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A theory of modern cultural shifts and meltdowns

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Many cultural attributes such as adornment, language slang, mannerisms and rituals are thought to have little or no influence on individual survival and reproduction, functioning rather as markers of cultural identity that promote group cohesion. Here, I show that if cultural markers are under weak selection and subject to loss or substitution, then the breakdown of cultural cohesiveness may proceed without stabilizing reactions until many or most of a culture's identifiers are forever lost. This may culminate in a 'cultural meltdown', whereby the culture is caught in a vortex of ever-decreasing membership and insufficient selection against the accumulation of unfamiliar markers. In progressively altering the topology of communication from diffusion to broadcasting, globalization may be both accelerating the erosion of cultural identities and amplifying dominance behaviours above their normal adaptive levels.

Keywords: cultural meltdown; dominance; globalization; prestige; human cultural evolution

1. INTRODUCTION

A major challenge in cultural anthropology is to understand the forces responsible for cultural change. Of particular interest are observations of cultural decline and extinction coinciding with the persistence of some segment of the peoples who embody a culture (e.g. Soltis *et al.* 1995; Putnam 1999; Turchin 2003). One possible explanation for such phenomena is that innovations spread rapidly in structured populations (Boyd & Richerson 2002), carrying with them large suites of novel cultural characters. However, cultural disbandment is difficult to explain on the basis of selective sweeps alone (Soltis *et al.* 1995; Henrich 2001) and empirical evidence suggests that some neighbouring cultures are often only differentiated by apparently neutral markers such as adornment, rituals and mannerisms (Barth 1969; Soltis *et al.* 1995; McElreath *et al.* 2003). Recent theory shows that such cultural markers may influence social behaviours (McElreath *et al.* 2003) and, in so doing, augment group cohesion (e.g. Nettle & Dunbar 1997; Hochberg *et al.* 2003; McElreath *et al.* 2003) and channel reproductive preferences (Hochberg *et al.* 2003).

Here, I show how the endogenous evolution of cultural markers can lead to the alteration and even demise of group identity. Cultures are potentially vulnerable to a phenomenon that I call a 'cultural meltdown'. This type of process is well understood in population genetics (e.g. Lynch *et al.* 1993), where it is referred to as a 'mutational meltdown'. A meltdown requires that several conditions be met, but two of the most important are that (i) members of a culture are frequently exposed to novel markers (hereafter called 'deviations'); and (ii) deviations only have a significant selective effect when they occur in large numbers in each individual, by which time a sizeable fraction of the population harbours them. Part of the viciousness of a meltdown is that the symptoms of demise are initially unapparent, but gradually the most 'ideal' cultural states are eliminated one by one by the continual onslaught of deviations, ineffective selection to reduce individual deviation loads, and chance effects (i.e. drift). I suggest that constraints associated with mutational meltdowns could be relaxed for some human cultures.

2. MODEL

To see why certain cultures may be in danger, consider a simple model that tracks the dynamics of a single cultural population over the relatively short time-scales of years to tens of years. Based on previous study (Henrich & Boyd 2001; Henrich & Gil-White 2001; Boyd & Richerson 2002), I assume that cultural divergence is driven principally by prestige-based imitation, whereby cultural markers may be replaced by homologous markers acquired after either contact with the members of, or institutions representing, different cultural groups, or exposure to virtual media, such as telecommunications or the Internet (Holton 1998). Dominance behaviours such as policing and punishment are considered to be a central force maintaining group-level cohesion (Boyd *et al.* 2003). They are assumed here to contribute to the maintenance of cultural identity through selection (the loss of cultural membership for those individuals who have most diverged from cultural ideals) and regeneration (the assimilation of former or new members into the culture), although status- or prestige-based mechanisms may also be involved (Goode 1978). A detailed description of the model can be found in electronic Appendix A.

Briefly, the equations are

$$d_{t+b} = d_t + U + D_t\{N_t\}[\partial \ln W_t/\partial d]$$

and

$$N_{t+b} = N_t e^{r(1-N_t)-W_t},$$

where $d_{t+b} - d_t$ and N_{t+b}/N_t are the changes in the mean deviation load and population density, respectively, from time-step t to $t + b$, U is the input rate of deviations, D gauges the effects of drift ($D = \rho N_t/(1 + \rho N_t)$, where ρ converts density into numbers), W is the loss in cultural membership due to selection ($W = \exp\{-(sd_t)^x\}$, where s is the selection coefficient and x is the level of synergistic selection), and r is the regeneration rate of the culture.

3. RESULTS

Selection on cultural markers can arbitrate whether a culture persists in its ideal state, tolerates deviations among its constituents, or goes into demise, eventually disbanding. To understand the salient forces involved, consider first the interplay between selection and deviation input (figure 1*a*). By substituting appropriate functions

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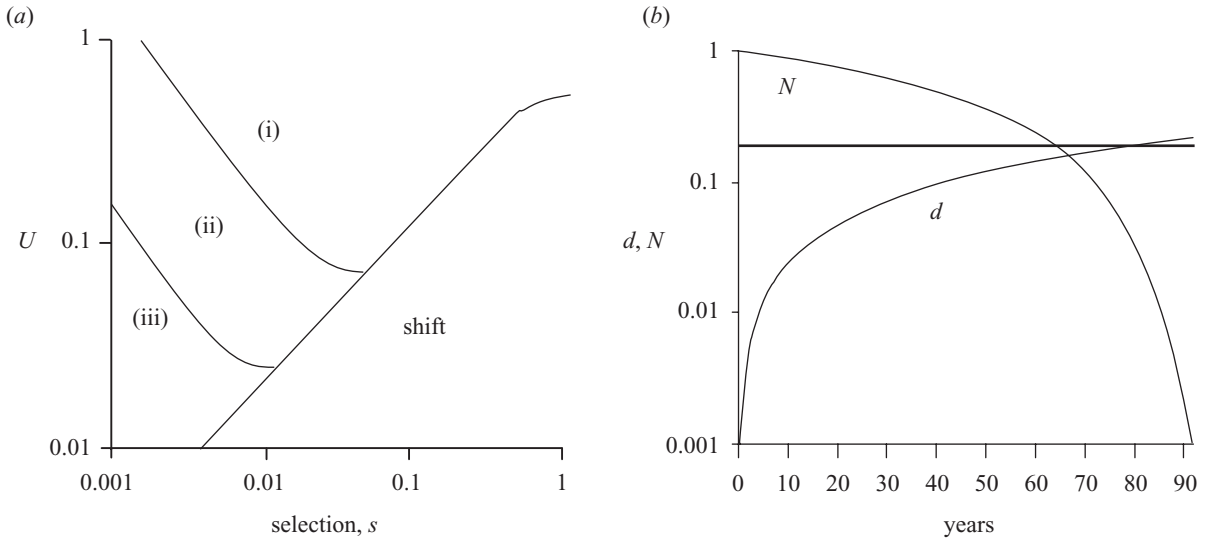

Figure 1. Cultures with intermediate selection are the most vulnerable to rapid demise. (*a*) Areas where the culture goes extinct in (i) less than 10 years; (ii) 10–100 years; and (iii) more than 100 years. In 'shift', the culture persists at an equilibrium deviation load, d^*, which can be calculated from the equations in § 3. (*b*) A typical example of a cultural meltdown. The thick horizontal line is the deviation threshold beyond which the meltdown occurs. Threshold and d are both scaled to $1/s$. Unless otherwise noted, $e^r = 1.2$, $U = 0.2$, $s = 0.001$, $\rho = 1000$ members, $b = 12$ months and $x = 1$.

into the equation for deviation change, we have $\Delta d = U - sxd_t^{x-1}$. When there is selection, deviations initially accumulate at a rate approximately equal to U. As the deviations grow, selection acts with increasing strength and in so doing, begins to limit the load. However, in parallel to this process, membership losses accrue, and if the deviation load should cross the threshold quantity $(r/s)^{1/x}$ before attaining its potential steady state $d^* = (U/sx)^{1/(x-1)}$, then cultural membership declines and heads towards irrevocable extinction (figure 1*b*). Therefore, $d^* > (r/s)^{1/x}$ is the condition for a meltdown to occur.

If, however, $d^* < (r/s)^{1/x}$, then the culture is able to control the load and persists, with members of the culture expressing a variety of alternative markers if $x > 1$. In this situation, the mean deviation load attains d^* and the corresponding equilibrium population density is $N^* = 1 - s(U/sx)^{x/(x-1)}/r$. Tolerating the load means that selection is an ongoing process as novel markers continue to be absorbed into the culture, whereas others disappear following selection.

In agreement with the dynamics of nearly neutral genetic mutations (e.g. Lynch *et al.* 1993), we find that the most vulnerable cultures are those experiencing intermediate levels of selection (figure 1*a*). High selection means that membership losses occur essentially on an individual-by-individual basis and tend not to endanger the culture. Low selection, however, can lead to the emergence of a wave of deviations, which take extensive periods of time to finally induce a meltdown. Although not explicitly included in our formulation (because selection is expected to be inversely proportional to the total number of markers in a culture), these results indicate that cultures of intermediate marker number may be the most vulnerable to rapid demise. Further research employing more detailed models is necessary to evaluate this prediction.

Endogenous cultural characteristics not only influence persistence but may also affect population dynamics (figure 2*a*). In particular, if the regeneration rate, r, is greater than about two then the population cycles (figure 2*b*). The specific condition for this is $r > 2 + s(U/sx)^{x/(x-1)} - sx(x-1)(U/sx)^{(x-2)/(x-1)} - s^2x(x-1)(U/sx)^2/2$. Because r scales with the length of the assessment period b ($r \propto \ln\{b\}$), all else being equal, dominance-based, retroactive cultures are the most likely to show unstable population trajectories. The robustness of this finding is supported by the effects of other model parameters (figure 2*a*), whereby deviation input is lessened by dominance behaviours and synergism is a manifestation of retroactive selection.

4. DISCUSSION

Cultures are evidently far more complex than any simple set of equations can possibly embody, and due caution is necessary in interpreting the results presented here. The present model notably did not consider: (i) interactions between cultural and social change; (ii) realistic notions of cultural architecture, whereby certain cultural elements may be more vulnerable to deviation than others, or the vulnerability of certain elements may be dependent on the states of others; and (iii) the adaptive re-centring of ideals in shifted cultures and the fate of disbanded groups. My theory nevertheless provides a heuristic framework that can be extended along these lines to investigate how globalization may polarize, hybridize and homogenize cultures (Tomlinson 1999; Holton 2000).

How plausible are the predictions of this simple model? Consider how the level of broadcasting U affects demise. With parameter values chosen to represent a culture of 1000 individuals that assesses itself monthly ($b = 1$ month), shows moderate selective synergism ($x = 2$), exhibits low regeneration ($e^r = 1.3$ individuals per month) and acquires on average one new deviation per member every 10 months ($U = 0.1$), cultural endangerment is maximal when $s \approx 0.01$, that is when 0.1% of the population

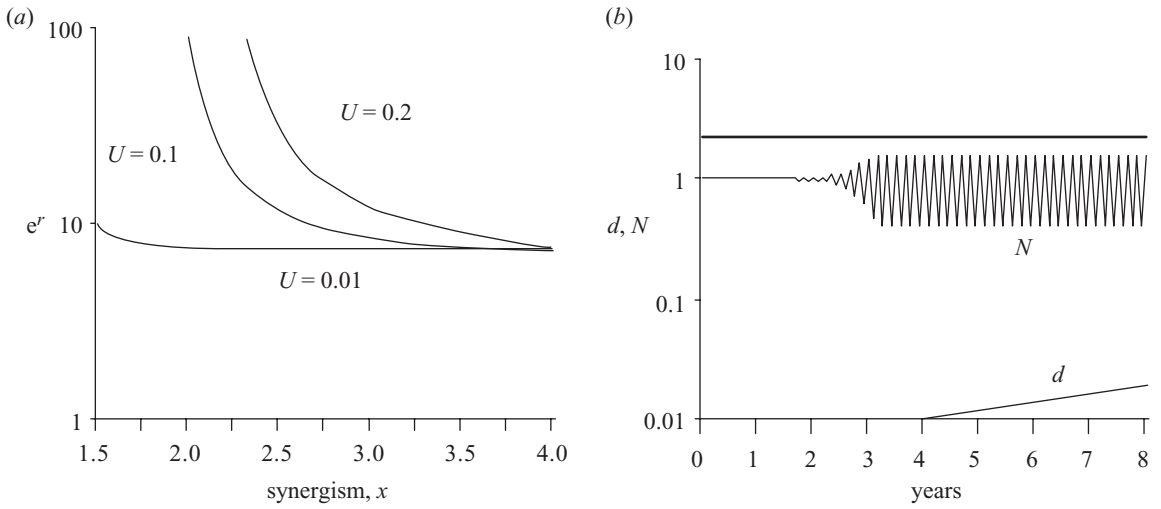

Figure 2. Dominant, retroactive cultures exhibit cyclic dynamics in cultural membership. (*a*) The effects of U and x on the critical level of regeneration r, beyond which the population cycles. (*b*) Deviation and membership dynamics for the case of $e^r = 10$. Parameters as for figure 1 unless otherwise indicated.

disbands per month at the onset of input broadcasting. This population goes into the meltdown phase after 31.2 years, at which time only 29 members (2.9% of the original population) remain. The culture finally disbands after 43 years. Now, if broadcasting were to be double, or $U = 0.2$, then the culture would have gone into the meltdown after only 3 years, counting 294 (or 29.4% of the original group) members, and would completely disband after only 5.7 years. Importantly, because broadcasting is not limited by diffusion dynamics, population size (ρ) has little effect on this result: this same culture, but with 1 000 000 rather than 1000 members, would last only an additional 1.6 years.

Studies confronting theory and data for cultural dynamics are scarce, but indicate that cultural groups, particularly those with small membership, are disappearing at an alarming rate. Soltis *et al.* (1995) confronted observations of group disbandment in five regions of Papua New Guinea and Irian Jaya with the predictions of a simple group selection model. They found that although between *ca.* 1% and 30% of groups went extinct over approximately a single generation, the model required tens or hundreds of generations to explain the observations. This means that attributes of major selective effect may play minor roles in at least some instances of group demise. Data on languages suggest that the extinction process itself is related to inter-group competition (Abrams & Strogatz 2003). Specifically, these authors employed a model to show how one language may usurp another through the effects of prestige-based imitation. The present study goes beyond theirs in proposing a detailed quantitative mechanism for cultural demise, and in showing that outcomes other than disbandment are possible.

There are several reasons why meltdowns could constitute a serious concern for some human cultures. First, a major difference with genetic systems is that deviation input U in cultural contexts is probably much higher (Henrich & Boyd 2002) than the genome-wide mutation rate in most organisms. Unlike the frequency-independent nature of genetic mutation, deviation input may have both frequency-dependent and independent components. For instance, if membership of a focal culture is low, then the conformist-based imitation (e.g. Henrich & Boyd 1998) of other numerically dominant cultures may lead to a demographic swamping effect (Henrich 2004). Second, through human history, cultural spread has relied less on border-crossing and subsequent infra-cultural diffusion (e.g. Turchin 2003), and more on border-hopping and broadcasting (Holton 1998). Going from diffusion-dominated to a mix of diffusion and broadcasting processes has meant that cultural elements can spread over longer distances, at faster rates, over greater contiguous areas, and at higher numbers. The sensitivity of cultural evolution to the resultant greater effective deviation input could mean that phenomena such as shifts and meltdowns will pose increasing risks to certain cultures in the future, especially as technological innovations in communication systems continue to emerge and spread globally. And third, if dominance behaviours are adaptive social traits that have evolved in our distant past, then some of their current expressions could be maladapted or pathological. This suggests that attempts at slowing or reversing perceived cultural shifts and meltdowns will not only entail substantial cost and effort, but could also take the form of aggressive and unethical dominance behaviours. An important challenge for future study will be to integrate social and economic contingencies into more realistic models of cultural evolution.

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