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The evolution of costly displays, cooperation, and religion

Credibility enhancing displays and their implications for cultural evolution

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1 **Abstract**

2 This paper lays out an evolutionary theory for the cognitive foundations and cultural emergence
3 of the extravagant displays (e.g., ritual mutilation, animal sacrifice, and martyrdom) that have so
4 tantalized social scientists, as well as more mundane actions that influence cultural learning and
5 historical processes. In Part I, I use the logic of natural selection to build a theory for how and
6 why seemingly costly displays influence the cognitive processes associated with cultural
7 learning—why do “actions speak louder than words”? The core idea is that cultural learners can
8 both avoid being manipulated by their models (those they are inclined to learn from) and more
9 accurately assess their belief-commitment by attending to displays or actions by the model that
10 would seem costly to the model if he held beliefs different from those he expresses verbally.
11 Part II examines the implications for cultural evolution of this learning bias in a simple
12 evolutionary model. The model reveals the conditions under which this evolved bias can create
13 stable sets of interlocking beliefs and practices, including quite costly practices. Part III explores
14 how cultural evolution, driven by competition among groups or institutions stabilized at
15 alternative sets of these interlocking belief-practice combinations, has led to the association of
16 costly acts, often in the form of rituals, with deeper commitments to group beneficial ideologies,
17 higher levels of cooperation within groups, and greater success in competition with other groups
18 or institutions. The broader implications of these ideas for understanding various religious
19 phenomena are discussed.
20

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

32 The argument proceeds in three parts. Part I lays out a theory for the evolution of one
33 particular component in the suite of cognitive adaptations that make up the human capacity for
34 cultural learning. The core idea is that, with the evolution of substantial communicative
35 capacities in the human lineage, cultural learners are potentially exploitable by manipulators
36 who can convey one mental representation but actually believe something else, or at least
37 misrepresent their depth of commitment to a particular belief. To address this adaptive
38 challenge, I propose that learners have evolved to attend to *credibility enhancing displays*
39 (CREDs) alongside the verbal expressions of their models (i.e., those individuals from whom
40 people learn). These displays provide the learner with reliable measures of the model's actual
41 degree of commitment to (or belief in) the representations that he has inexpensively expressed
42 symbolically (e.g., verbally). Learners should use such displays in determining *how much* to
43 commit to a particular culturally-acquired mental representation such as an ideology, value,
44 belief, or preference. After laying this out, I summarize supporting findings from psychology.

45 Building on this, Part II explores whether such a learning bias could create interlocking
46 sets of beliefs and costly practices that are self-stabilizing. That is, can this adaptive learning

47 bias lead to the emergence of stable combinations of beliefs and costly practices (displays) in a
48 social group that could not otherwise persist (remain stable). My formal model reveals the wide-
49 ranging conditions under which costly practices (acting as CREDEs) and associated beliefs are
50 self-stabilizing. Such stable cultural evolutionary states are interesting because they show how
51 particular displays or acts, which appear costly to one who does not hold the relevant
52 corresponding belief, can be sustained by cultural evolution.

53 Part III considers the possibility that such an interlocking system could also sustain
54 costly practices that elevate the commitment of group members to beliefs that promote group
55 benefits, larger-scale cooperation and solidarity, and—in particular—favor success in
56 competition with other social groups (or institutions). This competition among stable culturally-
57 evolved states favors social groups that are increasingly constituted by combinations of (a)
58 beliefs that favor in-group cooperation/harmony and out-group competition, and (b) practices
59 (e.g. rituals) that maximize participants' commitment to those beliefs.

60 To assess the plausibility of this account and compare it with existing approaches based
61 on signaling, I summarize evidence indicating that (1) belief-practice (ritual) combinations are
62 spread by cultural group selection, (2) participation in costly rituals is associated with prosocial
63 in-group behavior, because costly rituals *transmit* commitment to group-beneficial beliefs/goals
64 to participants, and (3) institutions requiring costly displays are favored by cultural evolution
65 because costly displays by members transmit higher levels of belief-commitment and thereby
66 promote cooperation and success in inter-group or inter-institution competition.

67 Together these three parts lay out a process, initiated by an evolved learning bias, that
68 connects costly, even extravagant, displays to cooperation and commitment to a group's beliefs
69 and ideology. The more costly the displays are the potentially deeper the degree of transmitted
70 commitment.

71 I close by discussing how such processes may illuminate why (1) religions are often
72 associated with prestigious paragons of virtue who make (or made) costly sacrifices, (2)

73 martyrdom is so persuasive, (3) religions and rituals are loaded with sacrifices of various kinds,
74 (4) gods and ancestors want costly acts, and (5) religious leaders take vows involving poverty,
75 celibacy, as well as other puzzles arising from evolutionary approaches to religion and ritual.

76 **The Evolution of our Cultural Capacities**

77 The application of the logic of natural selection to the evolution of social learning has
78 produced an array of novel theoretical insights, hypotheses, and empirical findings (for reviews
79 see: Joseph Henrich & McElreath, 2006; Richerson & Boyd, 2005). One central line of inquiry
80 arising from this research program has focused on how selection has shaped our cultural
81 learning processes in order to more effectively acquire ideas, beliefs, values, preferences and
82 practices from others in our social world. The set of related hypotheses about these cognitive-
83 operational details can be partitioned into two categories, those based on *context* (e.g., cues
84 about a model's prestige or success used in figuring out whom to learn from) and those related
85 to mental representations' *content* (e.g., aspects of the representations themselves). Below, I
86 briefly review some work in this area in preparation for laying out the *credibility enhancing*
87 *displays hypothesis*.

88 Contextual learning mechanisms use cues that allow learners to more effectively extract
89 and integrate adaptive information from the range of individuals available in the learners' social
90 world (Joseph Henrich & McElreath, 2003). One class of cognitive mechanisms, often glossed
91 as *prestige-biased transmission* (Joseph Henrich & Gil-White, 2001), proposes that learners use
92 model-based cues to figure out who, among their potential *models*, is most likely to possess
93 adaptive information suitable to the learner's current situation (e.g., his/her role in the social
94 group). Theory suggests, and a wide range of empirical findings have shown, that both children
95 and adults preferentially pay attention to and learn from others based on cues of prestige,
96 success, skill, age, ethnicity (marked by dialect, dress, etc.) and sex (N. S. Henrich & Henrich,
97 2007: Chapter 2). These effects influence a wide range of representations, including opinions,

98 economic decisions, food preferences, social strategies, beliefs, technological adoptions and
99 dialect. Moreover, these biases appear to operate across domains of expertise, as those with
100 skill or knowledge in one field (e.g., basketball) are granted influence in other arenas (e.g.,
101 fashion or politics). Given this, and anticipating what is to come below, a highly prestigious
102 individual motivated by self-interest could express a degree of commitment to a belief or opinion
103 different from her own, that—once adopted by others—could yield benefits to her and costs to
104 the learners.

105 Evolutionary approaches to culture also provide a rich set of cognitively-informed
106 hypotheses regarding how the *content* of representations influence their transmission (R. Boyd
107 & Richerson, 1985: Chapter 5; Sperber, 1996). The general insight is that learners should pay
108 particular attention to and remember representations likely to contain adaptive information.
109 Specifically, learners should be more likely to pay attention to and store representations when
110 these are judged, *ceteris paribus*, more (1) fitness relevant, (2) potentially actionable, and (3)
111 plausible or compatible. Regarding the first, natural selection should favor more attention and
112 recall for representational content of greater relevance to fitness, at least in ancestral
113 environments. Often such content sparks more positive or negative emotional responses, thus
114 adaptively biasing memory storage and recall.

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

124 *The plausibility or compatibility* of a representation involves the learners' expectations
125 about how the world works and, consequently, what is more and less likely to be true or reliable.
126 Some such expectations depend heavily on our evolved intuitions, including cognitive processes
127 in such domains as mechanics and biology. For example, representations from modern physics,
128 which involve objects (e.g. electrons) that exist only probabilistically at any point in space,
129 violate intuitive expectations from folkmechanics and thus don't readily transmit. Such
130 compatibility biases can also be culturally acquired, such that the possession of one mental
131 representation biases the acquisition of others. That is, having acquired a particular idea via
132 cultural transmission, a learner may be more likely to acquire another idea or practice, because
133 the two "fit together" in some cognitive or psychological sense.

134 A variety of hypotheses generated by this approach in domains involving dangerous
135 animals (H. C. Barrett, 2007), meat taboos (Fessler, 2003), the disgustingness of urban legends
136 (Heath, Bell, & Sternberg, 2001), and gossip (Mesoudi, Whiten, & Dunbar, 2006) have found
137 empirical support.

138 With regard to religious concepts, research has demonstrated how the presence of
139 some counter-intuitive content in concepts or narratives can bias memory in a manner that
140 would favor such concepts or narratives in cultural evolution (J. L. Barrett & Nyhof, 2001;
141 Lisdorf, 2004). Counter-intuitive concepts or events violate our core assumptions about the
142 nature of things in the world, usually about intentional beings, animals, inanimate objects, or
143 events (expectations from the domains of folkphysics, folkpsychology, and folkbiology). An
144 examples of a counter-intuitive concept from this literature is "a person who can be in two
145 places at once" (Pascal Boyer & Ramble, 2001). The presence of a few counter-intuitive
146 concepts in a narrative, even within a list of otherwise ordinary concepts, improves memory for
147 the entire narrative or list (Norenzayan, Atran, Faulkner, & Schaller, 2006).

148 From the above perspective, the mnemonic advantages of counter-intuitive
149 representations arise from a mixture of plausibility, applicability and fitness relevance. Many

150 religious beliefs, for example, would appear to be less plausible, more applicable, and more
151 fitness relevant than alternative non-religious concepts or explanations. Counter-intuitive
152 concepts—by definition—make stories or beings seem *less plausible* (less believable) than fully
153 intuitive concepts, which is likely part of the reason why the optimal number of such violations is
154 small. Many counter-intuitive representations are also likely to generate emotional responses,
155 like fear or interest (see Fredrickson, 1998), as well as actionable options and additional
156 inferences.

157 Heretofore, the application of ideas about counter-intuitiveness to religion has not
158 sufficiently distinguished (1) mnemonic and transmissibility effects from (2) believability of, or
159 commitment, to the representation. While many religious concepts or narratives do have
160 memory and transmissibility advantages, I propose that they have a believability or commitment
161 disadvantage. Thus, the counter-intuitiveness of concepts or stories can help explain the
162 popularity of different folktales, cartoons, superheroes, and myths (i.e., other people's religions),
163 but such counter-intuitiveness may actually steepen the challenge to explaining the deep
164 commitment to the agents found in religion. Counter-intuitive concepts ought to be better
165 remembered—but not committed to or believed in—because, if true, they are important
166 adaptively-relevant information. Accepting them as true, however, should require additional
167 learning cues not derived from representational content. Those who want to explain the ubiquity
168 of religious belief based only on representational content need to explain why people don't
169 adopt and commit to other people's gods as soon as they learn about them (represent their
170 content). Below, I argue that credibility enhancing displays can address this puzzle by providing
171 a mechanism for instilling deep commitment for otherwise difficult-to-accept representations.

172 **Part I: The emergence of an adaptive challenge**

173 The evolution of high fidelity cultural learning, with all its adaptive benefits, increases the
174 potential for exploitation by other members of one's group because cultural learners are open to

175 modifying their behavior, and underlying mental representations, in response to others'. Models
176 can manipulate learners by misrepresenting their (the model's) true underlying representations
177 or commitments. Tom Sawyer famously did this when he manipulated his mates into believing
178 that he (and they) actually *liked* painting a fence. However, prior to the evolution of sophisticated
179 forms of symbolic communication, of which language is the most relevant example, this
180 potential was minimal since learners had to actually observe their models "in action" to acquire
181 their practices, preferences, beliefs, or strategies. For example, in acquiring a particular tool
182 making practice, learners had to watch their chosen models actually making the tools, and the
183 final product testified—at least in part—to the effectiveness of the observed manufacturing
184 practices. A model who wanted to deceive others about his favored technique could
185 demonstrate a less effective technique in front of learners, but this would be costly in time and
186 effort, and the learner may not be fooled because in the end a less effective tool would result.
187 Similarly, in acquiring food preferences (diet choice), pre-linguistic cultural learners presumably
188 watched what foods others actually consumed, and how this food was located, extracted, and
189 prepared. Manipulation in this case would require consuming a non-preferred food, with all of its
190 associated costs, not to mention the opportunity costs of the search and processing time.

191 With the evolution of verbal communication, in which mental representations (e.g.,
192 beliefs) can transmit at low cost, the opportunities for Machiavellian manipulators to exploit
193 learners would have dramatically increased. These manipulators hold one mental
194 representation but express another (e.g., state it verbally) in an effort to cause others to do
195 things that will increase the manipulators' fitness. For example, a Sawyeresque manipulator
196 might believe 'blue mushrooms are mildly toxic' and therefore avoid eating them regularly. But,
197 in an effort to prevent others from eating his preferred grey mushrooms (which are rarer and, he
198 believes, delicious and nutritious), this manipulator might enthusiastically announce that "blue
199 mushrooms are tastier and more nutritious than grey mushrooms". An unwitting learner who
200 has selected this prestigious Machiavellian as a model might then acquire the mental

201 representation that ‘blue mushrooms are tasty and nutritious’ and start eating relatively more
202 them, leaving more grey mushrooms for the manipulator (food preferences are heavily
203 influenced by cultural learning). Initially, the learner experiences no ill effects, since it takes
204 years to accumulate clinical levels of the toxin.

205 Since prestigious individuals can influence the beliefs (and other mental representations)
206 of many learners, a prestigious Machiavellian could dramatically increase his fitness with well-
207 designed culturally-transmitted “mind-viruses” that strategically alter others’ beliefs and
208 preferences. For example, people in many places believe “the wishes of our dead ancestors
209 must be obeyed”. A manipulator might transmit the belief—not held by him—that he is “the
210 mouthpiece for the ancestors, and they will talk through him; their first command is to pay the
211 mouthpiece for his service to the ancestors with one pig from each house.”

212 I hypothesize that natural selection addressed the emergent problem of Machiavellian
213 manipulators, not by suppressing the use of symbolic communication in cultural learning, but by
214 constructing a kind of cultural immune system. This immune system is designed to assess a
215 potential model’s ‘degree of belief or commitment’ to a symbolically communicated belief using
216 the model’s displays or actions. Cultural learners should look for displays that are most
217 consistent with the expressed representation(s) and—more importantly—look for actions that
218 would not be performed by a model believing something different from what the model
219 expressed symbolically. Such diagnostic actions are evidence of commitment to the expressed
220 belief. A model, for example, might express the view that donating to charity is important, but
221 not donate when given the opportunity. The action, not donating, should indicate to a learner
222 that while the model may believe in some sense that giving to charity is a good idea, he’s
223 probably not deeply committed to it. As we’ll see, cultural learners under such conditions would
224 simply acquire the practice of talking about how good it is to give to charity, without actually
225 giving. Learners imitate the model, in both actions (talking about how important charitable giving
226 is) and in degree of commitment (little). Conversely, when a model actually gives to charity at a

227 cost to himself, learners more readily acquire both the representation that giving to charity is
228 good, and a deeper commitment or belief in, that representation. Cultural learners are using
229 these actions to more accurately assess the models' degree of commitment or beliefs in the
230 expressed representation. Such diagnostic actions are *credibility-enhancing displays (CREDs)*.

231 CREDs will often *appear* costly to a person holding one particular belief about the world,
232 but seem substantially less costly, neutral, or even beneficial to a person holding an alternative
233 belief about the world. In the mushroom example, the act of regularly eating the blue
234 mushrooms would seem costly, and unlikely if the model believed that blue mushrooms were in
235 fact toxic. However, regularly eating the blue mushrooms would not seem costly to a model who
236 believed that blue mushrooms are tasty and nutritious. The action of regularly eating the blue
237 mushrooms is a CRED for the verbal expression of the underlying representation that blue
238 mushrooms are tasty and non-poisonous because the likelihood of regularly eating such a
239 mushroom if one actually believes they are poisonous is low. In this case, though not all cases,
240 whether the CRED has a net fitness cost depends on the true state of the world.

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

249 Finally, since attention to action in this approach evolved to help learners assess their
250 models underlying degree of belief or commitment (intrinsic motivation), costly actions that are
251 less diagnostic (or non-diagnostic) of a model's degree of underlying commitment because of
252 external threats or pressure to perform those actions will be relatively weaker as CREDs.

253 **Psychological findings**

254 The above logic proposes that learners ought to be more likely to acquire culturally-
255 transmitted representations, in the form of practices, beliefs, values or strategies, if their models
256 perform acts that are both consistent with the possession of the underlying representation
257 (which is expressed verbally) and inconsistent with alternative representations. Stated another
258 way: If identical models verbally express the same belief, preference or opinion, learners should
259 be—*ceteris paribus*—more likely to learn from models who perform accompanying CREDs.
260 Often, the more costly a model's display would seem to someone who did *not* hold the model's
261 expressed belief, the greater the influence of that model on the learner's subsequent
262 commitment to, or belief in, the expressed representation.

263 Here I unite findings from four areas of psychology, all of which study cultural learning in
264 one form or another. These programs focus on the transmission of (1) food preferences and
265 consumption, (2) opinions, (3) altruism, and (4) beliefs in intangible entities and non-intuitive
266 concepts. The acquisition of beliefs, attitudes or behaviors in the first three domains has already
267 been shown to be influenced by cultural transmission. The question addressed here is whether
268 learning in these areas *specifically* reveals evidence for the influence of CREDs.

269 *Food preference and consumption*

270 Both people's preferences for certain foods and the amount of food they consume are
271 substantially influenced by which foods those around them prefer and how much they eat. In
272 developmental research, findings indicate that learners actually shift their intrinsic food
273 preferences toward those of their models, especially when those models are same-sex, older
274 children (Birch, 1980, 1987; Duncker, 1938). Work with adults demonstrates that models can
275 influence the quantity consumed (Herman, Roth, & Polivy, 2003; Salvy, Romero, Paluch, &
276 Epstein, 2007).

277 If food choice is also influenced by CREDs, then learners should be more inclined to eat
278 novel foods when a model is first observed to eat the food himself. As in the mushroom
279 example, consuming something is a CRED for believing it is worthy of eating (or at least non-
280 toxic). Harper and Sanders (1975) report experimental findings in which a female experimenter
281 went to the homes of children (ages 14 to 48 months), spent at least 20 minutes playing with the
282 child until he or she seemed comfortable, and then presented the child with a novel food. In the
283 baseline treatment, the experimenter merely placed the novel food out (within reach of the child)
284 and declaratively stated “something to eat” to the child. In the CRED treatment, the
285 experimenter said the same thing as she sampled some of the food. In the baseline, only 25%
286 of children tasted the food, while in the CRED treatment 75% sampled ($p < 0.05$). This may
287 seem both intuitive and unsurprising, but it represents a manifestation of a tendency for learners
288 to look for displays in models that indicate the model actually believes what she is saying.

289 *Opinion transmission*

290 Psychologists have long studied both the characteristics of effective “communicators” in
291 the context of opinion change (Tannenbaum, 1956). From this evolutionary perspective,
292 persuasion or opinion change is merely a kind of cultural transmission. When models express
293 something verbally (or in writing), ostensibly their own underlying mental representations, this
294 may cause others to alter their own mental representations in an effort to move closer to the
295 representation inferred from the model’s expression. Opinion change research shows that
296 subjects shift their opinion substantially more when the model is more prestigious. This same
297 work also shows evidence of CREDs, although in a more nuanced manner than with food.

298 Walster et al. (1966) had subjects read newspaper articles in which either a high
299 prestige (famed prosecutor) or a low prestige (thug) individual expressed opinions about the
300 need for changes in the criminal justice system. Each model called for changes that would run
301 either *for* or *against* their own self interest. Opinion measures from the subjects show that when

302 models' expressed opinions that promoted their own interests, subjects' opinions shifted toward
303 the model substantially less than when models expressed an opinion contrary to their own (the
304 models') interests. Here, the CRED is the verbal opinion itself. It's credibility enhancing in this
305 context because the dissemination of the expressed opinion, which was given to the mass
306 media, runs against the self-interest of the model. It seems unlikely that a model would argue for
307 an opinion counter to his self-interest if he actually held an opinion consistent with his self-
308 interest.

309 The evidence also suggests that the influence of high-prestige individuals is damaged
310 more when they advocate for their own interests than when low-prestige individuals advocate
311 for their own interests. When a low prestige individual advocates for a view that runs counter to
312 his self-interest, his influence exceeds that of a high prestige individual advocating for a view
313 favoring his self interest (also see Eagly, Wood, & Chaiken, 1978). As mentioned earlier, these
314 findings suggest that our adaptation for using CREDs has been calibrated to recognize that high
315 prestige individuals have more incentives to make self-serving claims, since their opinions are
316 more likely to spread.

317 *Cultural transmission of altruism requires costly acts*

318 Developmental research on the cultural learning of altruism shows that a model's verbal
319 statements ("exhortations" or "preaching") to make costly charitable donations have little or no
320 impact on learners' donations unless such statements are accompanied by the model actually
321 making costly donations himself. Once the model donates, cultural learning powerfully transmits
322 altruistic behavior or charitable preferences. Actually donating is a CRED that would be unlikely
323 to be observed if the model held beliefs or preferences about charitable giving substantially
324 different from those he expressed verbally.

325 In the paradigmatic experimental setup, from which there have been many variations, a
326 child is brought to the experimental area to get acquainted with the experimenter. Then, the

327 child is introduced to a miniature bowling game and shown a range of attractive prizes that can
328 be obtained with tokens won during the bowling game. The subject is also shown the charity jar
329 for “poor children” where they can put some of their winnings, if they want. A model, who could
330 be a young adult or another peer, demonstrates the game by playing 10 or 20 rounds. On
331 winning rounds the model donates (or not, depending on the treatment) to the charity jar. After
332 the demonstration, the model departs and the child is left alone to play the bowling game
333 (Bryan, 1971; Elliot & Vasta, 1970; Grusec, 1971; Presbie & Coiteux, 1971).

334 Several studies compare the effect and interaction of models who preach generosity or
335 selfishness (“one ought to donate...”) and practice either generous or selfish giving. Preaching
336 alone usually has little or no effect on giving. Children’s behavior seems uninfluenced by
337 preaching when these exhortations are inconsistent with the model’s actions (Bryan, Redfield, &
338 Mader, 1971; James H. Bryan & Nancy H. Walbek, 1970; 1970; Rice & Grusec, 1975; Rushton,
339 1975). However, when a model actually donates generously, the subjects donate more
340 generously. Here, giving away tokens that one could use to exchange for toys is a CRED of
341 one’s commitment to the verbal claim that “one ought to donate.”

342 Verbal expressions are not irrelevant here. They help the learner figure out the
343 underlying details of the model’s mental representations—that is, the where, when, who and
344 why of charitable giving. Experimental work shows that exhortations combined with CREDs
345 allow learners to broaden the range of contexts for acquired altruism (Grusec, Saas-Kortsak, &
346 Simutis, 1978). Thus, verbal expressions can be critical to understanding what is learned, but
347 learners seem to “switch off” unless verbal statements about what one ought to do, when, and
348 why, are accompanied by a CRED.

349 *Counter-intuitive concepts*

350 Recent research suggests a similar need for CREDs in beliefs about intangible entities,
351 such as God or germs (Harris & Koenig, 2006; Harris, Pasquini, Duke, Asscher, & Pons, 2006).

352 This work shows that children only express beliefs in intangible entities that adults' behavior
353 seems to "endorse." Adults in this subculture pray to God, attend rituals, and tell children to
354 pray. Adults also refuse to eat dropped food and force children to wash their hands, while
355 expressing a concern for germs. To the learner, these are CREDs indicating adults actually hold
356 beliefs in God and germs. Meanwhile, entities that do not inspire CREDs in adults, such as
357 mermaids, are not strongly believed in by children. While only suggestive, such findings are
358 consistent with the idea that our capacities for cultural learning may have been shaped to weigh
359 a model's CREDs in adopting and committing to culturally transmitted representations.

360 **Part II: How do credibility enhancing displays affect cultural evolution?**

361 If indeed our species is endowed with a CRED-bias in cultural learning, what
362 implications does this have for cultural evolution? How might this influence the kinds of stable
363 cultural phenomena we observe across societies? Could it explain the widespread and unusual
364 nature of the costly displays such as animal sacrifice, subincision, scarification, self-mutilation,
365 or tattooing?

366 Building on standard cultural evolutionary approaches, this model adds a cognitive
367 mechanism that weighs CREDs to success-biased transmission. Cultural learners, in figuring
368 out who to learn from, consider both a model's success and whether the model's expressed
369 belief is also supported by a CRED. The model focuses on the coevolution of two different kinds
370 of mental representations, a *belief* (θ) and *practice* or display (x). For simplicity, the model
371 assumes that both θ and x are discrete dichotomous variables, taking on values of either 0 or 1.
372 To make this as stark as possible, I assume the two variants of belief θ (0 or 1) possess no
373 independent differences that impact their likelihood of transmission. Neither representational
374 variant, in and of itself, differentially affects model success nor does either possess a content
375 bias that independently favors one variant over the other. In terms of direct effects, θ is neutral.
376 The belief θ can be transmitted verbally (e.g., God is watching), without cost.

377 In contrast, the mental representation x generates a practice that does influence
378 success: individuals with $x = 1$ can be thought of as performing a costly act (e.g., attending long
379 boring rituals, undergoing subincision or getting tattooed) while those with representation $x = 0$
380 pay no costs (e.g., not attending rituals, etc.). However, the variants $x = 1$ and $\theta = 1$ are linked in
381 two interrelated cognitive senses. First, $x = 1$ is a CRED for $\theta = 1$, meaning that if a model
382 displays $x = 1$ and expresses $\theta = 1$, a learner will be more likely to acquire $\theta = 1$ than he would if
383 this same model had displayed $x = 0$. A learner observing a prestigious model who consistently
384 attends those boring rituals and says “God is watching” is—*ceteris paribus*—more likely to
385 acquire the idea that “God is watching” (or code “‘God is watching’ is true,” see B. Bergstrom,
386 Moehlmann, & Boyer, 2006). Second, individuals possessing $\theta = 1$ have a content (e.g.,
387 compatibility) bias for acquiring variant $x = 1$. This means that if you believe that “God is
388 watching” ($\theta = 1$) you are more susceptible to acquiring the practice of attending Sunday rituals
389 ($x = 1$) than if you hold the belief $\theta = 0$ (“God is not watching”). While here I am using a content
390 bias to model the link between having $\theta = 1$ and acquiring $x = 1$, there are other plausible ways
391 to think about how having $\theta = 1$ could influence performing $x = 1$. These are discussed below.

392 Consider this toy example. Suppose people with $\theta = 1$ deeply believe in, and are
393 committed to, the idea that eating high protein vegetable foods will improve long-term health
394 and fitness. Those with $\theta = 0$ don’t believe this, or are substantially less committed to it. Further,
395 suppose that those with $x = 1$ eat lots of unpalatable high protein tofu instead of mouth-watering
396 steak, and those with $x = 0$ eat mostly steak. When our adaptive cultural learner meets a
397 prestigious model who is observed only to verbally express his belief ($\theta = 1$) in the value of
398 eating high protein vegetable foods he substantially devalues this model in deciding whether to
399 change his θ belief to 1. However, if our learner also sees this prestigious model eating tofu ($x =$
400 1), he does not devalue the model as much in deciding whether to acquire the model’s belief. All
401 representations verbally expressed by models are devalued (weighted less) relative to the

402 learners' own since, in some sense, the learners' own representations are the only ones he can
403 be certain about. Observing a potential model eating lots of tofu ($x = 1$) is credibility enhancing
404 for a belief that vegetable protein is important for health, etc. because—let's assume—(1) few
405 people would actually eat tofu ($x = 1$) without some supporting belief in its health consequences
406 ($\theta = 1$) and (2) eating tofu is perfectly consistent with believing $\theta = 1$. With regard to acquiring x
407 (deciding what to eat), individuals who believe $\theta = 1$, that eating high protein vegetable foods is
408 key to long-term health, will find the practice of eating lots of tofu ($x = 1$) more attractive than
409 those who believe $\theta = 0$ (who experience only the bland mushy taste).

410 To formalize this, I minimally modified the standard approach to cultural evolutionary
411 modeling, using replicator dynamics, in order to build incrementally on a well understood
412 approach. The transmission of both beliefs (θ) and practices (x) assumes that during each time-
413 step a learner encounters one potential model. If the model expresses variants that are the
414 same as those already possessed by the learner, the learner does not modify his mental
415 representations. However, if the learner and model differ, the learner changes his variants with
416 a probability proportional to the difference in the learner's own weighting and that of the model.
417 For the transmission of θ , the weighting of the model will be influenced by both her success and
418 by the presence of the CRED ($x = 1$). Models with $x = 1$ have a success weighting in the cultural
419 learning process of $1 - c$, where c is the cost of the practice $x = 1$. Models with $x = 0$ have a
420 success weighting of 1. Since weightings must be greater than zero, we stipulate that $0 \leq c < 1$.

421 The effect of the CRED enters as the learner adjusts the success weighting of the model
422 depending on the model's observed practices (x). There are three possible adjustments:

- 423 1) If the model holds the belief/practice (θ/x) combinations of 1/0 or 0/1, the weight of the
424 model is adjusted by a factor of $(1 - \sigma)$, where $0 \leq 1 - \sigma \leq 1$.
- 425 2) If the model holds a belief/practice combination of 1/1, the weight of the model is
426 adjusted by a factor of $(1 - \sigma + \psi)$, where $0 \leq 1 - \sigma + \psi \leq 1$.

427 3) If the model possesses a belief/practice combination of 0/0, the weight of the model is
428 adjusted by a factor of $(1 - \sigma + \delta)$, where $0 \leq 1 - \sigma + \delta \leq 1$.

429 The parameter σ captures a generalized skepticism towards acquiring beliefs that are
430 cheaply expressed symbolically, while ψ and δ respectively capture the extra credibility
431 evidence provided by the presence of $x = 1$ for acquiring $\theta = 1$ and for $x=0$ for acquiring $\theta = 0$.
432 Since $x = 1$ is costly, we should expect $\psi > \theta$. In our tofu example, a model who expresses the
433 belief that eating high protein vegetable food is highly beneficial and is observed actually eating
434 tofu ($x = 1$) suffers less de-weighting than models with other belief/practice combinations— $\psi \geq \delta$
435 ≥ 0 . For example, perhaps $\sigma = 0.2$, $\psi = .01$, and $\delta = 0.002$.

436 Since the adjustment of the model's weighting is meant to capture the learner's
437 uncertainty about the model's actual underlying belief (θ), no adjustment is applied to the
438 learner's own weighting. I assume the learner knows—in some sense—his own beliefs, so $\sigma = \delta$
439 $= \psi = 0$ for learner's own success weighting. However, this simplifying assumption is not crucial.
440 Assuming that the learner is skeptical about his own beliefs won't change the model as long as
441 learners can be *less* skeptical about his own beliefs compared to those of models. Even if a
442 learner infers his own beliefs by observing his own behavior, he should still be less skeptical
443 about his own beliefs since he gets to observe himself more than he observes others.

444 For the transmission of x , all individuals with $x = 1$ will experience the same cost, c , as
445 above, but those learners with belief $\theta = 1$ will also experience an attractiveness, b , for the
446 content of the practice $x = 1$, giving models holding the belief/practice combination 1/1 a weight
447 of $1 - c + b$. Since practices/displays are not symbolically displayed (and thus untrustworthy), no
448 credibility adjustments need be applied to their success weightings ($\sigma = \delta = \psi = 0$). Table 1
449 summarizes the assignment of model weightings just described for each belief/practice
450 combination.

Table 1. Summary of model weightings for belief/practice combinations			
Belief value (θ)	Practice value (x)	Model weighting for transmission of θ	Model weighting for transmission of x
0	0	$1*(1-\sigma+\delta)$	1
0	1	$(1-c)*(1-\sigma)$	$1-c$
1	0	$1*(1-\sigma)$	1
1	1	$(1-c)*(1-\sigma+\psi)$	$1-c+b$

451

452 With these assumptions, along with ϕ to track the frequency of individuals with belief $\theta =$ 453 1 and q for the frequency of individuals with $x = 1$ in the population, two recursions emerge, one454 for the *change in* ϕ during each time step, $\Delta\phi$, and another for the *change in* q during each time455 step, Δq .

456
$$\Delta q = \beta q(1-q)[b\phi - c] \quad (1)$$

457
$$\Delta\phi = \frac{1}{2}\beta\phi(1-\phi)[(\psi q - \delta(1-q)) - c\psi q] \quad (2)$$

458 β in each of the above equations is a positive constant that expresses how learners convert

459 weightings into the probabilities of changing their representations and guarantees that the

460 difference in the weights multiplied by β does not exceed 1. The larger β is, the more learners461 weight any particular learning encounter. The terms $q(1-q)$ and $\phi(1-\phi)$ express the variance in ϕ 462 and q , respectively, and arise through the derivation. Table 2 summarizes the symbols.

463 There are three relevant stable equilibrium situations for this system. In the first

464 situation—the *no-cost state*—there is only one stable equilibrium point, and it occurs at $\phi = q =$ 465 0. That is, everyone believes $\theta = 0$ and no one is doing the costly practice. This situation arises466 if either $b \leq c$ or $\psi = \delta = 0$. This replicates existing work: without CREDs costly practices don't

467 have a stable equilibrium—we ought not to observe them in the world.

468 The second situation involves two simultaneously stable equilibria: (1) the no-cost
 469 equilibrium ($\phi = q = 0$; as above) and a costly one at which $\phi = q = 1$. This occurs when (3) and
 470 (4) are both satisfied (note, (3) and (4) require that $\psi, \delta > 0$).

471
$$\phi_t > c/b \tag{3}$$

472
$$q_t > \frac{1}{\frac{\psi}{\delta}(1-c) + 1} \tag{4}$$

473 Condition (3) sets the critical threshold
 474 for the frequency of those that believe in $\theta = 1$,
 475 ϕ_t . If ϕ exceeds the ratio of the cost of the
 476 practice to the effect of the content bias (the
 477 degree to which having $\theta=1$ make doing $x = 1$
 478 more attractive), condition (3) is satisfied. If c is
 479 greater than or equal to b , the condition cannot
 480 be satisfied, since ϕ cannot be greater than 1.

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

Table 2. Summary of symbols	
θ	dichotomous <i>belief</i> variant. $\theta = 1$ generates a content bias for $x = 1$.
x	dichotomous <i>practice</i> variant. $x = 1$ generates a CRED for $\theta = 1$.
ϕ	tracks the frequency of $\theta = 1$ believers
q	tracks the frequency of $x = 1$ practitioners
β	normalizes models' weights to probabilities
c	cost of practice $x = 1$ on individual's success
b	potency of content bias for $\theta = 1$ on acquiring $x = 1$
σ	across the board de-weighting of model's cheaply expressed beliefs
ψ	effect of $x = 1$ (CRED) on reducing the de-weighting for models expressing $\theta = 1$
δ	effect of $x = 0$ on reducing the de-weighting for models expressing $\theta = 0$

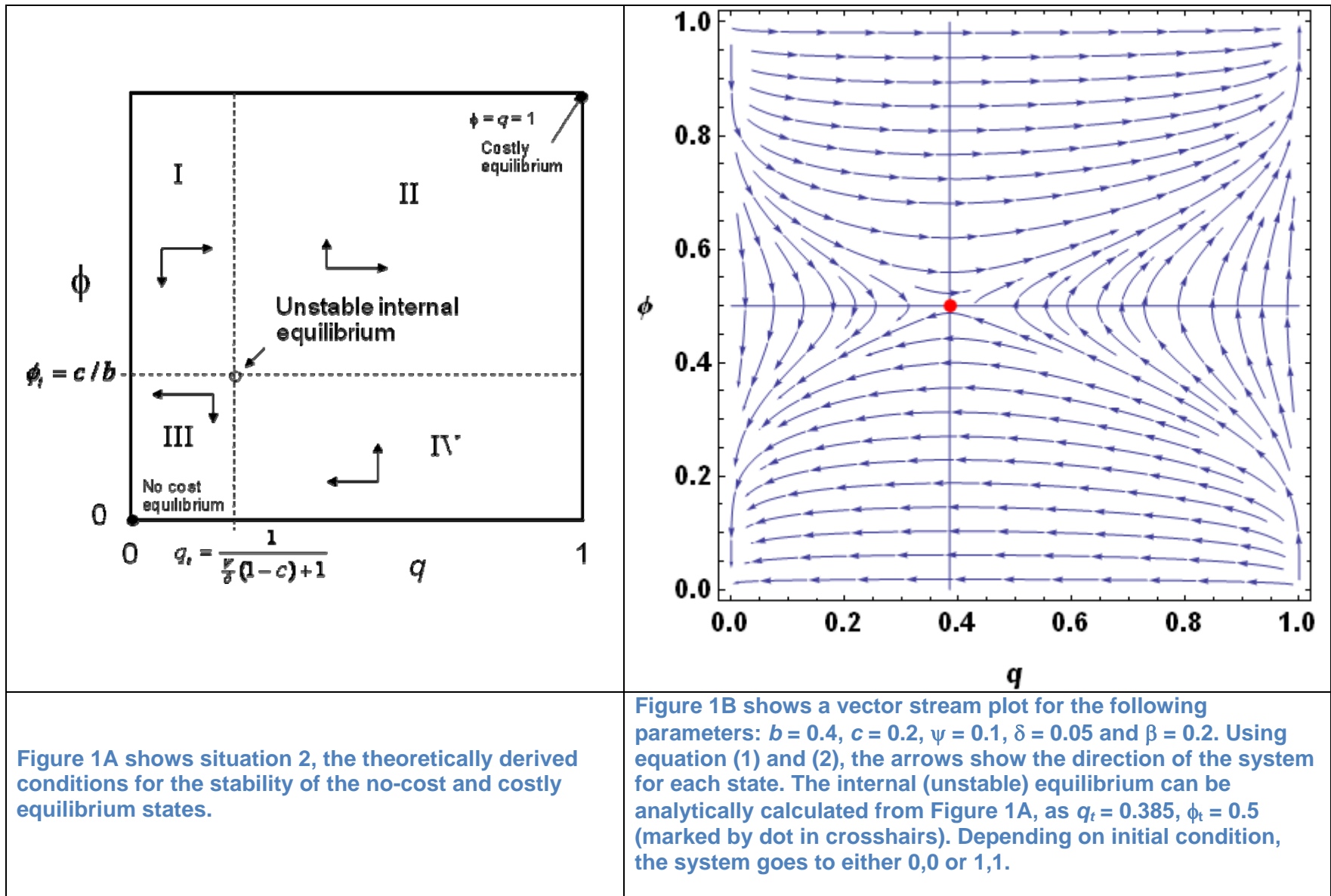
490 Condition (4) sets a critical threshold, q_t , for the frequency of those performing the costly
 491 practice that depends on the ratio of the effects of x on model weighting ψ/δ and on the cost of

492 performing x . If $x = 1$ is a credibility enhancing display for $\theta = 1$, then ψ/δ can be large. However,
493 as long as both ψ and δ are greater than zero, q_t exists and is between zero and 1.

494 Figure 1A illustrates the two simultaneously stable equilibria, graphically showing
495 conditions (3) and (4). When the system (ϕ, q) is in quadrant III it moves to the no-cost stable
496 state $(\phi=q=0)$. When the system (ϕ, q) is in quadrant II it moves to the costly stable state
497 $(\phi=q=1)$. When the system finds itself in either Quadrants I or IV, it will race toward the unstable
498 internal equilibrium, only to split off for either the $\phi = q = 0$ or $\phi = q = 1$ equilibrium, depending on
499 exactly where it started and the relative rates of change for the two variants.

500 Figure 1B shows a vector stream plot, using equations (1) and (2) for a specific set of
501 parameter values. The arrows show the direction the system moves for the full range of q and ϕ .
502 The internal unstable equilibrium, represented by the large dot in the crosshairs on Figure 1B,
503 can be calculated from the equations shown in Figure 1A.

504 Thus, for situation two, the model shows that costly practices interlocked via content
505 biases with beliefs can be sustained under a wide range of plausible conditions if learners use
506 these acts as persuasive evidence of holding the belief. Stable equilibria for such costly acts
507 exist simultaneously with the no-cost equilibria for the same parameter values. Thus, as with
508 reciprocity strategies such as tit-for-tat, the initial spread of individuals who engage in costly acts
509 requires a stochastic event that shocks ϕ and q into the basin of attraction of the costly
510 equilibrium (see Figure 1) or some kind of non-random pattern of association that permits ϕ and
511 q to move above their threshold values.



512 A third stable situation exists in which only the costly equilibrium ($\phi = q = 1$) is stable.
513 This occurs if $\psi > \delta$, $\delta = 0$, and $b > c$. For this stable equilibrium to exist, the $x = 0$ display must
514 provide the learner with *no hint* that the model is more likely to believe $\theta = 0$ than $\theta = 1$. Given
515 that this equilibrium *also requires* that $b > c$, which tends to link $x = 1$ and $\theta = 1$, such a stable
516 equilibrium might only exist under very specialized conditions. For the remainder of this
517 discussion we assume the above-described second situation (Figure 1), with multiple stable
518 equilibria, is the relevant and important one. To the degree that this third situation also arises, it
519 only makes the argument of this paper more powerful.

520 This model represents a first pass at formally exploring cultural evolution under the
521 influence of cognitive adaptations sensitive to credibility-enhancing displays. This modeling
522 effort gives theoretical plausibility to the idea that the genetic evolution of a cognitive adaptation
523 to avoid exploitation by deceptive models can lead to the existence of stable, culturally-evolved
524 states that can maintain costly practices at high frequency when those practices interlock in
525 some fashion with beliefs. This provides a potential explanation for the array of costly-practices
526 and supporting beliefs in the ethnographic record.

527 Additional work is needed on at least three fronts. First, the model should be
528 reconstructed using continuous traits, for θ and x . Second, one could introduce an epistemic
529 skepticism that would directly make learners less likely to accept $\theta = 1$. As it stands, the
530 tendency of those with $\theta = 1$ to acquire $x = 1$ creates a bias that will drive $\theta = 1$ completely out of
531 the population unless CREDs exist, so there is an indirect bias against $\theta = 1$. The logic here is
532 that beliefs (as mental representations) don't matter unless they affect actions, so all the effects
533 on θ come in through actions. Introducing such an epistemic skepticism on θ would likely tighten
534 the conditions for situation two and shrink the basin of attraction of costly equilibrium. Neither of
535 these effects is critical to this argument. Third, I modeled the effect of holding belief $\theta = 1$ on
536 acquiring practices $x = 1$ as a content bias. There are other ways to incorporate the causal

537 impact of holding a particular belief (like $\theta = 1$) on acquiring or performing a practice or action
538 (that could deliver a CRED). For example, the practice $x = 1$ might not be culturally transmitted
539 behavior but a behavioral decision evoked under rare circumstances by weighing the costs and
540 benefits of alternative outcomes. To illustrate, believing in God and salvation ($\theta = 1$) might make
541 one substantially more likely to martyr one's self ($x = 1$), given the choice between renouncing
542 God (and losing salvation) or biological death. Here performing $x = 1$ (dying instead of
543 renouncing) is a CRED for commitment to $\theta = 1$, even though most people with this belief won't
544 then actively seek martyrdom. Sociopolitical circumstances that present the faithful with such a
545 choice (e.g., denounce your god or face execution) may lead to the spread of the faith by
546 providing opportunities for the committed to perform CREDs (Stark, 1997).

547 Before proceeding, I should clarify that the difference between a CRED and a costly act.
548 CREDs need not be costly but costly acts can, under the right circumstances, provide
549 particularly powerful CREDs. Consider two examples. In the mushroom example above, eating
550 blue mushrooms is a CRED of one's belief that blue mushrooms are edible and non-toxic. If this
551 is true, the CRED is not costly. Similarly, ritual scarification can, under the right circumstances,
552 be interpreted as a CRED of a model's belief in, and commitment to, a particular supernatural
553 being. If such a being exists, and does in fact require the ritual as a pre-requisite for delivering
554 various benefits, the cost of the scarring may be minor compared to the benefits.

555 **Part III. Cultural Group Selection favors interlocked belief-display** 556 **combinations that increase cooperation**

557 Part II demonstrated that a genetically evolved reliance on CREDs can, under a wide
558 range of conditions, yield a cultural evolutionary process with multiple stable equilibria. If this
559 were all there were to it, the story would not be very interesting as individuals at equilibria
560 involving costly acts would get lower payoffs than those in groups stabilized at the other
561 equilibrium. However, by showing that a reliance on CREDs can stabilize costly practices, the

562 door opens to the possibility that such costs could be directed, in some fashion, to supply group
563 benefits and increase group competitiveness. There are several ways to think about this. First,
564 the practice ($x = 1$) could be a cooperative or prosocial act in itself, and cooperation would
565 increase the success and competitiveness of the group/institution. For example, giving alms to
566 the poor could be a CRED for a belief in Allah and a group beneficial act. Second, the practice
567 might be an act of punishment that penalizes non-cooperators (this could stabilize cooperation,
568 and similarly benefit the group). There's no first or second order free rider problem here, since
569 the costly act is already stabilized by the interlocking effects of the CRED (as modeled in Part
570 II). Third, it is possible that the costly practice in and of itself delivers nothing to the group
571 (scarification or tattooing) but that it elevates and stabilizes a strong commitment to a group
572 ideology ($\theta = 1$) that itself favors other group-beneficial contributions related to cooperation in
573 war, self-sacrifice, bravery, etc. Costly ritual sacrifices, for example, may favor the transmission
574 of high degrees of commitment to beliefs in a lovely afterlife. Strong commitments to beliefs in
575 God and an afterlife could permit individuals to charge an enemy, aid the sick during a plague
576 (Stark, 1997), or help build a community member's house after a storm. Social groups with
577 costly acts that generate CREDs for beliefs that promote in-group cooperation and out-group
578 competitiveness can spread more effectively—via competition among cultural groups—than
579 those that don't.

580 The process of competition among social groups locked in at different stable states is a
581 kind of *cultural group selection* (CGS). Understanding both the importance and plausibility of
582 CGS requires recognizing the intersection of two different lines of modeling work. First, several
583 models including the one developed in Part II demonstrate various ways in which cultural
584 learning gives rise to multiple stable states, including states that sustain individually costly
585 behavior (cooperation is one type of costly behavior). Two other examples of such models come
586 from (1) Henrich and Boyd (2001), who show how culturally transmitted forms of punishment
587 can stabilize costly norms, and (2) Panchanathan and Boyd (2004), who show how reputation

588 can stabilize costly norms by linking them to behavior in a dyadic helping game. Thus, the
589 above model represents yet another means by which cultural evolution can stabilize costly
590 behaviors, including cooperation. Each of these models reveals a range of stable equilibria
591 involving costly practices that vary in their group payoffs, but no built-in way to determine which
592 equilibrium eventually emerges. That is, cooperative equilibria represent only a tiny fraction of
593 the stable states for costly behaviors, thus neither model alone can explain the prevalence of
594 prosocial norms or large-scale cooperation.

595 However, a second line of modeling work on CGS demonstrates that competition among
596 social groups at different culturally-evolved stable equilibria provides a plausible, theoretically
597 well-studied mechanism that can favor the diffusion of cooperative, group-beneficial beliefs,
598 practices, and norms (R. Boyd & Richerson, 2002; R. Boyd & Richerson, 1990; Fehr &
599 Fischbacher, 2003; Joseph Henrich, 2006). This kind of cultural group selection, involving
600 competition among *stable* states, suffers none of the problems typically associated with
601 application of genetic group selection to the evolution of altruism (Joseph Henrich, 2004).

602 CGS can occur in several ways. First, the most straightforward form of CGS occurs
603 when social groups—due to superior institutions for cooperation that create technological,
604 military or economic advantages—drive out, eliminate, or assimilate groups at alternative
605 equilibria (J. Soltis, R. Boyd, & P. J. Richerson, 1995). “Institutions” here refers to the integrated
606 sets of beliefs, values, and practices that organize social interactions in groups. Second, social
607 groups may compete demographically, with groups at some stable equilibria putting out more
608 culture bearers than other groups, or attracting more migrants than groups stuck at other inferior
609 equilibria (R. Boyd & Richerson, forthcoming). A third form of CGS is perhaps the most subtle
610 and important. Our evolved adaptations for cultural learning may cause people in groups stuck
611 at less group-beneficial equilibrium to preferentially imitate the beliefs and practices of people
612 from groups at more group-beneficial equilibrium because they show higher payoffs (R. Boyd &
613 Richerson, 2002). This can cause sets of ideas, beliefs and practices to differentially spread

614 from more successful groups to less successful groups. This can describe how institutions
615 spread from one social group to another, or how institutions compete for membership within a
616 social group.

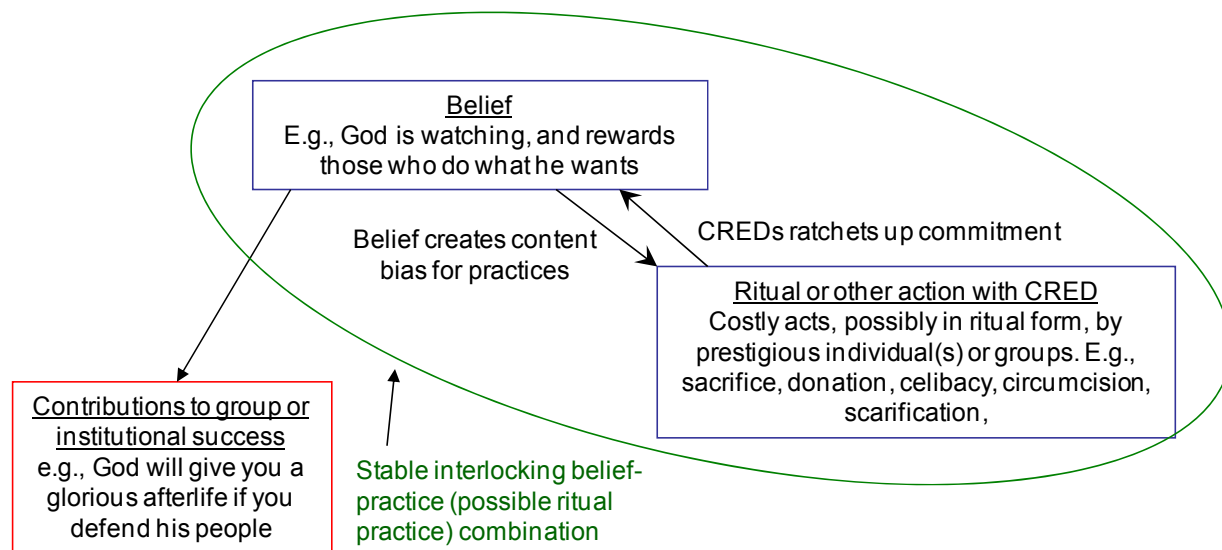
617 Building on this theoretical foundation there are now numerous lines of empirical
618 evidence supporting CGS, including data from ethnography (S. Atran et al., 2002; Scott Atran et
619 al., 2002; J. Soltis, R. Boyd, & P. Richerson, 1995), archeology (Bettinger & Baumhoff, 1982;
620 Flannery & Marcus, 2000; Spencer & Redmond, 2001; Young & Bettinger, 1992), ethno-history
621 (Kelly, 1985; Sahlins, 1961), and even laboratory experiments (Gurerk, Irlenbusch, &
622 Rockenbach, 2006).

623 Below, I (1) draw together insights derived above regarding CREDs with existing work
624 on cultural group selection and apply them to the evolution of rituals, and the relationship
625 between rituals, costly acts, cooperation and deep commitment to group ideologies, (2) highlight
626 some *prima facie* empirical findings that packages of rituals, costly acts, and group
627 ideologies/religions do spread by CGS, and (3) interpret recent findings concerning rituals,
628 costly acts, and cooperation to illustrate their consistency with this approach.

629 **CGS favors rituals that exploit evolved learning mechanisms**

630 Since both religious and secular rituals have frequently been associated with costly
631 displays—such as firewalking and scarification—and with the promotion of group solidarity,
632 cooperation, and competitiveness in warfare (Scott Atran, 2002; Durkheim, 1995; Richard Sosis
633 & Candace Alcorta, 2003; Sosis & Ruffle, 2003), I apply the above ideas to rituals, thus
634 incorporating rituals into the discussion, and then consider empirical evidence linking rituals,
635 cooperation, beliefs, and costly acts. My goal is only to suggest how cultural evolutionary forces,
636 rooted in our evolved cultural learning capacities, may have shaped rituals alongside other
637 forces (P. Boyer & Lienard, 2006; McCauley & Lawson, 2002; Whitehouse, 2000).

638 Competition among groups or institutions should favor rituals that more effectively exploit
639 our capacities for cultural learning in order to transmit deeper commitments to ideas, beliefs or
640 values that increase in-group cooperation and solidarity (and perhaps out-group enmity).
641 Groups with rituals that more effectively transmit commitment to group-beneficial (self-sacrificial)
642 beliefs will—*ceteris paribus*—outcompete groups with less effective ritual-belief combinations,
643 causing these belief-ritual complexes to spread by the various forms of CGS discussed above.
644 Figure 2 illustrates the process described.



645
646 **Figure 2 diagrams the key relationships that give rise to the linkage between group**
647 **beneficial acts like cooperation, religious beliefs, and costly acts, including rituals.**

648 If rituals are evolving via CGS to more effectively exploit our capacities for social
649 learning, then we can make predictions about the nature of rituals based on our understanding
650 of these evolved mechanisms. Effective rituals should variously make use of (1) prestige-bias
651 transmission (Joseph Henrich & Gil-White, 2001), capturing our tendency to weight information
652 coming from prestigious individuals more heavily than from others, (2) conformist transmission
653 (Joe Henrich & Boyd, 1998), exploiting our tendency to use the frequency of others doing or
654 professing something as a cue in adopting it, (3) folkethnicity (Gil-White, 2001; N. S. Henrich &
655 Henrich, 2007: Chapter 9), tapping our tendencies to essentialize, preferentially interact with,
656 and differentially learn from those who share our hard-to-fake symbolic markers (dialect, dress,

657 painful tattoos), (4) mimicry, exploiting our tendencies to both use mimicry to improve our
658 reading of others emotions and to assess relative prestige differences, and most importantly, (5)
659 CREDs, exploiting our reliance on diagnostic actions or displays to assess the depth of our
660 models' commitments.

661 Under such selective pressures, rituals will tend to (1) put key lessons or statements of
662 belief in the mouths of the older, more prestigious, and more successful members of the
663 community, (2) involve group professions of belief to cue conformist transmission (e.g. in
664 prayers, chants, group public oaths), (3) make use of costly-to-acquire symbolic markers that
665 distinguish community members from other groups, (4) include music, rhythm, and synchrony to
666 elevate solidarity (Wiltermuth & Heath, forthcoming) via mimicry, and (5) showcase practices
667 that only deeply committed believers would engage in, such as practices that allow prestigious
668 members to demonstrate their degree of belief (e.g. snake handling while preaching) or
669 practices that involve several members undergoing harsh, painful or frightening experiences.
670 These characteristics would evolve via CGS to target participants and observers because they
671 more effectively exploit our evolved cognitive capacities for cultural learning to convey deeper
672 commitments. Over time, this would result in ratcheting up people's degree of commitment to
673 some underlying beliefs.

674 Costly acts, particularly those found in rituals, will be more important for sustaining
675 commitment to religious beliefs than to secular beliefs or ideologies. There are three interrelated
676 reasons for this. First, religious beliefs often involve commitments to counter-intuitive agents.
677 Committing deeply to counter-intuitive concepts may require CREDs by models because, in and
678 of itself, counter-intuitiveness violates content plausibility (see opening section). Acquiring and
679 committing to secular ideologies often does not require accepting and committing to counter-
680 intuitive propositions, and thus may not face the same uphill battle. Second, once committed to,
681 many counter-intuitive concepts—like supernatural agents (ancestors and gods)—cannot easily
682 be falsified by real world events or experiences in the same way or to the same degree that

683 secular beliefs can. This means that degrees of commitment to secular ideologies will be more
684 subject to real events and outcomes compared to religious ideologies. When religious beliefs
685 can be directly falsified by experience, they tend not to stick around for the same reasons. For
686 example, various groups have come to believe that faith, or a ritual, can provide protection from
687 bullets. Such beliefs have tended not to endure for long periods once the shooting starts. Third,
688 religious beliefs, *once deeply committed to*, are likely more powerful than secular beliefs at
689 galvanizing cooperation. Supernatural agents can police (e.g., seeing all, reading minds, etc.)
690 and motivate adherents (e.g., by bringing sickness, death, afterlife, etc.) in ways that secular
691 agents cannot. This combination of elements means that costly acts, particularly those found in
692 rituals, will tend to be associated with sustaining or increasing religious convictions, and any
693 associated group-beneficial behaviors, in a manner not found for secular beliefs.

694 In signaling terminology (Maynard Smith & Harper, 2003) CREDs began as *cues*
695 inadvertently or incidentally given off by individuals, according to their beliefs, that are used by
696 learners as *indices* (more or less accurate measures) of belief-commitment by learners. These
697 indices can become true signals when (1) genetic evolution, (2) cultural evolution, or (3)
698 individual decision-making favors “transmitters” strategically using these indices to influence
699 others. Here, individuals become active transmitters or signalers as CRED *cues* evolve into
700 *signals*. The genetic evolution of our reliance on CREDs (as cues) created an opportunity for
701 cultural evolution to turn these cues into signals in the form of rituals and ritualized acts that
702 exploit our learning psychology to favor deeper commitments to certain kinds of beliefs, such as
703 those favored by CGS.

704 **Preliminary Lines of Evidence**

705 This approach makes predictions about the relationship between ritual, costly acts,
706 cooperation, and group solidarity. The three predictions addressed here ask (1) Is there any
707 evidence suggesting that these packages of rituals, beliefs, and costly acts do spread via

708 CGS?, (2) Does ritual attendance indeed increase commitments to group ideologies?, and (3)
709 Does requiring costly acts improve a group's relative survival compared to groups demanding
710 fewer costly acts?

711 *Belief-ritual packages spread by cultural group selection*

712 Ethnographic, ethno-historical, and comparative research indicate that belief-ritual
713 packages are spread by CGS. I've only space to mention four studies. In New Guinea, Boyd
714 (2001) describes how a village explicitly decides to imitate the pig-raising package of practices,
715 beliefs and rituals from their most successful and prestigious neighbors. In the East Sepik, Tuzin
716 (1976; 2001) analyzes how the largest village in the region (five times larger than average)
717 sustains harmony, cooperation and solidarity using a package of costly rituals, ideologies, and
718 institutions that was copied from the Abalam, a highly successful and aggressively expanding
719 society. In the New Guinea Highlands, Wiessner and Tumu (1998) describe belief-ritual
720 complexes associated with painful or frightening rites, which promote "identity, welfare and
721 unity," as spreading by a process of emulating the more successful groups. Such rich
722 ethnography helps us understand the cultural evolution of the observed relationship between
723 warfare and costly rites for males (Sosis, Kress, & Boster, 2007). Increasing warfare means
724 cultural groups with more costly rites galvanize greater cooperation and solidarity among males
725 (more commitment to group ideals), and thus these groups survive, expand, and are imitated
726 more frequently by other groups.

727 *Costly rituals will elevate people's degree of belief-commitment.*

728 Participation in rituals involving costly acts will elevate people's degree of belief-
729 commitment. If the professed beliefs involve group commitment, cooperation toward fellow in-
730 group members, or the hatred of out-groups, than ritual attendees will trust, identify, and
731 cooperate with in-group members more than non-attendees. Demonstrating this, Sosis and
732 Ruffle (2003; 2004) performed behavioral experiments among secular and religious members of

733 Israeli kibbutzim to explore the relationship between ritual participation and cooperation. In
734 these experiments, two anonymous participants from the same kibbutzim were given a
735 monetary sum and a one-shot opportunity to contribute any portion of it to a common pot.
736 Whatever money was contributed to this pot was increased by 50% and split equally between
737 the pair. Pure self-interest favors contributing zero to the pot, so positive contributions are a
738 measure of increasing cooperativeness towards the other player. Consistent with the above
739 prediction, their results show that greater attendance at public rituals predicts higher
740 contributions in the religious kibbutzim (controlling for a variety of other factors).

741 These findings also illustrate the expected link between ideological commitment, ritual,
742 and in-group favoritism. Sosis and Ruffle also used treatments in which participants knowingly
743 interacted with either another anonymous kibbutzim member or another Israeli in general. High
744 ritual attenders in religious kibbutzim contributed substantially more to their fellow kibbutzim
745 members compared to non-members. Members of secular kibbutzim treated fellow members in
746 the same way as other non-member Israelis. This suggests that ritual attendance is associated
747 with in-group favoritism.

748 Work by Ginges et. al. (2007) affirms this link between ritual participation and
749 commitment for both in-group cooperation and out-group aggression. Both survey and
750 experimental findings from Palestinians and Jewish Israelis show that ritual participation
751 predicts more support for suicide bomber attacks against outgroups independent of religious
752 devotion (as measured by prayer) and a wide range of other factors. Similarly, using
753 representative samples of Indonesian Muslims, Mexican Catholics, British Protestants, Russian
754 Orthodox, Jewish Israelis, and Indian Hindus, these researchers also showed that greater ritual
755 attendance, independent of a person's prayer frequency and other factors, predicts both
756 declaring a willingness to die for one's god or gods, and that other religions are responsible for
757 much of the world's troubles.

758 *Groups that require more costly acts (CREDS) galvanize greater solidarity and cooperation*
759 *because these displays effectively transmit belief-commitment*

760 In their study of utopian communities, Sosis and Bressler (2003) assembled data on
761 longevity, group size, and costly requirements (e.g., rituals, taboos, etc.) for 83 religious and
762 secular utopia movements in the 19th century. Costly requirements included restrictions on food,
763 sex, material possessions, marriage, and parenting rights, among other things. As predicted, the
764 number of costly requirements strongly predicts the longevity of religious communes, though
765 this effect does not emerge for secular communes. The authors also explored some contextual
766 data suggesting that the driving factors for longevity were indeed related to solidarity, group
767 commitment, and cooperation. They report that some commune members explicitly recognized
768 that costly requirements *increased* the belief-commitment and solidarity of members.

769 These findings, in addition to illustrating the relationship between costly displays and
770 group success (as measured by group survival), provide a stark example of CGS in action.
771 These communes varied in their number of costly requirements and the data show that those
772 with the most costly requirements survived longer. Over time, the differential survival of some
773 groups ratcheted up the mean number of costly requirements per commune by selecting out
774 those groups unable to sustain solidarity and cooperation. It's difficult to interpret this as
775 anything but a prime example of CGS influencing cultural evolution.

776 The authors, however, use these data to support a ritual signaling hypothesis, arguing
777 that signaling predicts that those individuals who are committed to the group's ideals will be able
778 to perform the costly requirements more cheaply than non-believers (the less committed), and
779 thereby sustain more cooperation by suppressing free-riders. There are several problems with
780 this interpretation.

781 1) These findings are derived from a pattern created by a historical process in which
782 groups with more costly requirements survived longer than groups with fewer
783 requirements. It's not clear how their signaling hypothesis actually predicts such group

784 dynamics, or historical processes. The signaling models cited by these authors are not—
785 at this point—imbedded in a cultural evolutionary framework capable of yielding
786 historical (non-genetic) dynamics occurring over decades.

787 2) This signaling approach does not predict that costly requirements will ratchet up
788 commitment to beliefs or ideologies. The authors, however, report that commune
789 members believed costly requirements did increase group commitment.

790 3) In contrast to most signaling applications, it's not clear why (in a fitness sense) it is more
791 costly for non-believers to perform the costly requirements than believers (more
792 committed people). Holding a particular mental representation is not obviously parallel to
793 possessing a physical attribute, like size, strength, or stamina (as in the non-human
794 literature on signaling). In non-human cases of signaling it is often clear why creating a
795 certain kind of signal is more costly for some individuals than others. Smaller animals,
796 for example, can't just "get big" for signaling purposes. But, a human could always
797 acquire a mental representation, if holding that representation will lead to higher fitness.
798 Approaching this requires a theory of *belief acceptance* (i.e., a theory of cultural
799 transmission) to explain where these ideologies come from, why people are committed
800 to them, or why humans (and not other animals) have ideologies, which can be
801 committed to, in the first place.

802 4) Lacking a theory of cultural learning, it's unclear why members don't just invent more
803 costly requirements and thus obtain more group benefits. If this is—in fact—because the
804 requirements are culturally transmitted or that multiple signaling equilibria exist (which is
805 likely), then one is back to needing to embed signaling in a theory of cultural evolution.

806 5) A broader problem with *ritual* signaling theory is the lack of any formal evolutionary
807 model showing how this can solve the *n*-person prisoner's dilemma. Existing modeling
808 efforts suggest that it cannot (McElreath & Boyd, 2007). And, since both signaling
809 models (C. T. Bergstrom, Szamado, & Lachmann, 2002; M. Lachmann & Bergstrom,

810 2004; Michael Lachmann, Szamado, & Bergstrom, 2001) and n -person models of
811 cooperation (R. Boyd, 1988; R. Boyd & Richerson, 1992) have repeatedly yielded results
812 (including multiple stable equilibria) that contradicted previous verbal theorizing,
813 modeling this seems crucial.

814 Nevertheless, both my hypothesis and a version of the above signaling hypothesis may
815 be important to explain the intersection of rituals, belief, and cooperation. Individuals likely need
816 to both calibrate their degree of commitment during cultural learning, and assess the degree to
817 which their fellow group members are also committed and willing to cooperate. Norm adherence
818 and cooperation will be maximized when (a) individuals' commitments are deepest and (b)
819 everyone believes everyone else is also deeply committed. The problem with much existing
820 work is that it fails to address how people get deeply committed to certain beliefs—such as
821 those involving counter-intuitive agents—in the first place.

822 **Discussion: Implications for understanding religion**

823 These ideas have numerous implications for understanding the cultural evolution of
824 various religious phenomena. Here I'll sketch how some of these processes may have shaped
825 certain aspects of religion.

826 *Why are religions often associated with prestigious paragons of virtue who make (or*
827 *made) costly sacrifices?* Applying the above reasoning to this question begins by considering
828 our evolved psychology for cultural learning. In learning how to behave and what to believe,
829 learners give weight to both prestige and CREDs, among other things. Thus, successful cultural
830 forms, especially those involving deep commitment to counter-intuitive beliefs, will tend to begin
831 with and be sustained by prestigious individuals performing CREDs. Cues of prestige influence
832 who people pay attention to for learning while CREDs convince them that the prestigious model
833 really believes (is committed to) his or her professed beliefs. The “virtuousness” arises from
834 these prestigious individuals' role as models. CGS will favor, over long swaths of historical time,

835 religions with role models who effectively transmit beliefs and practices that strengthen in-group
836 cooperation, promote intra-group harmony, and increase competitiveness against out groups.

837 *Why martyrdom is powerful.* As a corollary of the above, martyrs—be they suicide
838 bombers or saints—can provide powerful CREDs to learners regarding their degree of
839 commitment. Anthropologists have considered suicide bombing as a costly signal of group
840 commitment (S. Atran, 2003; Sosis & Alcorta, forthcoming), which it may be. However, this
841 approach fails to explain the impact of these costly actions on learners' beliefs. The most
842 important thing about martyrdom is not that everyone now knows the martyr is a committed
843 member of the group (signaling), but that observing this CRED increases the commitment of the
844 (still living) learners—i.e., some moderates become radicals in the process.

845 Two cases help illustrate this point. First, early Christian martyrs, executed in public
846 events, are believed by many (Stark, 1997), including observers at the time, to have
847 substantially fueled the spread of early Christianity. Ignatius, Bishop of Antioch, after being
848 condemned to be ripped apart by wild beasts in a Roman Amphitheatre exulted in his
849 opportunity to “imitate the passion of my God!” He then wrote letters to Christian communities
850 along the road to Rome, who might attempt a rescue, pleading with them to allow him to go and
851 die. A Platonist philosopher, Justin, explains that he was convinced of the divinity of Jesus, and
852 converted to Christianity, after personally witnessing the commitment demonstrated by the
853 torture and death of some martyrs. Justin was later martyred, himself (Pagels, 1989). Second,
854 back in his hometown of Zarqa, Jordan, the death of the locally prestigious Palestinian Abu
855 Musab al-Zarqawi at the hands of the American military ignited an epidemic of young male
856 volunteers flowing into Iraq for martyrdom, often to die as suicide bombers.

857 This reasoning explains why the oppression of religious minorities, or other ideologically
858 committed groups, may actually energize the spread of these groups. Government directed
859 crackdowns, involving torture and execution, provides the faithful with opportunities for CREDs.
860 Interested members with low commitment might not otherwise have the opportunity to observe a

861 potent CRED from a prestigious leader, such as seeing them crucified, stoned, beheaded, eaten
862 by wild cats, etc. Making these displays public is a really bad idea if you want to stamp out a
863 religious movement.

864 *Why religious leaders take vows involving celibacy, fasting, and poverty.* Beliefs of any
865 kind, but especially the counter-intuitive ones found in religions, will best proliferate when
866 expressed by prestigious individuals performing CREDs. Avoiding sex, food, and wealth can all
867 act as CREDs of deep belief-commitment. Individuals sticking to such vows (or appearing to)
868 increase their potency as transmitters of the faith. Religions that prescribe the avoidance of
869 food, sex, and wealth among leaders, while effectively dealing with the obvious defection
870 problem, will tend to proliferate because they've made their leaders better transmitters of
871 commitment.

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

878 From this perspective, costly acts by high status leaders demonstrate—and thereby
879 more effectively culturally transmit—the leader's professed beliefs. Atran (2002), for example,
880 relates a scene described in Mayan glyphs in which a new ruler rises to power in Palenque. In
881 the accession ritual the new ruler first sacrifices a captive, by personally plunging a knife into the
882 victim's chest, and then pierces his own penis three times, in order to pull through long strands
883 of bark, which he then watches turn red. Such actions are likely to provide a CRED for some
884 portion of the audience. Observing the leader's display may ratchet up the commitment to the
885 leader's professed beliefs of his counselors, senior members of the government, the military,
886 and perhaps even the populace.

887 *Why counter-intuitive agents (e.g., gods or ancestors) want costly acts.* The above logic
888 proposes that religions will culturally evolve to possess counter-intuitive agents, like gods, that
889 demand or at least want CREDs. The reason for this is straightforward. Counter-intuitive agents
890 that demand CREDs can cause the transmission of deeper commitments to that agent, and
891 further spread belief in that agent. The more counter-intuitive the agent, the more CREDs will be
892 required to sustain commitment.

893 *Why Mickey Mouse is not a god, and why people don't believe in other people's gods.*
894 The prevailing view in evolutionary-cognitive circles is that religious representations spread
895 because of their content (Pascal Boyer, 2001). However, many of the counter-intuitive denizens
896 of cartoons and folktales would often seem to have the "right" content to become faiths, yet no
897 one seems ready to commit deeply to such representations. Similarly, adherents to one faith
898 often have substantial knowledge of other faith's supernatural agents, yet they are not
899 persuaded to commit to those gods merely by virtue of holding the same representational
900 content as believers. This presents a problem for approaches based exclusively on content,
901 especially when the content biases arise from innate aspects of human cognition. From the
902 theory summarized earlier, we distinguish the effects of content on *memory* from its effects on
903 *commitment* to, or belief in, the representation in question. Particular content may increase a
904 representation's memorability and transmittability, but not influence a learner's degree of
905 commitment to that representation. To turn Mickey Mouse into God, we need CREDs, especially
906 by prestigious individuals or large groups (conformist transmission), and preferably by models
907 sharing the learners' sex and ethnicity (two other evolved biases). From the perspective of a
908 learner, the difference between Mickey and Yahweh, or Yahweh and Zeus, is that learners
909 observe members of *their* social group, including their chosen models, performing CREDs. This
910 makes religious commitment a cognitive, social, and cultural evolutionary phenomenon.

911 **Conclusion**

912 I began by hypothesizing that, over the course of human evolution, cultural learners
913 faced an adaptive challenge created by our increasing capacities for symbolic (cheap) cultural
914 transmission that drove the evolution of our reliance on credibility enhancing displays in
915 determining how much to commit to, or believe in, a particular representation. Learners evolved
916 to look for displays (often actions) that indicate a model's degree of commitment to, or belief in,
917 verbally expressed representations. These CREDs are actions that (a) are consistent with a
918 model's professed beliefs, and (b) a model would be unlikely to perform if he believed
919 something different from what he expressed symbolically.

920 Building on this, I examined the implications of this evolved bias on cultural evolution by
921 constructing a simple formal model. The model reveals a wide range of conditions under which
922 this reliance on CREDs can create multiple stable states, with one of these involving an
923 interlocking combination of a costly practice and a belief. Such situations can arise when (1)
924 particular practices influence the transmissibility of certain belief adoptions (CREDs), (2)
925 committing to a belief favors some practices over others (compatibility content bias), and (3)
926 learners tend to copy more successful people (prestige-bias cultural learning).

927 The presence of multiple stable equilibria involving a costly practice sets up the
928 conditions for cultural group selection. Some stable practices may be only individually costly
929 while others may also contribute benefits to the social group. Social groups that have stabilized
930 on costly-practice-belief combinations that deliver group benefits, in the form of cooperation,
931 solidarity, and group success, can spread at the expense of social groups at alternative
932 equilibria. This leaves open the possibility that particular groups may get stuck at cultural
933 equilibria involving interlocking belief-practice combination that are purely costly (maladaptive)
934 for both individuals and groups. Over the long-haul of culture history, CGS will ensure these
935 groups do not spread, though they may endure for long periods (Edgerton, 1992).

936 Overall, this approach suggests that the frequently observed connection between costly
937 actions and rituals with larger-scale cooperation, solidarity and success in inter-group
938 competition may be an emergent product of the interaction between an evolved cognitive
939 adaptation for avoiding exploitation during social learning and larger-scale processes of cultural
940 evolution.

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