Chapter 3
Globalization May Cause Cultural Accumulation in the Whole Population

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Abstract We constructed an agent-based model (ABM) that tested how globalization, frequent movements of individuals between local societies, affects the accumulation of cultures. In the model, multiple groups were connected as a circular stepping-stone formation without boundaries. Agents copy cultural traits of others in their groups; agents may gain or lose their cultural traits through the process, depending on the traits of opponents, which is called within-boundary communication. Agents periodically migrate between adjacent groups. Agents also visit adjacent groups, copy the cultural traits in those groups, and return to their group, which is called cross-boundary communication. The model indicates that cultural traits may accumulate in the whole population even if they migrate frequently. The necessary conditions are that agents also frequently communicate cross-boundary by finding an appropriate group.

Keywords Globalization • Cultural traits • Try and error • Migration • Groups

1 Introduction

Individuals transmit cultural traits through teaching and learning, which is different from biological inheritance through DNA (Cavalli-Sforza and Feldman 1973). Here cultural traits are languages, rituals, festivals, clothes, cuisine, art, and social norms maintained in local societies. Cultural phenomena are found in many vertebrates, particularly in our closest relative, the chimpanzee (Whiten et al. 1999). However, cumulative characteristics are only found in human cultures. The metaphor "ratchet" is often assumed to be a cumulative characteristic of human culture (Tomasello 1999).

Humans have created complex cultures due to these ratchet effects. Due to the cumulative features of human culture, a variety of local cultures are found around the world. Individuals gain local culture by learning from others, who are residents

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of their local society. Local cultures usually do not directly contribute to the utility of the carriers. Nevertheless, residents maintain their local culture to ensure group identity. Each local society has grown and preserved its original local culture, by which the society is distinguished from other local societies.

Now many local societies have lost their culture due to the effects of globalization. In the age of globalization, individuals have been freed from local society restraints. They no longer require group identities for their social life. Local cultures now provide few benefits to their carriers. Additionally, mass migration has caused serious damage to local cultures since the great explosion of the fifteenth century. Immigrants from most cultures do not usually respect the local cultures of minorities; thus, it is difficult for residents of a minority culture to preserve their local culture. In fact, they may abandon their minority culture to conform to the majority culture. The influx of tourists also leads to negative effects on local culture, and local residents often relinquish their traditional local culture due to the impact of large numbers of tourists. Hence, globalization has seriously damaged local culture.

Globalization may not only result in negative effects on local cultures. Particularly, we should note the existence of certain individuals as keepers of local culture. They are often outsiders, who may be immigrants or visitors to the local society. Freed from the boundaries of local societies, some individuals seek identities shared with others. By learning about different local cultures, they may revive the local cultures of their targeted local societies. Thus, they contribute to maintaining local cultures that might otherwise disappear. A new culture, revived by outsiders, may fascinate others beyond the boundary of a local society. Actually, Horiuchi (2012) found that many visitors emotionally and financially support local artists; some immigrants or visitors participate in performing local arts, and local arts become media through which the local society is activated, with local residents and outsiders acting together. Young residents, eager to succeed in a local culture, can encounter depopulation and aging in the local society. Thus, globalization may also contribute to maintaining local cultures.

Accordingly, it is an open and important question whether globalization has negative or positive effects on local cultures (Cowen 2004). Sociology should elucidate the process of how interaction among individuals at the micro level affects local cultures at the macro level, following the idea of the Coleman boat (Coleman 1990). Interactions among individuals are nonlinear and complex. It is difficult to fully grasp such interactions and effects on local cultures only by observation and intuition.

The agent-based model (ABM) is an efficient tool when interactions among individuals are complex and difficult to grasp intuitively. Several ABM studies have modeled culture as a cumulative real number to analyze the cumulative features of cultures (Powell et al. 2009; Premo and Kuhn 2010; Lewis and Laland 2012). They predict that a large population size has positive effects on cultural accumulation. In contrast, Axelrod (1997) modeled culture as vectors, with each element representing an independent cultural trait. This model predicts that large population size has negative effects on cultural diversity. Following Axelrod's study, later studies tested the effects of global information flow (Shibanai et al. 2001), the range of local communications (Greig 2002), complex networks (Klemm et al. 2005), or communication links constructed by agents (Centola et al. 2007) on cultural traits.

These studies did not fully model the complex features of culture. Culture is cumulative and, at the same time, different aspects within cultures can be contradictory. Thus, culture should be modeled as a vector, and each element can be summed up. Individuals evaluate the summed values. Lehman et al. (2011) or Horiuchi and Kubota (2013) modeled culture as being composed of independent multiple traits. If an agent knows or does not know a cultural trait, the trait is given a 1 or 0, respectively. Multiple cultural traits may be summed, and large numbers represent an elaborate culture. These modeling assumptions are valid for testing both the cumulative and contradictory features of a culture. In this study, we constructed an ABM to study the effects of an agent's interactions on diversity and accumulation of culture following these ideas.

2 Simulation Method

We constructed a simple ABM to elucidate how interactions among agents affect culture. The ABM assumed N agents and G groups. The G groups were arranged as circular stepping-stones without boundaries. N/G agents belonged to each group under the initial conditions. The model assumes N to be a multiple value of G, so the number of members is initially the same integer value for all groups. A number from 1 to N was denoted for each agent and for each group from 1 to G.

Each agent had their own culture, represented by the vector $(p_{i,1}, p_{i,2}, \ldots, p_{i,K})$ for agent i. If the agent knows or does not know the kth cultural trait $(1 \leq k \leq K)$, $p_{i,k}$ was 1 or 0, respectively. P_i is denoted as the total number of cultural traits that agent i knows, or $P_i = \sum_k p_{k,i}$. Additionally, the vector $(q_{g,1}, q_{g,2}, \ldots, q_{g,K})$ is denoted for group g $(1 \leq g \leq G)$. If one or more agents knows or no agents know the kth cultural trait in the group, $q_{g,k}$ is 1 or 0, respectively. Q_g denotes the total number of cultural traits remaining in the group g, or $Q_g = \sum_k q_{g,k}$. The range is $0 \leq P_i$, $Q_g \leq K$ for any agent and any group (Fig. 3.1).

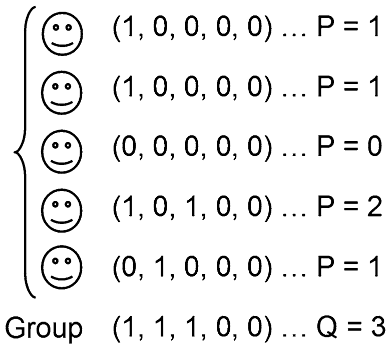


Fig. 3.1 *P* and *Q* calculated for each agent and their group

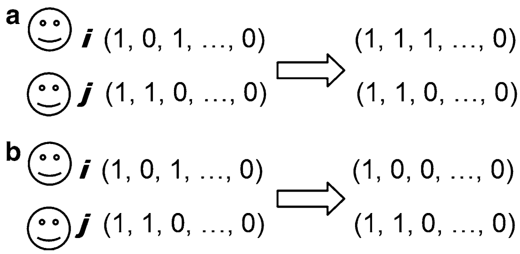


Fig. 3.2 The process of within-boundary communication. (**a**) Agent *i* gains the second cultural trait by copying a cultural trait of agent *j*, (**b**) but loses the third cultural trait by copying another cultural trait

Under the initial conditions, agents of group g know only the gth cultural trait, so $P_i = 1$ for all agents and $Q_g = 1$ for all groups. Here, a cultural trait g is the endemic knowledge of group g. The model assumes that the total number of groups equals the total number of cultural traits, or $G = K$, for simplicity. Hence, the set of all groups is matched against the set of all cultural traits.

At each turn, agents learn the cultural traits of others within their group, which is called within-boundary communication. Agent i is selected randomly during this process. Another agent, j, is selected randomly from the same group as agent i. A cultural trait, k, is randomly selected. The cultural trait k of agent i becomes equivalent to that of agent j: $c_{i,k}$ equals $c_{j,k}$. As a result, agent i may gain a new cultural trait (Fig. 3.2a) or lose her original cultural trait (Fig. 3.2b). The same agent may be selected twice, or $i = j$, in which case social learning does not occur, but it is likely to occur when the number of members is small in that group.

A randomly selected agent migrates to one of the two adjacent groups for each R_m turn. The range of R_m is $1 \leq R_m \leq 10^6$. Lower values of R_m indicate that agents migrate between groups more frequently. The agent emigrates into a group with probability S_m, where Q is larger in the two adjacent groups. The agent misses the group with probability $1-S_m$, where Q is larger; and randomly emigrates into one of the two groups.

A randomly selected agent visits an adjacent group and learns the cultural traits of another agent there for each R_c turn. This process is called cross-boundary communication. The range of R_c is $1 \leq R_c \leq 10^6$. Lower values of R_c indicate that agents communicate cross-boundary more frequently. The agent finds a group with probability S_c, where Q is larger in the two adjacent groups. He visits the group and randomly selects an agent j in that group with cultural trait k. After copying the cultural trait, k, the agent returns to his own group. The cultural trait k of the agent i becomes equivalent to that of agent j: $c_{i,k}$ equals $c_{j,k}$, like within-boundary communication. The agent misses the group with probability $1-S_c$ where Q is larger; he randomly visits one of the two groups and copies a cultural trait k from an agent j.

After enough turns, the total number of cultural traits remaining in the whole population, U, is the index of culture that remains. A larger value of U suggests that more cultural traits remain in the whole population. We checked the average number of cultural traits for each agent, V, which equaled $\sum P_i/N$. Larger values of V suggest that agents know more cultural traits on average. We also checked the diversity of local cultures, W, which equals $\sum\sum_{g \neq h}\sum_k |q_{g,k} - q_{h,k}|/\{G\,(G-1)\}$. A larger value of W suggests that different local cultures are maintained in different groups. The ranges are, $0 \leq U, V, W \leq K$.

3 Results of the Simulation

We first fixed these values: $N = 200$, $G = K = 20$. The simulation investigated the values of U, V, and W at each (R_m, R_c, S_m, S_c). We determined how the U, V, and W values changed as time passed to examine how many iterations was sufficient for the system. At equilibrium, U and V should match each other and W should be 0. By testing the simulation with several values of R and S, we concluded that 300,000 turns was sufficient (Fig. 3.3). Note that we did not need to wait for the simulation to reach equilibrium. If agents rarely migrate or visit, a variety of different local cultures are more likely to persist, as the system does not reach equilibrium, which is an important point to be elucidated. Hereafter, we show the results after 300,000 turns had passed.

We set the parameters $S_c = 0$ and $S_m = 0$. In this case, the agent randomly migrated and randomly communicated cross-boundary with one of the two adjacent groups. Figure 3.4 shows a box plot of U, V, and W along the value of $\log_{10}R_c$ when $\log_{10}R_m = 3$ (Fig. 3.4a–c) or $\log_{10}R_m = 0$ (Fig. 3.4d–f); we ran the simulation 30 times for each condition. The figure suggests that, as the value of R_c decreased, U and W decreased significantly, but V did not change. Figure 3.5 shows a box plot of U, V, and W along the value of $\log_{10}R_c$ when $\log_{10}R_m = 3$ (Fig. 3.5a–c) or $\log_{10}R_m = 0$ (Fig. 3.5d–f), when the parameters $S_m = 0.5$ and $S_c = 0$. In this case, the agent migrated to a group with a larger Q with a probability of 0.5 but randomly communicated cross-boundary with one of the two adjacent groups. The figure shows a similar trend for U, V, and W with that of Fig. 3.4. Figure 3.6 shows a box plot of U, V, and W along the value of $\log_{10}R_c$ when $\log_{10}R_m = 3$ (Fig. 3.6a–c) or $\log_{10}R_m = 0$ (Fig. 3.6d–f), when the parameter $S_m = 0$ and $S_c = 0.5$. In this case,

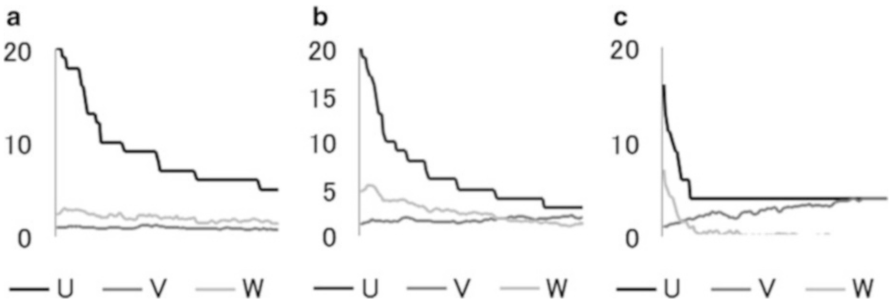


Fig. 3.3 The values of U, V, and W over time ($0 \leq \text{T} \leq 10_6$). (**a**) $R_m = 10_3$, $R_c = 10_3$, $S_m = 0$, $S_c = 0$. (**b**) $R_m = 102$, $R_c = 102$, $S_m = 0.5$, $S_c = 0$. (**c**) $R_m = 1$, $R_c = 1$, $S_m = 0$, $S_c = 0.5$

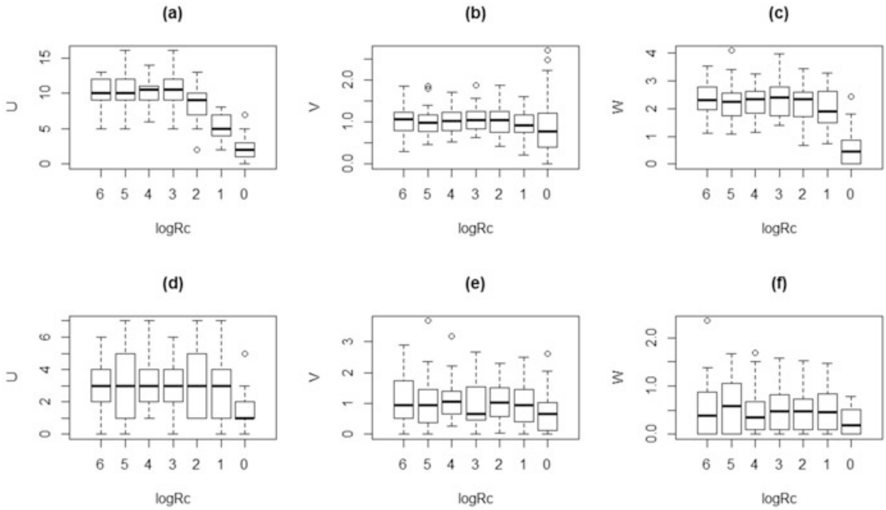


Fig. 3.4 A box plot of U, V, and W from 30 trials with the value of $\log_{10}R_c$ when $S_m = 0$ and $S_c = 0$. (**a**–**c**) $\log_{10}R_m = 3$. (**d**–**e**) $\log_{10}R_m = 0$

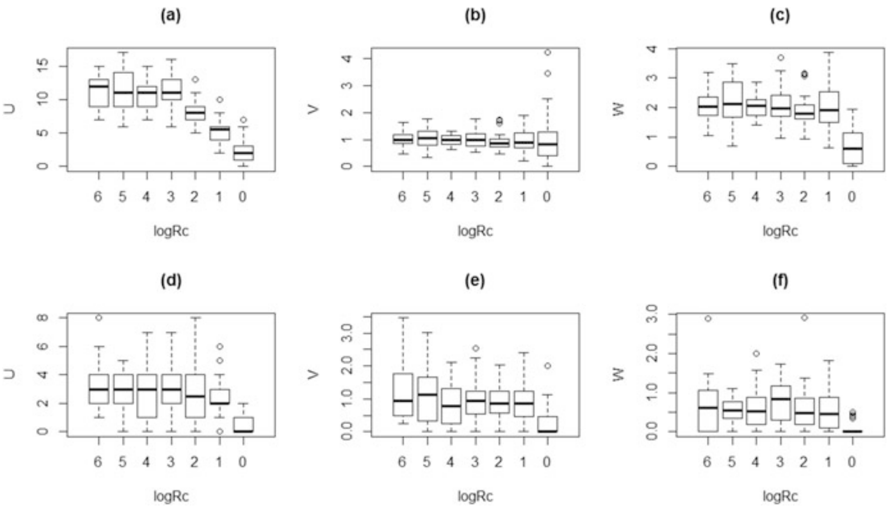


Fig. 3.5 A box plot of U, V, and W from 30 trials with the value of $\log_{10}R_c$ when $S_m = 0.5$ and $S_c = 0$. (**a**–**c**) $\log_{10}R_m = 3$. (**d**–**e**) $\log_{10}R_m = 0$

the agent randomly migrated to one of the two adjacent groups and communicated cross-boundary with a group with a larger Q and probability of 0.5. The figure suggests that when the value of $\log_{10}R_m = 0$, U increased significantly as the value

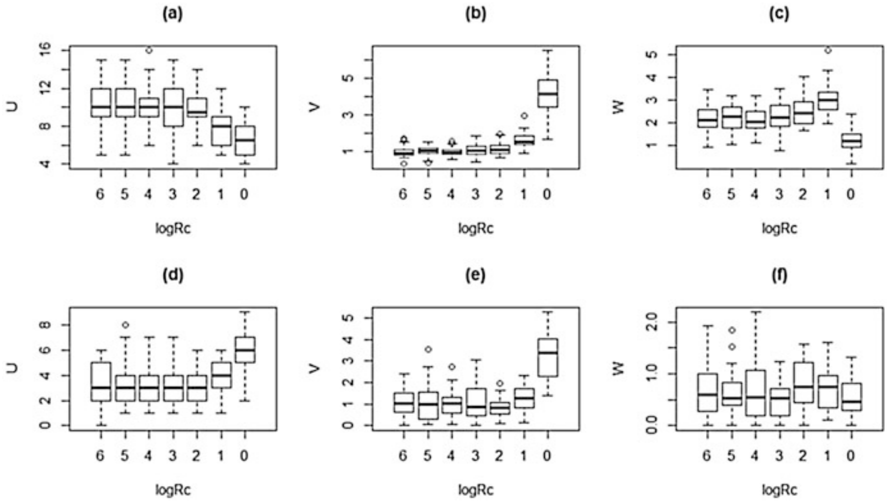


Fig. 3.6 A box plot of U, V, and W from 30 trials with the value of $\log_{10}R_c$ when $S_m = 0$ and $S_c = 0.5$. (**a–c**) $\log_{10}R_m = 3$. (**d–e**) $\log_{10}R_m = 0$

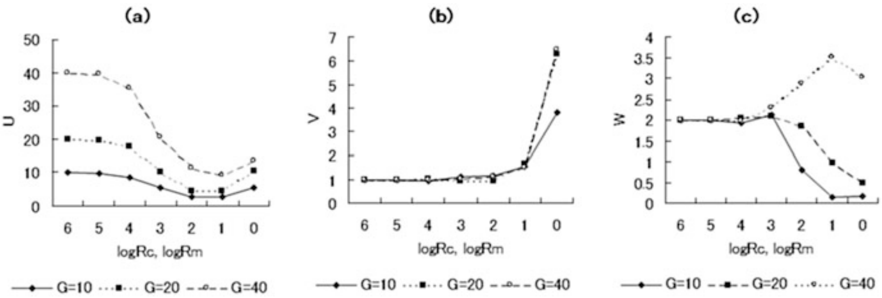


Fig. 3.7 The average values of (**a**) U, (**b**) V and (**c**) W along the change of $\log_{10}R_c$ and $\log_{10}R_m$. *Solid curve*: G (= K) = 10. *Dotted curve*: G (= K) = 20. *Dashed curve*: G (= K) = 40

of $\log_{10}R_c$ decreased. V increased significantly as the value of $\log_{10}R_c$ decreased, regardless of the value of $\log_{10}R_m$. W represents the highest value when $\log_{10}R_m = 3$ and $\log_{10}R_c = 1$.

Now we set $R_c = R_m$, as both values should decrease at the same time as globalization proceeds. Figure 3.7 shows the average values of U, V, and W along the value of $\log_{10}R_c$ (= $\log_{10}R_m$), when the parameter $S_m = 0$ and $S_c = 1$. We set the value of $G = K$ as 10, 20, or 40. In the simulation, the value N was fixed at 200, as different values of N require different simulation times for equilibrium. Accordingly, the number of agents at the local society was 20, 10, and 5, respectively, for each $G = K$ is 10, 20, and 40. We ran the simulations 30 times under each condition. Regardless of the value of K or G, the values of U showed U shaped curves and those of V showed increasing curves along the change of $\log_{10}R_c$

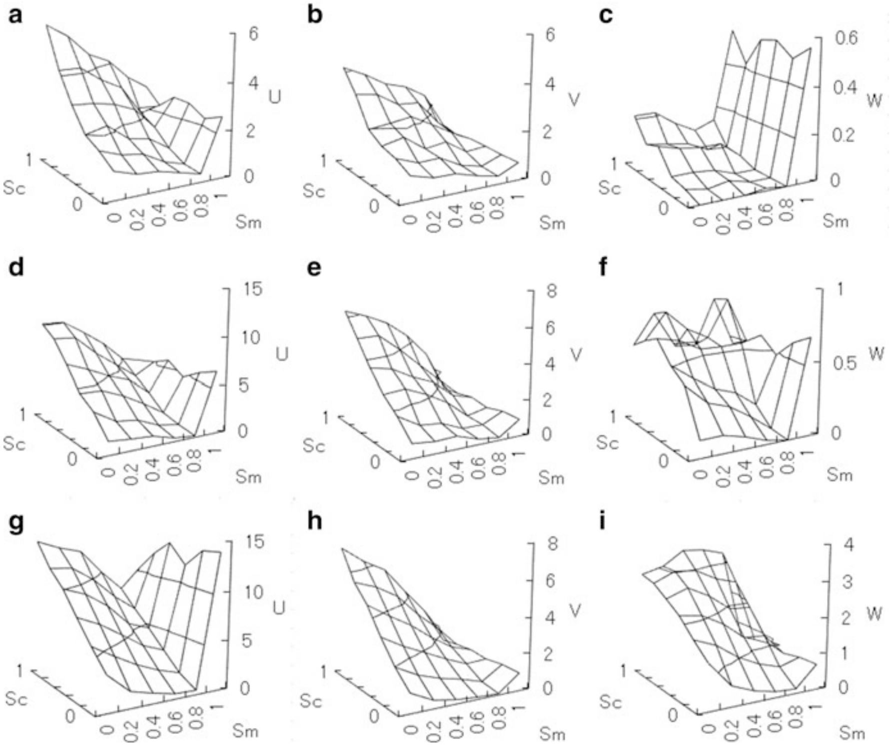


Fig. 3.8 The average values of U, V, and W of 30 simulations at each (S_m, S_c) when $R_c = R_m = 1$. (**a–c**) $G = (K =)$ 10. (**d–f**) $G = 20$. (**g–h**) $G = 40$

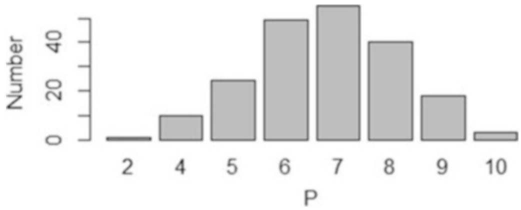
and $\log_{10}R_m$. In contrast, the values of W showed different curves depending on the value of G or K along the change of $\log_{10}R_c$ and $\log_{10}R_m$.

Finally, we set the value of $R_m = R_c = 1$, most frequent migration and cross-boundary communications, and changed the values of S_m and S_c from 0 to 1. We ran the simulation when the value of G $(= K) = 10$, 20, or 40, respectively; the number of agents was 20, 10 and 5, respectively at each G and K. Figure 3.8 shows the average values of U, V, and W along the values of S_m and S_c; we ran the simulation 30 times for each condition. Depending on the value of G or K, the values of U and W showed different curves along the change of S_m and S_c.

4 Discussion

The present model clarified how the movement frequency of agents affects cultural accumulation in the whole population. If agents migrate between groups or communicated cross-boundary frequently, the total number of cultural traits remaining

Fig. 3.9 The number of agents with P when $(R_m, R_c, S_m, S_c) = (1, 1, 0, 1)$



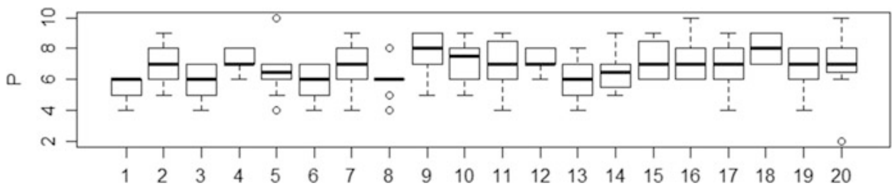


Fig. 3.10 A box plot of P at each local society when $(R_m, R_c, S_m, S_c) = (1, 1, 0, 1)$

should decrease in the whole population, which is due to the negative effects of globalization. The simulation certainly showed such expected results as long as S_m and S_c were low; U decreased as the value of R_m or R_c decreased, or as agents moved more frequently. The simulation thus followed naïve intuition that, as individuals are freed from local societies and move between groups more frequently, or as globalization proceeds, the total number of cultural traits remaining should decrease more. On average, only one cultural trait should remain in the world, or $U = 1$, as $K/G = 1$ is the modeling assumption ($K = G$).

However, the simulation also showed that frequent movements of agents might result in a high U value or more cultural traits remaining in the whole population. The results arise depending on the value of S_m and S_c. When S_c is large, or agents are likely to visit groups with rich cultural traits and engage in cross-boundary communications, more cultural traits will remain in the whole population as agents communicate cross-boundary frequently. That should be natural as some groups with rich cultural traits attract many agents for social learning, who are likely to relay their learned traits to their original local societies. When agents engage in cross-boundary communication with a group of higher Q, some agents maintain their original cultural traits as well as the new cultural traits. Agents who are equipped with many cultural traits are "cultural elites". Figure 3.9 shows the existence of cultural elites who have more cultural traits than average; a few agents with the value of $P = 10$ can be the cultural elites.

Cultural elites should scatter at all local societies if the values of R_m and S_m are small. Cultural elites with the largest P may appear in any local society (Local societies 5, 16, and 20 in Fig. 3.10). As long as many agents communicate cross-boundary around local societies that include cultural elites, cultural traits will accumulate in the world. Thus, random frequent migration and non-random cross-boundary communication result in a high value of U, or more remaining cultural traits. Accordingly, we should encourage cultural elites to work across boundaries of local societies to maintain and accumulate various cultural traits. In other words, as long as we cannot stop frequent migration of individuals between local societies, we should also promote their frequent and selective cross-boundary communication. Cultural elites should be respected as holders of many cultural traits.

The results depend on the number of groups or cultural traits (G and K). If there are few local societies or few cultural traits, fewer cultural traits will remain in the whole population as agents selectively migrate between groups (large S_m). In this case, some local societies, which are accidentally rich in cultural traits, attract many agents, and the immigrant agents should loss their original cultural traits. If there are many local societies or cultural traits, more cultural traits may remain in the whole population as agents selectively migrate between groups. In this case, quite a few local societies function as cultural refugees, in which sufficient cultural traits remain. Multiple cultural refugees are more likely to be distantly distributed, as there are more local societies. So, the number of cultural traits in the world, as well as the diversity of local cultures, is more likely to be maintained due to high S_c and high S_m in this case. This result follows my previous study in which frequent but selective migration by agents causes cultural diversity (Horiuchi 2011). If agents are assumed to migrate or communicate cross-boundary far away from their original groups, by assuming complete, small world or scale free graphs (Albert and Barabasi 2002), such effects may hardly appear. We should also note that individuals usually copy not only the cultural traits of others but also innovate new cultural traits that are unknown by others (Lehman et al. 2011). If agents innovate new cultural traits, cultural traits are more likely to accumulate. Future studies should test how the distance of an agent's movements and innovation affect cultural accumulation and diversity.

Culture is not only a characteristic of humans but is also expressed by other animals such as birds, monkeys, and apes. However, even chimpanzees, who have various cultures, cannot accumulate culture as much as humans. Archaeological studies also show that the Neanderthals could not accumulate culture like modern humans (Mellars 1989). We accumulate our culture partly because we engage in cross-boundary communication, which was not common among the Neanderthals (Marwick 2003). Cross-boundary communication, coupled with migration, contributed to our cultural accumulation and made us homo sapiens.

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