because the likelihood of eating the blue mushroom if one actually believes mushrooms are poisonous and foul tasting is low. In this case, though not all cases, whether the inferentially potent display has a net fitness cost depends on the true state of the world.

This approach does not mean that learners ignore verbal statements, or other forms of symbolic communication. Such symbolic expressions can be extremely informative in a learner's efforts to replicate the underlying mental representations of a chosen model or models. Since context and content transmission biases don't disappear in the absence of inferentially potent displays, cultural learners will still recall the verbal statements of, for example, prestigious individuals better than the statements of others (Henrich and Gil-White, 2001). The key is that, in the absence of inferentially potent displays, learners are not committed to those recalled representations in a manner that propels behavior beyond simply repeating the verbal expression itself.

Psychological findings

The evolutionary logic laid out above proposes that learners ought be more likely to acquire a culturally-transmitted mental representation, in the form of practices, beliefs, values, and strategies if their potential models perform acts that are both consistent with the possession of the underlying mental representation (which might be expressed verbally) and not consistent with holding an alternative mental representation. Stated another way: If identical cultural models verbally express the same belief, preference or opinion, learners should be—*ceteris paribus*—more likely to learn from models who perform accompanying inferentially potent displays. Often, the more costly a model's display would seem to someone who did *not* hold the expressed belief, the greater the influence of that model on learners' subsequent commitment to, or belief in, the expressed representation.

Here I unite findings from four seemingly independent areas of psychology, all of which study cultural learning in one form or another. These research programs focus on the cultural transmission of (1) food preferences and consumption, (2) opinions, (3) altruism and social behavior, and (4) beliefs in intangible entities and non-intuitive concepts. The acquisition of beliefs, attitudes or behaviors in the first three domains has already been shown to be influenced

by prestige-biased transmission or conformist transmission. The question addressed here is whether learning in these areas *also* reveals evidence for the influence of inferentially potent displays.

Food preference and consumption

Both people's preferences for certain foods and the amount of food they consume are substantially influenced by which foods those around them prefer and how much they eat. In research with children, findings indicate that learners actually shift their intrinsic food preferences toward those of their models, especially when those model are older and of the same sex (Birch, 1980, 1987; Duncker, 1938). Work with adults demonstrates that models can influence the quantity consumed, and that this may be the most important factor in quantity eaten (Herman et al., n.d.; Herman et al., 2003). These data indicate that food is influenced by the kinds of adaptive cultural learning biases that influence other domains of culture.

If the domain of food is also influenced by inferentially potent displays, then learners should be more inclined to eat novel foods when a model is first observed to eat the food himself. As in our blue mushroom example, eating is an inferentially potent display for believing something is worthy of eating (or at least not toxic). Harper and Sanders (1975) report experimental findings in which a female experimenter went to the homes of children (ages 14 to 48 months), spent at least 20 minutes playing with the child until he or she seemed comfortable, and then presented the child with a novel food. In the baseline treatment, the experimenter merely placed the novel food out (within reach of the child) and declaratively stated "something to eat" to the child. In the inferentially potent display treatment, the experimenter said the same thing as she sampled some of the food. In the baseline only 25% of children tasted the food while in the second treatment, 75% sampled ($p < 0.05$).[4] This may seem both intuitive and unsurprising (it should), but I will argue it represents a manifestation of a tendency for cultural learners to

[4] The findings also reveal the expected sex-bias, with girls copying the female experimenter more than boys. Also note that while non-human primates do show some effects of social facilitation on trying novel foods (they are more likely to try a novel food if others are eating something), human children focus on what is actually being consumed by others, and will *only* sample the novel food if the others are eating the *same thing* (Addessi et al., 2005; Visalberghi and Addessi, 2001; Visalberghi et al., 2003).

look for displays in potential models that indicate the model actually believes what he or she is saying.

Opinion transmission

Under the rubric of persuasion, psychologists have long studied both the characteristics of effective "communicators" and the contexts of opinion change (Tannenbaum, 1956). From my evolutionary perspective, persuasion or opinion change is merely one kind of cultural transmission. When models express something verbally (or in writing), ostensibly their own underlying mental representations, this may cause others to alter their own mental representations in an effort to move closer to the representation that they perceived from a model. As predicted by the above approach, opinion change research shows that subjects show greater opinion shift both when the model is more prestigious and when the frequency of others expressing similar opinions is greater (conformist transmission; people move their opinion toward that of the majority). This same work also shows evidence of inferentially potent displays, although in a more nuanced manner than with food.

Walster el. al. (1966) had subjects read newspaper articles in which either a high prestige individual (a famed prosecutor) or a low prestige individual (a thug) expressed opinions about the need for changes in the criminal justice system. Their opinions called for changes that would run either *for* or *against* their own self interest. Opinion measures from the subjects show that when models' expressed opinions that promoted their own interests, subjects' opinions shifted toward the model substantially less than when models expressed an opinion contrary to their own (the models') interests. Here, the inferentially potent display is the verbal opinion itself. It's inferentially potent in this context because the dissemination of the expressed opinion, which was given to the mass media (newspaper article), runs against the self-interest of the model. It seems unlikely that a model would argue for opinion counter to his self-interest if he actually held an opinion consistent with his self-interest.

The evidence also suggests that the influence of high-prestige individuals is damaged more when they advocate for their own interests than when low-prestige individuals advocate for their own interests. When a low prestige individual advocates for a view that runs counter to his self-interest, his influence exceeds that of a high prestige individual advocating for a view favoring his self interest (also see Eagly et al., 1978). As mentioned earlier, these findings

suggest that our adaptation for using inferentially potent displays has been calibrated to recognize that high prestige individuals have more incentive to make self-serving claims, since their opinions are more likely to spread.

Cultural transmission of altruism requires acts of altruism

Research with children on the social learning of altruism toward anonymous others shows that a model's verbal statements ("exhortations" or "preaching") to make charitable donations have little or no impact on learners unless such statement are accompanied by the model actually making costly donations himself. Once the model donates, cultural learning powerfully transmits altruistic behavior or charitable preferences. Actually donating is an inferentially potent display that would be unlikely to be observed if the model held beliefs or preferences about charitable giving substantially different from those he expressed verbally.

In the paradigmatic experimental setup, from which there have been numerous variations, a child is brought alone to the experimental area (often a trailer on school grounds) to get acquainted with the experimenter. Then, the child is introduced to a miniature bowling game and shown a range of attractive prizes that he or she can obtain with the tokens (or pennies or gift certificates) won during the bowling game. The subject is also shown the charity jar for "poor children" where they can put some of their winnings, if they want. This jar is next to the bowling game and often has a "March of Dimes" poster over it, or some facsimile. A model, who could be a young adult or another peer, demonstrates the game by playing 10 or 20 rounds. On winning rounds, which are pre-set, the model donates (or not, depending on the treatment) to the charity jar. After finishing the demonstration, the model departs and the child is left alone to play the bowling game, often monitored through a one-way mirror.

As background, the results from numerous researchers involving hundreds of children (ages 5 to 11) and a wide range of experimental variations, demonstrate three robust findings. First, children spontaneously acquire either the generosity *or selfishness* of the model. Compared to the amount that children donate in the absence of a model, children donate more to the charity jar if they see a model donate and they donate less if they saw a model fail to donate. The more the model donates the more the children donate, and the more opportunities a child has to observe the model the greater the degree of transmission (Bryan, 1971; Bryan and Walbek, 1970b; Grusec, 1971; Presbie and Coiteux, 1971). Presence of the model during the donation

phase of the experiment has little effect (Rosenhan and White, 1967). Third, these effects endure over months in retests (without any model) and extend to similar contexts (Elliot and Vasta, 1970; Midlarsky and Bryan, 1972; Rice and Grusec, 1975; Rushton, 1975).

Specific to our interests here, several studies compare the effect and interaction of models who preach generosity or selfishness ("one ought to donate…") and practice either generous or selfish giving. Preaching alone usually has little or no effect on giving. Children's behavior seems uninfluenced by preaching when these exhortations are inconsistent with the model's actions (Bryan et al., 1971; Bryan and Walbek, 1970a; Bryan and Walbek, 1970b; Rice and Grusec, 1975; Rushton, 1975). However, when a model actually donates generously, the subjects donate more generously. Here, giving away tokens that one could use to exchange for toys is an inferentially potent display of one's commitment to the verbal claim that "one ought to donate."

Researchers have looked for, but not found, a detrimental effect on acquiring altruism from hypocritical models. Researchers hypothesized that children may give less than they would in a no-model control after observing a model that said one thing (e.g., "give a lot") and did another (gave nothing). Instead, the children seemed to give little weight to a model's words, in the absence of an inferentially potent display (Bryan et al., 1971; Midlarsky et al., 1973).

Verbal expressions, however, if they are accompanied by inferentially potent displays help the learner figure out the underlying details of the model's mental representations—that is, the where, when, who and why of charitable giving. Experimental work shows that exhortations combined with inferentially potent displays allow learners to broaden the range of contexts for acquired altruism (Grusec et al., 1978). Thus, verbal expressions can be critical to understanding what is learned, but these young learners seem to "switch off" unless verbal statements about what one ought to do, when, and why, were accompanied by an inferentially potent display.

Counter-intuitive concepts

More speculatively, recent research by Harris and colleagues seems to suggest a similar need for inferentially potent displays in beliefs about intangible entities, such as God or germs (Harris and Koenig, 2006; Harris et al., 2006). As explained earlier, developmental research shows that children only express beliefs in intangible entities that adults' behavior seems to "endorse." Adults in this society pray to God, attend rituals, and tell children to pray. Adults also refuse to

eat dropped food or force children to wash their hands, while expressing a concern for germs. To the learner, these are inferentially potent displays that indicate that adults actually hold beliefs in, or commitment to, the existence of both God and germs. Meanwhile, entities that do not inspire inferentially potent displays in models (e.g., adults), such as mermaids or monsters, are not strongly believed in by children.[5]

Such empirical findings, which apply to both children and adults, suggest that our capacities for cultural learning may have been shaped to weigh a model's inferentially potent displays in adopting and committing to culturally transmitted representations. Of course, at this point this work is only suggestive, so substantially more research is needed to understand precisely how this aspect of cognition works. Now I turn to the implications of this cognitive learning bias for cultural evolution.

Part II: Do inferentially potent displays affect cultural evolution?

If indeed our species is endowed with a cognitive learning mechanism that weighs inferentially potent displays in cultural learning, what implications does this have for cultural evolution? How might this influence the kinds of stable cultural phenomena we observe across societies? Could it explain the widespread and unusual nature of the costly displays I highlighted at the outset, such as animal sacrifice, subincision, scarification, self-mutilation, or tattooing? Here, I begin to explore this possibility by constructing a simple cultural evolutionary model that incorporates the effects of inferentially potent displays.

Analytical model

Building on standard cultural evolutionary approaches, this model adds a cognitive mechanism that weighs inferentially potent displays to the standard use of success-biased transmission. Cultural learners, in figuring out who to learn from, consider both a model's success and whether their expressed belief is also supported by an inferentially potent display.

[5] I deviate here somewhat from the interpretation supplied by Harris et. al. (2006). This work on "testimony" seems narrowly focused on verbal exposition and does not acknowledge all the non-verbal information that a cultural learner has at his disposal. Nevertheless, in their discussion these authors do seem to leave some breadth for just how adults "endorse" their testimony.

The best evolutionary models strip away as many details as possible in order to analyze on the internal governing dynamics. To this end, my model focuses on the cultural coevolution of two different kinds of mental representations, a *belief* (θ) and *practice* or display (*x*). For simplicity, the model assumes that both θ and *x* are discrete dichotomous variables, taking on values of either 0 or 1. What I mean by *belief* and *practice/display* will become clear as we proceed.[6] In the principal situation under investigation, the two belief variants of θ (0 or 1) have identical content and context biases. This means both that (1) possessing a particular value of θ does not directly affect an individual's success or their attractiveness as a model, and (2) no aspects of the representational content of variants 0 or 1 make any relative differences in their likelihood of transmission. In terms of its direct effects, θ is neutral. The belief θ is a mental representation (e.g., God is watching) that can be transmitted verbally, and without cost. In contrast, the mental representation *x* generates a practice that does influence success: individuals with $x = 1$ can be thought of as performing a costly act (e.g., attending long boring Sunday rituals or getting a painful tattoo) while those with representation $x = 0$ pay no costs (e.g., not attending Sunday rituals, or not getting a tattoo). However, the variants $x = 1$ and $\theta = 1$ are linked in two interrelated cognitive senses. First, $x = 1$ is an inferentially potent display for $\theta = 1$, meaning that if someone displays $x = 1$ and expresses $\theta = 1$, a learner will be more likely to acquire $\theta = 1$ than he would if his model had displayed $x = 0$. A cultural learner observing a prestigious model who consistently attends those boring rituals and says "God is watching" is—*ceteris paribus*—more likely to acquire the idea that "God is watching" (or code "'God is watching' is true," see Bergstrom et al., 2006). Second, individuals possessing $\theta = 1$ have a content (e.g., compatibility) bias for acquiring variant $x = 1$. This means that if you believe that "God is watching" ($\theta = 1$) you are more susceptible to acquiring the practice of attending Sunday rituals ($x = 1$) than if you hold the belief $\theta = 0$ ("God is not watching"). While here I used a content bias to model the link between having $\theta = 1$ and acquiring $x = 1$, there are other ways to think about how having $\theta = 1$ could influence performing $x = 1$. These are mentioned at the end of this section.

[6]This simple model submerges the difference between knowing a belief is out there (e.g. that others believe it) and committing deeply to a belief. If an individual has $\theta = 1$, he believes in and is deeply committed to whatever this belief represents. If an individual has $\theta = 0$, he is not committed to this belief, but he may or may not know that others are committed to such a belief.

To illustrate all this, consider this simplified example. Suppose people with θ = 1 deeply believe in, and are committed to, the idea that eating mostly high protein vegetable foods will improve long-term health, fitness, and attractiveness. Those with θ = 0 don't believe this (although some do profit from selling tofu). Further, suppose that those with x = 1 eat lots of very expensive, high protein tofu, and those with x = 0 do not. When our adaptive cultural learner meets a prestigious model who is observed only to verbally express his belief (θ = 1) in the value of eating high protein vegetable foods he substantially devalues this model in deciding whether to change his θ belief to 1. However, if our learner also sees this prestigious model eating tofu (x = 1), he does not devalue the model as much in deciding to acquire the model's belief. All representations verbally expressed by models are devalued (weighted less) relative to the learners' own since, in some sense, the learners' own representations are the only ones he can be totally certain about (note, this assumption is shown to be irrelevant below). Observing a potential model eating a lot of tofu (x = 1) is inferentially potent for a belief that vegetable protein is important for health, etc. because—let's assume—(1) few people would actually eat tofu (x =1) without some supporting belief in its health consequences (θ = 1) and (2) eating tofu is perfectly consistent with believing θ = 1. With regard to acquiring x (deciding what to eat), individuals who believe (θ = 1) that eating high protein vegetable foods is key to long-term health, fitness and attractiveness will find the practice of eating lots of tofu (x =1) more attractive than those who believe θ = 0 (who experience only the costs of the bland mushy taste).

To formalize this, I sought to minimally modify the standard approach to cultural evolutionary modeling, using replicator dynamics, in order to build incrementally on a well understood approach. The transmission of both beliefs (θ) and practices (x) assumes that during each time-step a learner encounters one potential model. If the model expresses variants that are the same as those already possessed by the learner, the learner does not modify his mental representations. However, if the learner and model differ, the learner changes his variants with a probability related to the difference in the learner's own weighting and that of the model. For the transmission of θ, the weighting of the model will be influenced by both her success and by the

presence or absence of the inferentially potent display ($x = 1$).[7] To keep things simple, this analysis assumes that the underlying belief in question is neutral with regard to success (as mentioned above), so only the value of x influences the transmission of θ. Models with $x = 1$ have a weighting in the cultural learning process of $1 - c$, where c is the cost of the practice $x = 1$. Models with $x = 0$ have a weighting of 1. Since weightings must be greater than zero, $c < 1$. The learner adjusts the weighting of the model depending on the model's observed practices (x). If the model holds the belief-practice combination of 1/0 or 0/1 the weight of the model is adjusted by a factor of $(1- \sigma)$, where σ is between zero and 1. If the model holds a belief/practice combination of 1/1 the weight of the model is adjusted by a factor of $(1- \sigma + \psi)$. If the model possesses a belief/practice combination of 0/0 the weight of the model is adjusted by a factor of $(1-\sigma + \delta)$. The parameter σ captures a generalized skepticism towards acquiring beliefs that are cheaply expressed symbolically, while ψ and δ capture the extra inferential evidence provided by the presence of $x = 1$ for acquiring $\theta = 1$ and for $x=0$ for acquiring $\theta = 0$. In our toy tofu example above, a model who expresses the belief that eating high protein vegetable food is highly beneficial and is observed actually eating tofu ($x = 1$) suffers less de-weighting than models with other belief/practice combinations—$\psi \geq \delta \geq 0$.

Since the adjustment of the model's weighting is meant to capture the learner's uncertainty about the model's actual underlying belief (θ), no adjustment is applied to the learner's own weighting (the learner knows, in some sense, his own beliefs: $\sigma = \delta = \psi = 0$ for learner's weighting).

For the transmission of x, all individuals with $x = 1$ will experience the same cost, c, as above, but those learners with belief $\theta = 1$ will also experience an attractiveness, b, for the content of the practice $x = 1$, giving models holding the belief/practice combination 1/1 a weight of $1 - c + b$. Since practices or displays are not symbolically (and cheaply) displayed, no inferential adjustments need be applied to the success weights ($\sigma = \delta = \psi = 0$).

[7] In general, the differences in weightings arise from the learner's perceived differences between himself and the model in success, sex, age, skill, etc. and any content biases.

Using the above assumptions, along with ϕ to track the frequency of individuals with belief θ = 1 and q for the frequency of individuals with $x = 1$ in the population, two expressions emerge, one for the change in ϕ (Δϕ) and another for the change in q (Δq).

$$\Delta q = \beta q(1-q)\left[b\phi - c\right] \tag{1}$$

$$\Delta \phi = \tfrac{1}{2}\beta\phi(1-\phi)\left[(\psi q - \delta(1-q)) - c\psi q\right] \tag{2}$$

β in each of the above equations is a positive constant that expresses how learners convert weightings into the probabilities of changing cultural variants and guarantees that the difference in the weights multiplied by β does not exceed 1. The larger β is, the more individuals weight any particular learning encounter. The terms q(1-q) and ϕ(1-ϕ) are also always non-negative and express the variance in ϕ and q, respectively.

A analysis of this system shows that there are three potentially stable situations, depending on the parameter values, one in which only the no-cost (ϕ = q = 0) equilibrium is stable, one in which only the costly (ϕ = q = 1) equilibrium is stable, and a third in which both of these equilibria are stable at the same time. In the first situation, the no-cost equilibrium (ϕ = q = 0) is the sole stable equilibrium if either of the following conditions are met: $b \leq c$ or ψ = δ =0. This essentially replicates existing work: without inferentially potent displays costly practices don't have a stable equilibrium.

In the second situation, only the costly equilibrium (ϕ = q = 1) is stable. This can occur if ψ > δ = 0 and $b > c$. For this stable equilibrium to exist, the $x = 0$ display must provide the learner with *no hint* that the model is more likely to believe θ = 0 than θ = 1. Given that this equilibrium *also requires* that $b > c$, which tends to link $x = 1$ and θ = 1, such an stable equilibrium might only exist under very specialized conditions.

The third, most interesting, situation involves two simultaneously stable equilibria, the no-cost one (ϕ = q = 0) and the costly one (ϕ = q = 1), as illustrated in the phase plot in Figure 1. This occurs when (3) and (4) are both satisfied (this assumes ψ and δ > 0).

$$\phi_t > b/c \tag{3}$$

$$q_t > \frac{1}{\frac{\psi}{\delta}(1-c)+1} \tag{4}$$

When the system is in either quadrant II or III in Figure 1, it moves toward the costly and no-cost equilibrium, respectively. When the system finds itself in either Quadrants I or IV, it will race toward the unstable equilibrium, only to split off for either the $\phi = q = 0$ or $\phi = q = 1$ equilibrium, depending on exactly where it started and the relative rates of change for the two cultural variants.

It may seem unlikely that *b*, a content bias, would ever be greater than *c*, a real world cost in terms of things like sex, pain, labor, or cash. But, for example, suppose $\theta = 1$ involves being convinced that an eternal, blissful afterlife can be achieved, and that performing $x = 1$ is part of achieving this. Suddenly, *c* seems small compared to *b*, but only for the $\theta = 1$ believers. I briefly discuss below how performing the costly act could be re-conceptualized in a decision theoretic (or utility based) framework.

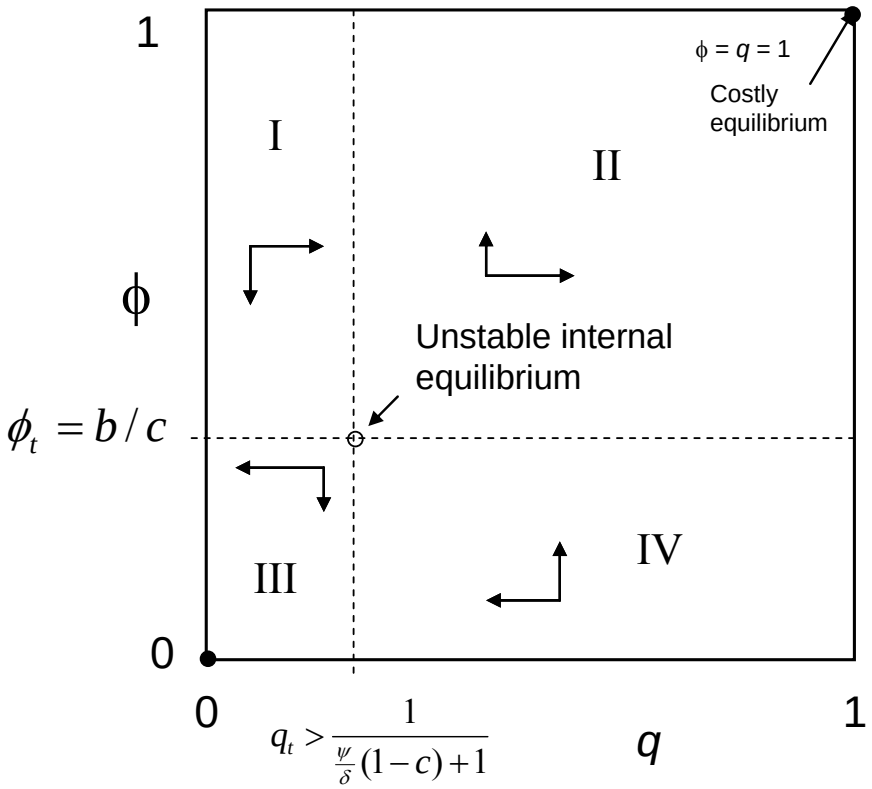

Figure 1 shows the conditions for the stability of the no-cost and costly equilibrium states.

Limitations of model

The above model represents a first pass at formally exploring cultural evolution under the influence of cognitive adaptations sensitive to inferentially potent displays. Substantial additional work is needed. First, the models should be reconstructed using continuous traits, for θ and *x*. Second, the manner of introducing inferentially potent displays needs to be explored. I chose to enter this into the model by reducing the amount of de-weighting (via multiplication) applied to the model's expressed beliefs. Alternatively, one could subtract a term from the model's weighting, depending on the presence of an inferentially potent display. There are also other possibilities such as considering a display that can vary quantitatively in strength. Third, I modeled the effect of holding belief θ = 1 on acquiring practices *x* = 1 as a content bias. There are, however, numerous other ways to incorporate the causal impact of holding a particular belief (like θ = 1) on acquiring or performing a practice or action (that could deliver an inferentially potent display). For example, the practice *x* = 1 might not be culturally transmitted behavior but a behavioral decision evoked under rare circumstances by weighing the costs and benefits of alternative outcomes. To illustrate, believing in God and salvation (θ = 1) makes one substantially more likely to martyr one's self (*x* = 1), given the choice between renouncing God (and losing salvation) or biological death. Here performing *x* = 1 (dying instead of renouncing) is an inferentially very potent display of commitment to θ = 1 (even though most people with this belief won't then actively seek martyrdom). Sociopolitical circumstances that present the faithful with such a choice (e.g., denounce your god or face execution) may lead to the spread of the faith by providing opportunities for the committed to perform inferentially potent displays (Stark, 1997).

Part II Discussion

This modeling effort gives theoretical plausibility to the idea that the genetic evolution of a cognitive adaptation to avoid exploitation by deceptive models can lead to the existence of stable, culturally-evolved states that can maintain costly practices at high frequency when those practices interlock in some fashion with beliefs. This provides a theoretically grounded explanation for the array of costly-practices and supporting beliefs that anthropologists have noted across the ethnographic record. Below, I extend the inquiry to consider what happens when a stable equilibrium's costly practices contribute a group benefit in some fashion.

I should emphasize the difference between an inferentially potent display and a costly act. Inferentially potent displays need not be costly but costly acts can, under the right circumstances, provide particularly powerful inferentially potent displays. Consider two examples. In our mushroom example above, eating blue mushrooms is an inferentially potent display of one's belief that blue mushrooms are edible and non-toxic. If this is true, the inferentially potent display is not costly. Similarly, ritual scarification can, under the right circumstances, be interpreted as an inferentially potent display of a model's belief in, and commitment to, a particular supernatural being. If such a being exists, and does in fact require the ritual as a pre-requisite to delivering various benefits, the cost of the scarring is minor.

Part III Cultural Group Selection

This section discusses the possibility that competition among social groups or institutions may favor the spread of cultural beliefs and costly practices (which interlock to form the above discussed stable equilibria) that generate group benefits, such as larger-scale cooperation and group solidarity. I will (1) introduce cultural group selection, (2) explain how it can influence the spread of the above-described stable equilibria, (3) apply these ideas to ritual and consider the spread of belief-ritual combination via cultural group selection, and (4) summarize some of the existing empirical findings that support the ideas of this section.

Introduction to cultural group selection:

Building on a firm theoretical and empirical foundation of evolved learning mechanisms, theoretical work on cultural evolution shows that competition among social groups stabilized at different culturally evolved equilibria, which have differing effects on group competitiveness, generates a process that can favor the diffusion of beliefs and practices that promote some forms of cooperation (Boyd and Richerson, 2002; Boyd and Richerson, 1990). Previous theoretical work has shown how cultural evolution can stabilize individually costly behavior: Henrich and Boyd (2001) have shown how culturally transmitted forms of punishment can stabilize costly norms, including cooperative norms. Panachanathan and Boyd (2004) have shown how

reputation can stabilize costly norms by linking them to behavior in a dyadic helping game.[8] Both of these analytical models provide a range of stable equilibria involving costly practices that vary in their equilibrium group payoffs, but no built-in way to determine which equilibrium will eventually emerge. Competition among social groups at different culturally-evolved equilibria provides a plausible, theoretically well-studied mechanism that can favor the diffusion cooperative, group-beneficial norms (Fehr and Fischbacher, 2003; Henrich, 2006).

Cultural group selection can occur in several ways. First, the most straightforward form of cultural group selection occurs when social groups—due to superior institutions for cooperation and coordination that create technological, military or economic advantages—drive out, eliminate, or assimilate groups at alternative equilibria. "Institutions" here refers to the integrated sets of beliefs, values, and practices that organize social interactions in groups. Second, social groups may also compete demographically, with groups at some stable equilibria putting out many more culture bearers than groups, stuck at other equilibria. A third form of cultural group selection is perhaps the most subtle and most important. Our evolved adaptations for cultural learning may cause people in groups stuck at less group-beneficial equilibrium to imitate the beliefs and practices of people from groups at more group-beneficial equilibrium (because they show higher payoffs). This can cause sets of ideas, beliefs and practices to differentially spread from more successful groups to less successful groups. This can describe how institutions spread from one social group to another, or how institutions compete for membership within a social group.

In considering cultural group selection it is crucial to understand that this process is substantially different from the genetic group selection of altruism, which has been so hotly debated within evolutionary biology. In the genetic group selection of altruism, there is only one *within*-group equilibrium: no indiscriminate altruism. This means that the between group component of selection (acting on genes for altruism) must overcome a strong within-group selective force, if natural selection is to favor such altruism in the long run. Since migration among groups will always deplete the variation between groups, while increasing the variation within groups (and these variances are the respective fuel for the engines of between and within-

[8] Similarly, Gintis et. al. (2001) suggests how costly signals that stabilize group contributions by high quality individuals can spread via cultural group selection.

group selection), there is good reason to remain skeptical about pure genetic group selection for altruism in humans (see Henrich, 2004 for an extended discussion; Henrich and Henrich, 2007).

The situation for cultural group selection that we focus on here is totally different. The above model shows that this situation involves multiple stable within-group equilibria—not just one internal equilibrium as with genes and altruism above. A stable within-group equilibrium means, essentially, that the selective forces within groups cancel out, and the between group component can run rampant, unopposed by within-group forces. Migration, if it is too high, can still destabilize the within group equilibrium. However, unlike in the genetic case, the mixing effect created by migration, which can deplete the strength of the between group component, is dampened by the stabilizing selective forces of the within-group equilibria.

Besides the fact that cultural transmission creates many more alternative equilibria than genetic transmission, due to the non-vertical biases in transmission, cultural evolution has two other differences that make between-group competition more likely to be important than in genetic evolution: **cultural evolution is noisy and fast**. The noisiness of cultural transmission, meaning the introduction of variation (chance or otherwise) during transmission, means that cultural evolution is much more likely to reach alternative equilibrium than standard genetic processes. Cultural evolution is also often more rapid than genetic evolution, meaning it can get to and "test out" more of these stable equilibria than genetic evolution (Boyd and Richerson, 1990).

Building on a foundation of formal models and computer simulations, there are now many lines of empirical evidence to support cultural group selection, including data from laboratory studies, archeology, history, and ethnography. In the laboratory, Gurerk et. al. (2006) has shown how individuals migrate from lower payoff institutions to higher payoff ones, and adopt the local norms of that group (Henrich, 2006). Atran et. al. (2002a; 2002b) has shown how conservation-oriented ecological beliefs spread from locally prestigious Itza Maya to Ladinos in Guatemala, and how highland Q'eqchi' Maya, with tightly bound cooperative institutions and commercially-oriented economic production, are spreading at the expense of both Itza and Ladinos. Soltis et al. (1995), using quantitative data gleaned from New Guinea ethnographies, has shown that even the slowest forms of cultural group selection (conquest) can occur in 500 to 1000 year time scales. Using ethnohistorical data, Kelly (1985) has demonstrated how

differences in culturally acquired beliefs about brideprice fueled the Nuer expansion over the Dinka, and how different social institutions, underpinned by cultural beliefs about segmentary lineages, provided the decisive competitive advantage. Sahlins (1961) has argued that cultural beliefs in segmentary lineages facilitated both the Nuer and Tiv expansions. At the global level, Diamond has made a cultural group selection case for the European expansion after 1500AD, as well as for the Bantu and Austronesian expansions. Using archeological data, anthropologists are increasingly arguing for the importance of cultural group selection in prehistory (Flannery and Marcus, 2000; Spencer and Redmond, 2001), including competition among foragers (Bettinger and Baumhoff, 1982; Young and Bettinger, 1992). Below, I summarize additional evidence that particularly targets the relationship between inferentially potent displays and inter-group or inter-institution competition.

The spread of interlocked belief-display combinations that favor cooperation, solidarity, and group competitiveness

The formal model in Part II shows that the genetic evolution for a reliance on inferentially potent displays creates a cultural evolutionary process with multiple stable equilibria. If this were all there was to it, the cultural group selection part of the story would not be very interesting as individuals at equilibria involving costly acts would get lower payoffs than those in groups stabilized at the other equilibrium. This suggests that sometimes a group might be stuck at a costly maladaptive equilibrium, but that over the long-haul of cultural history, these groups should not endure. This may explain idiosyncratic combinations of committed beliefs and *purely* costly practices, as has been observed (Edgerton, 1992).

However, by showing that a reliance on inferentially potent displays can stabilize a costly practice, the door opens to the possibility that the costly practice could be directed, in some fashion, to supply group benefits and increase group competitiveness. There are several ways to think about this. First, the practice ($x = 1$) could be a cooperative act in itself, and cooperation would increase the success and competitiveness of the group/institution. For example, giving alms to the poor could be an inferentially costly display for a belief in Allah and a group beneficial act. Second, the practice might be an act of punishment that penalizes non-cooperators (this could stabilize cooperation, and similarly benefit the group). There's no second order free rider problem here, since the costly act is already stabilized by the interlocking effects of the

inferentially potent display (as modeled in Part II). Third, it is possible that the costly practice (x =1) in and of itself delivers nothing to the group (scarification or tattooing) but that it elevates and stabilizes a strong commitment to a group ideology ($\theta = 1$) that itself favors other group-beneficial contributions related to cooperation in war, self-sacrifice, bravery, etc. Costly ritual sacrifices, for example, may favor the transmission of high degrees of commitment to beliefs in a lovely afterlife or in the oath and code of conduct sworn to by United States Marines. Strong commitments to beliefs in God and an afterlife, for example, could permit individuals to charge an enemy, aid the sick during a plague (Stark, 1997), or help build a community member's house after a storm. The Marine oath concludes with "So help me God." Social groups with costly acts that generate inferentially potent displays for beliefs that promote in-group cooperation and out-group competitiveness can spread more effectively than those that don't.

Cultural evolution of rituals and belief-ritual institutions

Since both religious and secular rituals have frequently been associated with costly displays—such as firewalking, the drinking of toxic substances and scarification—and the promotion of group solidarity, cooperation, and competitiveness in warfare (Atran, 2002; Durkheim, 1995; Sosis and Ruffle, 2003; Sosis and Alcorta, 2003b), I will briefly apply the ideas developed so far to the cultural evolution of rituals. Recently, there has been much excellent work on rituals, which is for the most part compatible with the view I present here (or could easily be made compatible). My goal here is only to suggest some cultural evolutionary forces, rooted in our evolved capacity for social learning, that may have shaped rituals along with the many other forces that have already been identified (Boyer and Lienard, 2006; McCauley and Lawson, 2002; Whitehouse, 2000).

The central idea is that rituals evolve via cultural group selection to more effectively exploit our capacities for cultural learning in transmitting increasing degrees of commitment to the associated ideas, beliefs or values. Social groups or institutions with rituals that more effectively transmit belief-commitment (commitment to the relevant in-group, anti-out-group, or cooperative beliefs) will be more successful than other groups or institutions and will spread. These belief-ritual complexes will spread by the various forms of cultural group selection discussed above, including the cultural transmission from more successful groups to less successful groups.

If rituals are evolving—via cultural group selection—to more effectively exploit our capacities for social learning, then they likely make use of (1) prestige-bias transmission, capturing our tendency to weight information coming from prestigious and successful individuals more heavily than from others, (2) conformist transmission and our tendency to use the frequency of others doing or professing something as a cue in adopting it, and (3) inferentially potent displays because these yield evidence of the degree of commitment held by models. Rituals under these selective pressures will tend to (1) put key lessons or statements of belief in mouths of the older, more prestigious, and more successful members of the community, (2) involve group statements of beliefs (cueing conformist transmission, e.g. in confessions of faith, chants, group public oaths), and (3) deploy practices that only deeply committed believers would engage in, such as practices that allow prestigious members to demonstrate their degree of belief (e.g. snake handling while preaching) or practices that involve several members undergoing harsh, painful or frightening experiences. These characteristics would evolve via cultural group selection to target other participants and observers by more effectively exploiting our evolved cognitive capacities for cultural learning. This would result in ratcheting up people's degree of commitment to some underlying beliefs. Figure 2 illustrates the key relationships.

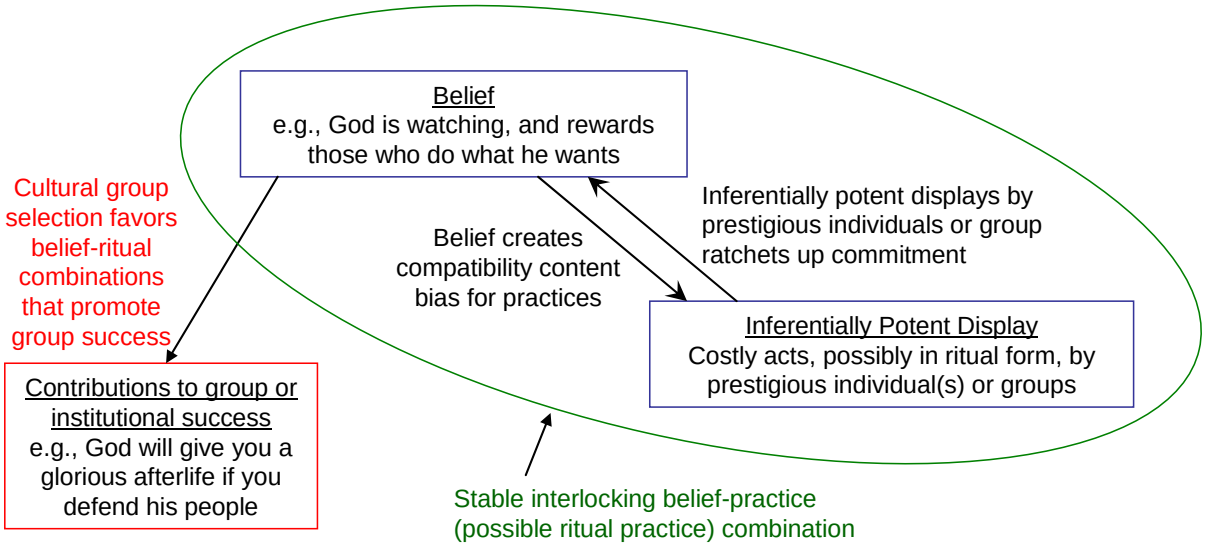

Figure 2 diagrams the key relationships that give rise to the linkage between group beneficial acts like cooperation, religious beliefs, and costly acts, including rituals.

Costly acts, particularly those found in rituals, will be more important for sustaining commitment to religious beliefs than to secular beliefs or ideologies. There are three interrelated reasons for this. First, religious beliefs often involve commitments to counter-intuitive agents. Committing deeply to counter-intuitive concepts requires inferentially potent displays by models because, in and of itself, counter-intuitiveness violates content plausibility (see opening discussion of cultural transmission). Counter-intuitive content may improve recall for these concepts, but should also inhibit commitment to such beliefs. Acquiring and committing to secular ideologies often does not require accepting and committing to counter-intuitive propositions, and thus does not face the same uphill battle. Second, once committed to, many counter-intuitive concepts—like supernatural agents (ancestors and gods)—cannot easily be falsified by real world events or experiences in the same way or to the same degree that secular beliefs can. This means that degrees of commitment to secular ideologies, influenced by inferentially potent displays, will be more influenced by real events and outcomes compared to religious ideologies. When religious beliefs can be directly falsified by experience, they tend not to stick around for the same reasons as secular beliefs fail. For example, various groups have come to believe that faith or a ritual can provide protection from bullets. Such beliefs have tended not to endure for long periods. Third, religious beliefs, once deeply committed to, are likely more powerful than secular beliefs at galvanizing cooperation. Supernatural agents can motivate (e.g., by bringing sickness, death, afterlife, etc.) and police adherents (e.g., seeing all, reading minds, etc.) in ways that secular agents cannot. This combination of elements means that costly acts, particularly those found in rituals, will tend to be associated with sustaining religious convictions, and any associated group beneficial behaviors, in a manner not found for secular beliefs.

Preliminary Lines of Evidence

The above approach yields a wide range of empirical predictions. Below, I will layout three of these, focusing on those for which evidence already exists.

Attendance at rituals involving costly acts will elevate people's degree of belief-commitment. If the professed beliefs involve trust, group commitment, cooperation toward other in-group members, or the hatred of out-groups, than ritual attenders will trust,

identify, and cooperate with in-group members, and distain out-groups, more than non-attenders.

Sosis and Ruffle (2003; 2004) performed behavioral experiments among secular and religious members of kibbutzim in Israel to explore the relationship between ritual participation and cooperation. In these experiments, two anonymous participants were given access to a sum of real money and the opportunity to contribute any portion of it to a common pot. Whatever money was contributed to this common pot was increased by 50% and split equally between the pair. The experimental game was played once; the identity of the other participant was kept secret; and, all players were tested on their understanding of the rules before playing. Game theory shows that pure self-interest favors contributing zero to the common pot, so positive contributions are a measure of increasing cooperativeness towards members of one's kibbutzim. Consistent with the above prediction, the results show that greater attendance at public rituals predicts higher contributions to the common pot in the religious kibbutzim.[9]

The findings also illustrate a link between ideological commitment, ritual, and in-group favoritism, as predicted. Sosis and Ruffle used treatments in which participants knowingly interacted with either other anonymous members of their kibbutzim or another Israeli in general. High ritual attenders in religious kibbutzim contributed substantially more to other kibbutzim members, compared to non-members. Members of secular kibbutzim treated fellow members in the same way as other non-member Israelis. It appears that rituals in the religious context may be what are pushing up in-group contributions.

These findings are consistent with the theory proposed above, but in and of themselves they do not exclude alternative hypotheses. Costly signaling theory applied to ritual has been claimed to predict that more ideologically committed individuals will tend to participate in costly

[9] Since it is males in religious kibbutzim that participate in public rituals, the effect of participation in public religious rituals on contributions had to be decoupled from other sex differences by examining the difference between males and females in secular kibbutzim. In secular kibbutzim no sex differences emerged. Moreover, the differences among males in the religious kibbutzim are largely attributable to differences in ritual participation. Secular kibbutzim lack the frequent rituals of religious kibbutzim, but in these situations attendance at communal meals predicts (weakly) contributions. The researchers also controlled for people's beliefs about how much the other participant would contribute, which means the observed effects are not reducible to differences in beliefs about others behaviors, or to differences in risk aversion.

rituals more than less committed people. Here, ideological commitment would predict both public ritual participation and contribution in the above behavioral experiment. Figure 3 illustrates the difference in the two hypotheses. The solid arrows illustrate the proximate psychological pathway of causation from my model while the dashed arrows illustrate the same for the costly signaling.

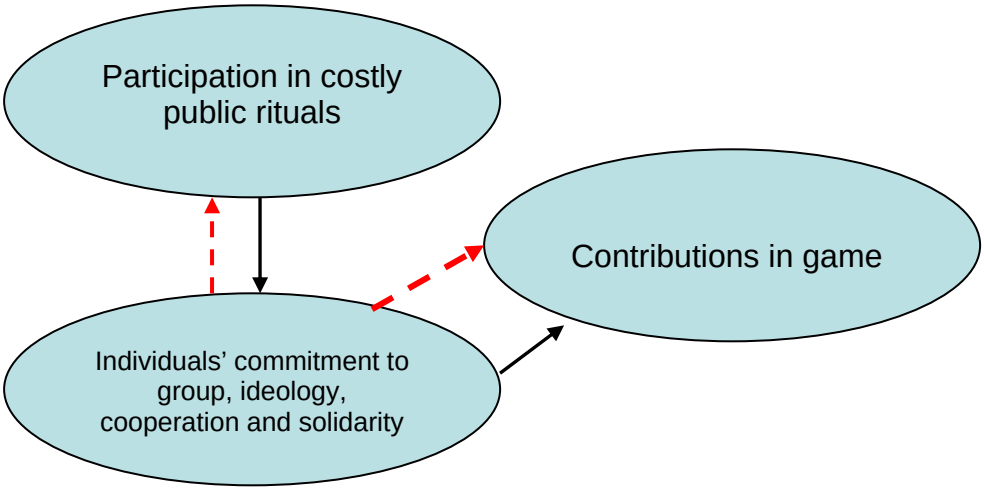

Figure 3 shows the difference between the costly signaling hypothesis and the inferentially potent displays hypothesis. The dashed line represents the causal connections for costly signaling hypothesis while solid lines illustrate the relationship for the inferentially potent displays hypothesis.

Recent work by Ginges et. al. (2007) affirms the link between ritual participation and commitment to both in-group cooperation and out-group aggression. Both extensive survey data and experimental findings from Palestinians and Jewish Israelis in the West Bank and Gaza shows that ritual participation predicts more support for suicide bomber attacks against outgroups independent of religious devotion (as measured by prayer) and a wide range of other factors. Similarly, using representative samples of Indonesian Muslims, Mexican Catholics, British Protestants, Russian Orthodox, Jewish Israelis, and Indian Hindus, these researchers also showed that greater ritual attendance, independent of a person's prayer frequency, predicts both declaring a willingness to die for one's god or gods, and that other religions are responsible for much of the trouble in the world.

It should be emphasized that the inferentially potent displays and costly signaling hypotheses are not mutually exclusive explanations. Both may be important.

Groups or institutions whose membership requires more costly acts (resulting in inferentially potent displays) will galvanize greater solidarity and more cooperation because these displays more effectively transmit belief-commitment, especially for religious institutions.

Sosis and Bressler's (2003) elegant study of the longevity of utopian communes provides evidence for this prediction. These authors assembled data on longevity, group size, and costly requirements (e.g., rituals, taboos, etc.) for 83 religious and secular utopia movements in the 19th century. Costly requirements included restrictions on food, sex, material possessions, marriage, and parenting rights, among other things. As predicted, the number of costly requirements strongly predicts the longevity of religious communes, though not for secular communes. The authors also explored some contextual data suggesting that the driving factors for longevity were indeed related to solidarity, group commitment, and cooperation, and reported that some commune members and leaders recognized that costly requirements *increased* the belief-commitment of members.

These findings, in addition to illustrating the relationship between costly displays and group success (as measured by group survival) provide a stark example of cultural group selection in action. These communes varied in their number of costly requirements and the data show that those with the most costly requirements survived longer. Over time, cultural group selection ratcheted up the mean number of costly requirements per commune by selecting out those groups unable to sustain solidarity and cooperation. Today, of the communes studied, only the Hutterites continue to prosper.

Sosis and Bressler use these data to support a version of costly signaling applied to religious ritual. The authors argue that costly signaling predicts that individuals who are committed to the group's ideals will be able to perform the costly requirements more cheaply than non-believers (the less committed), and thereby sustain more cooperation by suppressing free-riders. I have some general concerns with the costly signaling approach, not the least of

which is that it has never been formally modeled,[10] but here I restrict my comments to the specific prediction at hand. To begin, Sosis and Bressler's findings are derived from a pattern created by a historical process. In this historical process groups with more costly requirements survived longer than groups with fewer requirements. It's far from clear how costly signaling actually predicts this. Costly signaling models are not—at this point—imbedded in a cultural evolutionary framework capable of yielding historical (non-genetic) dynamics occurring over decades. Such predictions appear to be more derived from Sosis and Bressler's well-informed intuitions than from any real model in evolutionary biology. Second, costly signaling does not predict that costly requirements will ratchet up commitment to beliefs or ideologies. The authors, however, report that commune members and leaders believed costly requirements did increase group commitment. Third, unlike animal models of costly signaling or even other applications to humans (Bliege Bird et al., 2001), it's hard to fathom why (in a fitness sense) it is more costly for non-believers to perform the costly requirements than believers (more committed people). Holding a particular transmittable mental representation is not obviously parallel to possessing a physical attribute, like size, strength, or stamina (as in the non-human literature). In animal cases of signaling it is often clear why creating a certain kind of signal is more costly for some individuals than others. Smaller animals, for example, can't just get big for signaling purposes. But, an individual human could always acquire a mental representation, if holding that representation will lead to him receiving benefits of cooperation. Approaching this requires an evolutionary theory of belief acceptance (a theory of cultural transmission) to explain why people might or might not commit to a particular belief. Fourth, with no theory of cultural transmission or psychology, it's unclear why people, who have according to the authors evolved to be costly signalers, don't just invent more costly requirements and get more group benefits. If the requirements are in fact culturally transmitted, then one is back to needing a theory of cultural transmission.

[10] There are no formal models that show how costly signaling can solve the *n*-person prisoner's dilemma to favor widespread cooperation in a group, and some efforts suggest quite the opposite (McElreath and Boyd, 2007). Since both signaling models (Bergstrom et al., 2002; Lachmann and Bergstrom, 2004; Lachmann et al., 2001) and *n*-person models of cooperation (Boyd, 1988; Boyd and Richerson, 1992) have repeatedly yielded non-intuitive results that contradicted previous efforts at verbal reasoning, it seems unwise to combine these two prickly evolutionary problems and proceed without a formal study. Gintis et. al. (2001) have provided a model linking costly signaling to group contributions by a small number of high quality individuals, but that model does not apply here.

Ritual-belief combinations spread via cultural group selection.

Historical and ethnographic evidence from a variety of sources indicates that belief-ritual combinations spread by cultural group selection. Here, I summarize findings from ethnographic, ethnohistorical, historical and sociological sources. First, using ethnographic and ethnohistorical data I discuss how ritual-belief complexes spread from more successful groups to less successful groups in New Guinea. Second, ethnographic patterns suggested by detailed ethnographic accounts are tested and confirmed with a cross-cultural analysis of the relationship between warfare and costly rituals. Third, using ethnographic and historical data from Ensminger, I discuss one of the ways in which Islam spread in Africa, with particular reference to Orma pastoralists. Finally, I discuss Stark's analysis of the spread of religiosity and religious institutions in America since 1776.

Boyd (2001) provides an ethnographically detailed account of how the village of Irakia in New Guinea adopted a particular ritual-belief complex from their more successful and prestigious neighbors, the Fore'. Throughout the Highlands of New Guinea a group's ability to raise large numbers of pigs is directly related to its success in competition with other groups. The ceremonial exchange of pigs allows groups to forge alliances, re-pay debts, obtain wives, and generate prestige through excessive displays of generosity. Given this, according to cultural group selection, if groups vary in their ability to produce pigs due to differences in integrated sets of beliefs, values and practices (institutions with rituals), then less successful groups should be inclined to copy these institutions from more successful pig-producing groups.

Late in 1971 the senior men in the Awa-speaking village of Irakia convened a series of meetings to determine how to energize their pig production so as to improve their abilities to form alliances (by hosting large pig feasts), re-pay debts, and raise their group's regional prestige. Numerous suggestions were proposed for raising pig production but after a long process of consensus building the senior men of the village decided to follow a suggestion made by a prestigious clan-leader who argued that they "must follow the Fore'" and adopt their husbandry practices and pig-related rituals. The Fore', a nearby ethnic group, were renown in the region for their productive pig raising.

The details of this adoption were formally presented to the rest of the village at a general meeting. The following points, which were explicitly acquired by observing the Fore, were

outlined by the village elders at the "kick off" feast, and the first two measures were immediately demonstrated.

1) All villagers must sing, dance and play flutes for their pigs. This ritual causes the pigs to grow faster and bigger.
2) Pigs should be fed first, from the oven, at feasts.
3) Pig should not be killed for breaking into another's garden. The pig's owner should assist the owner of the garden in repairing the fence. Disputes should be resolved following the procedures used by the Fore'.
4) Sending pigs to other villages is tabooed, until the festival feast.
5) Women should take better care of the pigs and feed them more food. Women should avoid spending time gossiping.
6) Men must plant more sweet potatoes for the women to feed to the pigs.
7) Men should not depart for wage labor (in distant towns) until the pigs have grown to a certain size.

While more follow-up data on the productive impact of this ritual would be desirable, Boyd did confirm that the group largely adopted these practices and that pig production did initially increase (we don't know what happened in later years). This complex involves several potentially inferentially potent displays, which the people of Irakia had observed the Fore' perform, including singing, dancing, and playing flutes for pigs. Commitments to several of these items, perhaps galvanized by the inferentially potent displays, could potentially help raise pig production (e.g., like planting more sweet potatoes, or not killing pigs that break into neighboring gardens).

Elsewhere in New Guinea, Tuzin has examined the historical co-emergence of a strong group ideology, an intricate form of social organization, a complex ritual system, and a high degree of cooperation and solidarity. In a region where villages often breakdown when they grow above approximately 300 people, this study of the Ilahita Arapesh reveals how an interlocking segmented moiety system, galvanized by the rehearsal of a secret ritual system called Tambara, allows 1,500 people to live together in harmony, sustain high levels of cooperation and solidarity, and survive in a very competitive regional environment that has long included both military and economic threats (Tuzin, 1976, 2001). The basic elements of the institutional-ritual complex, which the Ilahita Arapesh elaborated and improved upon, were first

imitated from a highly successful and aggressively expanding group called the Abelam around the 1870's. Their acquisition and modification (and improvement) of the Abelam systems probably permitted Ilahita to resist being driven out by the Ablelam, and has since permitted both military and economic success.[11]

In their ethnohistorical study of the Enga, Wiessner and Tumu (1998) lay out the evolution of various belief-ritual complexes in the highlands of New Guinea. Central to the emergence of these ritually galvanized ideological systems, which the authors describe as promoting "identity, welfare, and unity" within larger and larger groups over time, is the cultural transmission of belief-ritual complexes, or elements of them, both within and across linguistic boundaries. The authors write, "cults were readily transmitted across linguistic boundaries when (1) donors and recipients faced comparable problems, so that underlying beliefs and overt procedures were meaningful, and (2) the owners of the cults were perceived as being successful…Cults were imported in order to acquire new and more effective ways to communicate with the spirit world, as well as to emulate those who appeared more successful" (Wiessner and Tumu, 1998: 195-196). While the data is lacking for a precise calculation, it appears clear that the frequency and intensity of costly (frightening, painful, and strict) rituals increases along with sociopolitical complexity in New Guinea, in the face of increasing military and economic competition.

This contextually-rich ethnohistorical study fits with recent cross-cultural analyses of small-scale pre-industrial societies showing that greater participation in warfare predicts more costly rites for males (Sosis et al., forthcoming). Within my framework: increasing warfare means cultural groups with more costly rites galvanize greater cooperation and solidarity among males (more commitment to group ideals), and thus these groups survive, expand, and are imitated more frequently by other groups.

The alternative evolutionary theories, that these cross-cultural patterns were differentially evoked from some cognitive module or that they resulted from individual-level cost-benefit

[11] Tuzin argues that the Ilahita Arapesh also acquired their elaborate garden technology for growing yams from the Abelam. He also points out that the transmission was one way, from more successful to less successful. The rich mythology and elaborate hunting magic of the Ilahita Arapesh did not transmit to the Abelam, or anyone else (Tuzin, 1976: 79).

analysis, ignores the detailed ethnography showing that groups are explicitly imitating these practices, often in specific details, from other more successful groups, and that the distribution of these belief-ritual complexes are evolving on historical time scales.

In discussing one means by which Islam spread into Africa, Ensminger (1997) argues that Islamic beliefs—galvanized by inferentially potent displays involving abstaining from alcohol, avoiding pre- and extra-marital sex, not consuming blood or pork, and fasting—permitted greater trust, shared rules of exchange and the use credit institutions among converted Muslims. This facilitates more trade and greater economic success. The Orma (Kenyan pastoralists), and presumably other African groups, observed successful Muslim models performing inferentially potent displays and began adopting the religious beliefs along with the associated institutions and rituals. Ensminger describes an empirical pattern when she writes (p. 26-27), "such groups [Islamic groups] may have attracted followers at a greater rate than other, thus increasing the ranks of the converted." This pattern is quite reminiscent of the patterns observed in Gurerk et. al. (2006)'s laboratory experiments, which itself parallels the cultural group selection models constructed by Boyd and Richerson (2002; 1990). Ensminger also refers to cases in which Islam was imposed on conquered groups, another form of cultural group selection that influences the distribution of religious representations.

These processes are certainly not limited to small-scale societies. Finke and Stark (2005) paint a picture of cultural group selection when they argue that the dramatic expansion of religiosity in America since 1776 has been driven by competition among religious institutions for membership. Religious freedom permitted institutions with belief-ritual combinations demanding greater commitments and offering richer otherworldliness to spread at the expense of less vibrant, more theologically sophisticated, faiths requiring fewer costly displays. On this account, the devout faith and ritual character of religion in 21st century America, vis-à-vis Europe for example, results from the competition of religious institutions (a form of cultural group selection) initiated by an emphasis on religious freedom. The energetic evangelical sects (belief-ritual combinations) that have evolved under America's umbrella of religious freedom are now spreading through and replacing, via institutional competition for membership, the sleepy Catholicism of Latin America (Iannaccone, 1998).

The processes that Finke and Stark sketch for the evolution of American religious institutions bare a resemblance to the competition among different kinds of cults described by Wiessner and Tumu in the highlands of New Guinea. The New Guineans, however, were much more capitalistic, with some groups actually going to more successful groups and purchasing (payment in pigs, salt, etc.) their cults—buying "how to" lessons from ritual specialists.[12]

Discussion

This paper began by developing a hypothesis about the nature of our capacity for cultural transmission. The hypothesis proposes that, over the course of human evolution, cultural learners faced an adaptive challenge created by our increasing capacities for symbolic (cheap) cultural transmission that drove the evolution of our reliance on inferentially potent displays in determining how much to commit to, or believe in, a particular culturally transmitted representation. Learners evolved to look for displays (often actions) that indicate a model's degree of commitment to, or belief in, verbally expressed representations. These are (a) actions that are consistent with a model's professed beliefs, and (b) actions that a model would be unlikely to perform if he believed something different from what was expressed symbolically. Preliminary empirical findings from the literature in psychology were discussed.

Building on this, I sought to explore the implications of this inferentially potent display bias for cultural evolution by constructing a simple model to examine how this might influence the stable cultural forms that can emerge. The model reveals the conditions under which a reliance on inferentially potent biases can stabilize costly practices in a population. Such situations can arise (1) when a practice can act as an inferentially potent display for a belief and (2) when committing to that belief sufficiently favors the adoption of the practice.

The presence of stable equilibria involving an individually costly practice sets up the conditions for cultural group selection. Some stable practices may be only individually costly

[12] Those familiar with both New Guinea and America might note that both evince "boom-bust" phenomena in religious institutions. New high octane sects or cults spread rapidly, as energized rituals galvanize faith and cooperation, until eventually the group grows too large, informational channels weaken, faith weaken, and cooperation starts breaking. This is exactly the kind of phenomena that require both an understanding of our rich evolved cognitive architecture and a willingness to explicitly model cultural transmission and decision-making.

while others may contribute benefits to the social group. Social groups that have stabilized on costly-practice-belief combinations that deliver group benefits, in the form of cooperation, solidarity, and group success, will spread at the expense of social groups at alternative equilibria.

Empirical data was reviewed that (1) show a link between participation in costly rituals and group cooperation, (2) suggest a relationship between the number of costly acts required by a social group and group survival and showed how the mean number of costly requirements increased over time, and (3) revealed cultural group selection in action, in ethnographic, ethnohistorical and sociological data.

The approach suggests that the frequently noted interconnection between costly rituals and larger-scale cooperation, solidarity and success in inter-group competition (Durkheim, 1995; Rappaport, 1999; Sosis, 2003) is an emergent product of the interaction between an evolved cognitive adaptation for avoiding exploitation in acquiring culture and cultural evolution, driven by cultural group selection.

This approach also builds a firmer foundation for the emergence of certain kinds of signaling behavior from inferentially potent displays. In signaling terminology (Maynard Smith and Harper, 2003) inferentially potent displays are *cues* inadvertently given off by individuals, according to their beliefs, that are used by learners as *indices* (more or less accurate measures) of belief-commitment by learners. These indices can become true signals when (1) genetic evolution, (2) cultural evolution, or (3) individual decision-making favors "transmitters" using these indices strategically to influence others. Here, models become active transmitters or signalers, and inferentially potent displays (cues) become signals. The genetic and cultural evolutionary processes sketched above represent the first steps in this process—the evolution of a "receiver psychology" to use cues from models. Elsewhere I explore how the evolution of this receiver psychology creates the conditions for the emergence of certain kinds of signaling ("transmitter" or "sender" behavior) and in doing this solves a number of unaddressed problems with the evolution and application of costly signaling to rituals (Henrich, in prep; also see Plourde, 2005).

In complementing the existing efforts to link rituals and cooperation via signaling, my approach may provide a more natural approach to an essentially cultural phenomenon like ritual and religion than pure costly signaling. Religion and other ideologies are certainly shaped by our

evolved cognition but non-trivial aspects of their content are acquired by social learning, from other members of one's social milieu (Whitehouse, 2004). Previous evolutionary approaches to religion have tended to ignore the question of where people get their beliefs and practices. In costly signaling models applied to religion, individuals vary in their degree of commitment to group ideologies, and can signal their strong commitment by performing costly acts. Unfortunately, this approach fails to explain where these ideologies come from, why people are committed to them, or why humans (and not other animals that signaling models have been applied to) have ideologies, which can be committed to, in the first place. The evolutionary credentials of this work are often established by citing the application of costly signaling models to non-humans, despite the fact that these applications are not generally accepted (Lachmann and Bergstrom, 1998; Lachmann et al., 2001; Maynard Smith and Harper, 2003), and involve neither signaling commitment to a mental representation or *n*-person cooperation. By constructing a theory of inferentially potent displays out of dual inheritance theory, which explicitly theorizes (formally models) both the genetic evolution of our cultural capacities and cultural evolution, the above approach provides a potentially richer evolutionary framework for theorizing about cultural phenomena like religion and ritual.

In this preliminary account, I lack the space to fully explore the potential implications for understanding cultural evolution and religion, in light of an evolved bias to rely on inferentially potent displays; however, I offer a few interrelated suggestions. Please keep in mind that I'm arguing that the presence of an evolved psychology for inferentially potent displays may have shaped these aspects of culture (including religion), not that the above theory is in any way a full accounting of these complex phenomena.

Why are religions often associated with prestigious paragons of virtue who make (or made) costly sacrifices? An application of the above reasoning to this question begins by considering our evolved psychology for cultural learning. In learning how to behave and what to believe, learners give weight to both prestige and inferentially potent displays, among other things. Thus, successful cultural forms, especially those involving deep commitment to counter-intuitive beliefs, will tend to begin with and be sustained by prestigious individuals performing inferentially potent displays. Cues of prestige influence who people pay attention to for learning while inferentially potent displays convince them that a prestigious model really believes (is committed to) his or her professed beliefs. The "virtuousness" arises from these prestigious

individuals' role as model. Cultural group selection will favor, over long swaths of historical time, religions with role models who effectively transmit beliefs and practices that strengthen in-group cooperation, promote intra-group harmony, and increase competitiveness against out groups.

Why martyrdom is powerful. As a corollary of the above, martyrs—be they suicide bombers or saints—can provide powerful, inferentially potent displays to learners regarding their degree of commitment. Anthropologists have sought to explain suicide bombing as a costly signal of group commitment (Atran, 2003; Sosis and Alcorta, forthcoming), which it may be. However, this approach fails to explain the impact of these costly actions on learners' beliefs. The most important thing about martyrdom is not that everyone now knows the martyr is a committed member of the group (costly signaling), but that observing this inferentially potent display increases the commitment of the (still living) learners—some moderates become radicals in the process. Two cases in point: (1) Early Christian martyrs, executed in public events, are believed by many (Stark, 1997), including observers at the time, to have substantially fueled the spread of early Christianity. Ignatius, Bishop of Antioch, after being condemned to be ripped apart by wild beast in a Roman Amphitheatre exulted in his opportunity to "imitate the passion of my God!" He then wrote letters to Christian communities along the road to Rome, who might attempt a rescue, pleading with them to allow him to go and die for his God. A Platonist philosopher, Justin, explains that he was convinced of the divinity of Jesus, and converted to Christianity, after personally witnessing the commitment demonstrated by the torture and death of some martyrs. Justin was later martyred too (Pagels, 1989). (2) Back in his hometown of Zarqa, Jordan, the death of the locally prestigious Palestinian Abu Musab al-Zarqawi at the hands of the American military seems to have ignited an epidemic of young male volunteers flowing into Iraq for martyrdom, often to die as suicide bombers.

This reasoning explains why the oppression of religious minorities, or other ideologically committed groups, may actually energize the spread of these groups. Government directed crackdowns, involving punishment and execution, provides the faithful with opportunities for inferentially potent displays. Interested members with low commitment might not otherwise have the opportunity to observe an inferentially potent display from a prestigious leader, such as seeing them crucified, stoned, beheaded, eaten by wild cats, etc. Making these displays public is a really bad idea if you want to stamp out a religious movement.

Why are religious ideologies interlaced with ritual sacrifices of various kinds? Sacrifices may involve the killing of a person or non-human animal, or giving of money, at a public event. Such acts may arise for many reasons, but in some cases such sacrifices are inferentially potent displays that help transmit deep commitments to participants and observers. Religions with such rituals tend to survive and grow because these rituals instill deeper commitment than would otherwise be possible.

From this perspective, costly acts by high status leaders demonstrate—and thereby more effectively culturally transmit—the leader's professed beliefs. Costly acts may be inferentially potent displays, not merely costly signals. Atran (2002), for example, relates a scene described in Mayan glyphs in which a new ruler rises to power in Palenque. In the accession ritual the new ruler first sacrifices a captive, by personally plunging a knife into the victim's chest, and then pierces his own penis three times, in order to pull through long strands of bark, which he then watches turn red. Atran provides this as an example of a costly signal of group commitment. However, such actions are also likely to provide an inferentially potent display for some portion of the audience. Observing the leader's inferentially potent display may ratchet up the commitment to the leader's professed beliefs for his counselors, senior members of the government, the military, and perhaps even the populace.

Why counter-intuitive agents (e.g., gods or ancestors) want costly acts. The above logic proposes that religions will culturally evolve to possess counter-intuitive agents, like gods, that demand or at least want inferentially potent displays. The reason for this is straightforward. Counter-intuitive agents that demand inferentially potent displays can cause the cultural transmission of deeper commitments to that agent. The more counter-intuitive the agent, the more inferentially potent displays will be required to sustain commitment.

Why religious leaders take vows involving sex, fasting, and poverty. Beliefs of any kind, but especially the counter-intuitive ones found in religions, will best proliferate when expressed by prestigious individuals performing inferentially potent displays. Avoiding sex, food, and wealth can all act as inferentially potent displays of deep belief-commitment. Models sticking to such vows (or appearing to) increase their potency as transmitters of the faith. Religions that prescribe the avoidance of food, sex, and wealth among leaders, while effectively dealing with the obvious defection problem, will tend to proliferate.

Why Mickey Mouse is not a god. The prevailing view in evolutionary-cognitive circles is that religious representations spread because of their optimal counter-intuitiveness (Atran and Norenzayan, 2004; Boyer, 2001). However, from the theory summarized earlier in this article on representational content biases, it is important to distinguish the effects of counter-intuitiveness on *memory* from its effects on *commitment* to, or belief in, the representation in question. Consistent with existing empirical work, counter-intuitiveness may increase a representation's memorability and transmitability (of stories or cartoon characters), but not influence a learner's degree of commitment or belief in that representation. To turn Mickey Mouse into God, and overcome the negative effects of counter-intuitiveness (on plausibility), we need inferentially potent displays, especially by prestigious individuals or large groups (conformist transmission), preferably sharing the learners sex and ethnicity. From the perspective of a learner, the difference between Mickey and Yahweh (e.g.) is that learners observe many people, including their chosen models, performing actions that only someone who actually believed in Yahweh would bother with. Inferentially potent displays by preferred models may be what turn interestingly and fanciful counter-intuitive agents into gods.

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