Modeling Meta-Cultures

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Abstract. In this work, we are exploring mechanisms that may contribute to cultural diversity and that rely on our everyday understanding of culture as a set of attitudes, behaviors, tools, ways of thinking etc., some of which are not directly exposed to the outside. We are using as a starting point an extended Axelrod model that defines a Moore neighborhood and generally heterogeneous sets of cultural features per agent. We briefly present next a number of psychologically realistic, basic and more advanced, conceptual models of selfish cultural affinity perception and imitation that have been shown to make the population stabilize to multi-cultural configurations. The shared individualistic, "selfish" nature of these models leads to the definition of another model explicitly representing non-exposed or hidden features that control regular, exposed features. We show that this meta model induces diversity even in the absence of individualistic behaviors and that an adaptation mechanism capable of slowly imitating control features would drive the system close to its theoretical limits. We also show that in some cases the control features' adaptation process presents punctuated equilibria. Finally, preliminary experiments with various social configurations have shown that the qualitative cultural characteristics of final populations after stabilization depend solely on the original cultures and not on the type of spatial interaction and contact. Thus in some cases initial cultural divides may persist. In sum, our results show that the presence of meta-processes, and especially of control features that are not exposed to the outside but that moderate other regular features, most often leads to stable multicultural but not polarized populations.

Keywords: Cultural simulation; Axelrod model; Selfishness; Indifference; Control features; Meta affinity.

1 Introduction

Modern anthropology is concerned with understanding human culture and its many facets. Furthermore it is nowadays well-established that culture is not a monopoly of the human species, but other, supposedly lower, species engage in activities and show behaviors that depend on what may be called an animal culture in its own right [1]. Even more important, the modern behavioral synthesis assumes that evolution is not only biological, but cultural as well, and that the two evolutionary processes interact and show various synergies [2]. In this line of ideas, it is necessary to proceed to model complex biological-cultural systems, human or not. One important parameter in the whole continuum of target systems from low-level insect cultures to the most technologically advanced human ones, is diversity, which is all too often not well understood and taken for granted. A first research objective is to understand the mechanisms that generate and maintain cultural diversity and why and how they may have evolved. Why are human cultures so rich and diverse? Is this due to properties that are unique to human nature or are there pro-primate, even pro-social properties that are responsible for diversity generation and in what context or on what condition? A second objective is to understand how culture interacts with other social mechanisms or structures. The usual assumption that economic relations define or at least significantly influence cultural dynamics within a society, does not look sufficient anymore. On the contrary, it is obvious to us from first-person experience that economic rules, political structures, religious organization, language structures etc. are all factors that are both outcomes and agents of cultural and biological evolution. This appears to be parallel to what is observed in animal species, where the corresponding cultural features, such as tool-usage, nest site selection procedures, etc., are both outcomes and agents of biological evolution. Our short-term goal is therefore to delve into the mechanisms that generate, influence or maintain diversity. The importance of the study of cultural diversity and its dynamics of evolution is twofold. First, since it is generally accepted that the human population is descendant of only a few individuals (not more than 10,000) that existed on earth about 60,000 years ago [3], then it is safe to assume that one initial more or less homogeneous culture (or very few of them) evolved and further specialized so as to present today the wealth of cultures around us: we would like to know which processes have led to this diversification of ever increasing complexity [4][5]. Second, although western culture and its subcultures are relatively homogeneous, this is not the rule: we would like to know how intrinsically multicultural populations have evolved and how they manage to remain socially stable [6][7]. Such studies may also find applications in everyday management or even large-scale policy-making for multi-cultural environments [8].

In this paper, we are exploring mechanisms that may contribute to cultural diversity and that rely on our everyday understanding of culture as a set of attitudes, behaviors, tools, ways of thinking etc., some of which are not directly exposed to the outside. In our era of globalized culture, one may observe that people from all around the globe have adopted a huge number of western cultural features (clothing, technological tools such as mobile phones and satellite TV, certain kinds of food, some recreation activities, even some institutional behaviors etc.), but are still perceived as very different from the western culture and from one another. We believe that these differences are at least partly the result of internal cognitive processes that are not directly exposed to the outside and thus cannot be copied or imitated right away; rather they should be the result of a long personal development within a cultural context.

Cultural simulation has been originally introduced by Axelrod [9] and subsequently developed and extended by several researchers, such as Shibanai, Trigg et al. [10][11][12][13][14] According to this approach, an agent is characterized by a number of **cultural features**, each one of which may take one of several values, called traits. These features represent real-life properties such as if it is allowed to eat fish (boolean feature), favorite sport (many-valued feature), bow or shake to greet (boolean feature) etc. Various cultural systems may thus be defined as populations of agents sharing trait values with one another in all features, but with ample differences between groups. Initial modeling by Axelrod showed that an initially fully heterogeneous population (with random traits) may lead eventually to compact cultural groups that are homogeneous internally but with large differences between them, provided that a simple **imitation process** takes place: an agent may imitate (copy) a trait of a neighbor probabilistically. The larger the actual **affinity** between two agents (coincidence of cultural traits), the larger the probability of each one of them to interact with the other. The original Axelrod model assumes a regular square two-dimensional grid where each position is occupied by a single agent and all interactions of an agent occur in a 4-neighbourhood: an agent selects randomly one of the four neighbouring agents (north, south, west or east of its position) to interact with. Interaction between two agents takes place with a probability that is equal to (F-n)/F, where F is the number of cultural features and n the number of features where the agents differ in trait. Interaction results in the initiating agent copying one of the different traits of its partner. This simple imitation process produces intricate diffusion dynamics that, surprisingly enough, do not lead to an homogeneous culture. Instead, stabilized spatial configurations in the grid are like the one given in fig. 1, where the color of the border between two grid places represents the degree of affinity between the two agents occupying these places: white color denotes 100% affinity (traits commonality), black color denotes 0 affinity and intermediate shades of gray denote intermediate degree of affinity (between 0 and 100%). Equilibrium is reached when adjacent cultural groups have no traits in common and therefore interaction is not possible anymore. However, as has been put forward by other authors (for instance [15]) and we have verified experimentally ourselves, this result is a combined side-effect of the model assumptions of 4-connectivity and fewer features than traits per feature. If instead, more features are used with fewer traits each, all systems eventually lead to monoculture. On top of this, if 8-connectivity (Moore neighborhood) is assumed, systems converge to full affinity substantially faster. It is this modeling intricacy that led us to reflect initially on the factors that may be responsible for the emergence of diverse cultural groups.

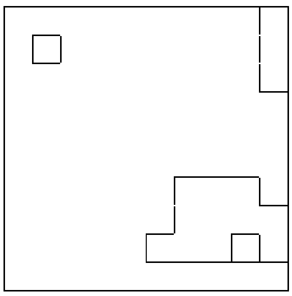

Fig. 1. Typical stable outcome of the original Axelrod model in a 10x10 world with 5 cultural features of 10 traits each (after 150000 cycles).

Section 2 presents a modified Axelrod model and various personalized models that are initially thought to promote diversity, while section 3 studies an explicit meta-cultural model. Section 4 concludes by discussing the results and drawing some directions for future research.

2 Modified Axelrod model

2.1 Diversified Number of Features and Traits

In the basic Axelrod model, all agents have the same features with diverse initial traits for each feature. However, this is only a little realistic; in practice, people in a multi-cultural context may also have different features, beside different traits. For example, in some non-western cultures, hats or jewels may be of different kinds, denoting various functions, or even societal ranks, while in western cultures there is no such notion and these features will go unnoticed. We expect agents in a mixed context to perceive and develop affinity (common traits) with "kin" in terms of common features and remain heterogeneous as far as uncommon features are concerned. In this case, cultural diversity will be persistent and will be due to heterogeneity in cultural features. We have modeled this option as agents having an array of M features, out of which only the K first features are active. We have run experiments with M=15 and K heterogeneous (up to M). Affinity between two agents is computed on the maximum number of features of both agents ($n/\max(F_1,F_2)$, where F_i is the number of features of agent-i and n the number of features where the agents differ in trait value) but imitation takes place only on the $\min(F_1,F_2)$ common features. The results are presented in fig. 2 and show that heterogeneous populations stabilize in medium affinities between agents, unlike homogenous populations that converge to full affinity. Final configurations in heterogeneous cases are also much more diverse apparently than final configurations in the original Axelrod model of homogeneous populations where interactions assume 4-connectivity (compare fig. 1 with fig. 2). This model therefore shows that cultural diversity may be due to the presence of uncommon features rather than to brittle spatial interaction modeling and specific initial conditions.

2.2 Personalized Models

The previous heterogeneous model is inaccurate in using an "ordered" set of features, where agents whose number of features differs by one are forced to have only one uncommon feature. For example, if agent-1 has 5 features and agent-2 has 6 features, then these features are respectively {1,2,3,4,5} and {1,2,3,4,5,6}, and not for instance {1,3,5,6,8} and {2,3,4,7,9,10}. Therefore, it is straightforward to think about relaxing this model and allowing free initialization of features in individual agents. Then, this arrangement raises the question of how individual agents will tackle uncommon features and how they will compute affinity.

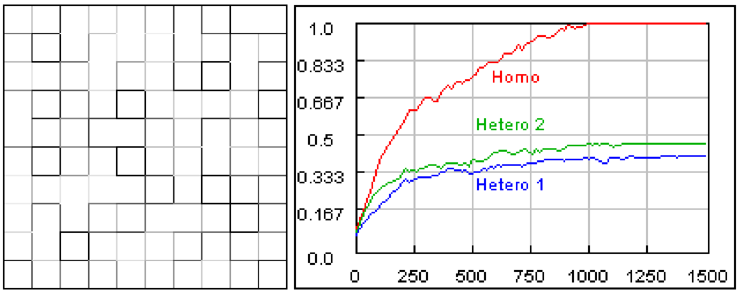

Fig. 2. (x: time in 100s of cycles, y: affinities) Typical outcomes of the modified Axelrod model in a 10x10 world with Moore neighborhood and up to 15 cultural features of up to 10 traits each (after 150000 cycles). The homogeneous case (all agents with exactly 15 features of exactly 10 traits each) leads to full affinity. Heterogeneous cases (features with different numbers of traits, and different number of features per agent) stabilize to partial affinity.

The obvious option is to have agents compute affinity on common features and define 0 affinity for uncommon features. Thus, for two agents with features [T_1,T_2,--,--,T_5,--,T_7,--,T_9,T_{10}] and [--,T_2,T_3,--,T_5,--,T_7,T_8,--,T_{10}], both agents could compute partial affinities as [0,aff,0,--,aff,--,aff,0,0,aff], where aff denotes the regular Axelrod affinity for the corresponding trait. This would lead to very quick stabilization to very low affinities for all agents, because most of the active features of an agent would not be shared with others. The psychologically valid affinity computation method is therefore to define the above partial affinities vector as [--,aff,--,--,aff,--,aff,--,--,aff], where affinity is computed only on common features and any feature perceived as not shared by an agent does not count. As shown in previous work of ours [16], this **selfish model** leads heterogeneous populations to converge much faster to full affinity, because affinity is computed only on shared features that converge therefore very fast.

Still, this model is homogeneous in the treatment of uncommon features, in the sense that a feature that is active for one agent and inactive for a second does not participate in affinity computation for either one of the agents. It seems more psychologically realistic to assume that agents compute affinities with neighbours in an individualistic manner that differs from agent to agent: an agent A will compute affinity with agent B only on A's features (and affinity will be 0 if A does not possess the corresponding feature), while B will compute affinity with agent A only on B's features. In the previous example, the partial affinity computation vector for the two agents will become respectively [0,aff,--,--,aff,--,aff,--,0,aff] and [--,aff,0,--,aff,--, aff,0,--,aff]. This **second selfish model** does not differ from the previous one in homogeneous populations. In heterogeneous populations, however, it shows a complex behavior, because the actual affinity (as perceived by an external observer), that is computed as before on common features, will converge fast to full affinity, so that common features will coincide, whereas the perceived affinity by each agent will be different and markedly lower. Fig. 3 shows how global perceived affinity converges to an intermediate value and how neighboring agents may have different views of their affinity with one another. Results are taken with a modified Axelrod model in a 10x10 world with Moore neighborhood and up to 15 features of up to 10 traits each.

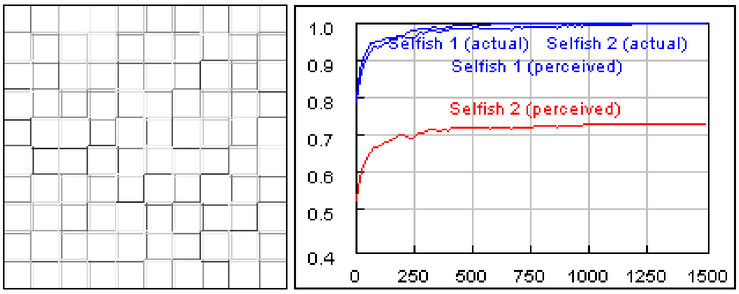

Fig. 3. Comparison of the first and second selfish model. (left) Perceived affinities in the final configuration for the second selfish model: every two neighboring agents regard their own relation and affinity differently – two lines are shown in each border instead of one, each line showing the perceived affinity by the agent on the corresponding side (right, x: time in 100s of cycles, y: affinities) In the first selfish model, actual and perceived affinity are the same and converge to full affinity. In the second selfish model, perceived affinity is much lower than the actual affinity that converges to full affinity.

A further development of psychologically realistic models is to assume that agents will handle differently the various cultural features, namely that there will be important features that contribute to their perception of affinity and others that do not count as much. The observation behind this development is that in some cultures people are indifferent to a particular trait, for example in modern western cultures, people are generally indifferent to whether a woman wears a skirt, a dress or trousers, while in other cultures this is not the case. Translated to everyday practice, this means that people do not regard themselves as different from others that have any trait value for this feature, and actually on many occasions people will temporarily align with their neighbors' behavior, precisely because they are indifferent to the particular cultural feature.

This **indifferent model** is implemented via the use of an additional dont-care vector storing a boolean value foreach feature (true for indifference). For instance, for two agents with 10 features (named T_1 to T_{10}) and dont-care vectors respectively [t,f,f,t,t,f,f,t,t,t] and [f,t,f,t,t,t,f,f,f,t], the corresponding partial affinity vector will be computed as [aff,aff,aff,--,--, aff,aff,aff,aff,--]. Again, this supposes an homogeneous feature handling method, where features for which both agents are indifferent do not count. As before, we define a **second indifferent model**, where the dont-care values are treated in an individualistic manner; in the previous example, the partial affinity vectors of the two agents become [--,aff,aff,--,--,aff,aff,--,--,--] and [aff,--,aff,--,--,--,aff,aff,aff,--], respectively. Results are presented elsewhere [16]. Again, the homogeneous population does not differ from previous cases, while heterogeneous ones present the inverse behavioral pattern as the one found in selfish models: in indifferent models, actual affinities are low, because of the different active features and dont-care values per agent, whereas perceived affinities are high, because only features shared in terms of dont-care value take part in affinity computation. This is sofar the most psychologically realistic model and its results are the closest to real-life observations, although not in the sense that the results are validated with real human-level data, but rather in the sense that conceptually/functionally they reflect our common understanding of cultural tolerance and indifference, better than the previous models. The realism stems principally from the fact that it is in practice impossible for an agent to *know* another agent's dont-care value, i.e., to know how it reasons internally. Because such knowledge is approximate, if any, it makes sense to compute affinity and act individually based mainly on own terms and perceptions.

2.3 Complex Model

We then define a new model that uses degrees of indifference toward cultural features. Each cultural feature is assigned a real-valued weight between 0 and 1: the lower its value, the more indifference the agent will show toward the feature. The perceived affinity of an agent with another one is defined accordingly as $\sum w_i aff_i$ / $\sum w_i$, while the actual affinity is defined as usually ((F-n)/F). Apparently, with this model it is very common to have agents that perceive each other very differently due to their different weight vectors. Typical results of five independent runs are given in fig. 4. Average actual affinity rises to full affinity (common features become uniform across the population), while average perceived affinity stabilizes to far lower values (not common features have different trait value for different agents). As before, the presence of features that are not shared across the population, creates initial diversity that is furthermore perceived differently by individual agents.

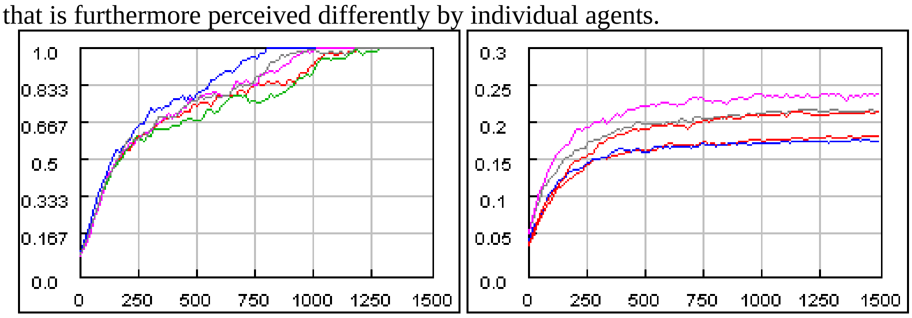

Fig. 4. (x: time in 100s of cycles, y: affinities) Typical outcome for a modified Axelrod model with complex agents (5 runs). (Left) Average actual affinity converges to full affinity. (Right) Average perceived affinity stabilizes to intermediate values.

3 Control features

Having set the scene with the design and implementation of the previous personalized and psychologically relevant models, we proceed with experimenting with an explicit control model of cultural features, where otherwise regular control features are controlled by other "hidden" cultural features. The midterm goal is to understand the dynamics of cultural systems that emerge out of the interaction of differentially developed cultures that happen to meet. It is well known that many, if not all, of the cultural systems that exist today are stable mixes of older cultures of populations that have met and sometimes fought with each other in the near or farther past. In previous experiments we have shown that some stable monocultures are due to mixing of two or more cultural systems rather than to predomination of one of them, and, that in some cases different cultural systems in contact may converge a little but remain distinct in certain respects. In the following experiments we intend to demonstrate that any features that operate at a meta level by controlling other features and that are available to the individual but not exposed toward the environment add significantly to the potential for buildup and maintenance of cultural diversity and constrain its future. Because all the above processes resemble usual evolutionary speciation processes, it will make sense in the future to import methodologies and ideas from evolutionary biology to the cultural domain. We note that different cultural systems will be defined via features and traits, as usually, as well as via control features and traits that are collectively shared and developed within the same population.

The cultural control mechanism works like this: every regular cultural feature is controlled by a control, or else meta, feature that is invisible to the outside. When a non shared cultural feature is selected for imitation during an encounter, its trait value may be copied only on condition that the corresponding control features match (both in type and in value). Some regular cultural features may share the control feature, so that usually we expect to have less control features than regular features; this arrangement induces implicit internal constraints between the various cultural features of an agent. The whole setup captures the fact that in everyday life some otherwise visible cultural values are not adopted when their internal logic is not being understood and, inversely, a few axiomatic and implicit cultural assumptions govern the exposed cultural features.

The first experiment concerns a population of Axelrod-type agents having 15 cultural features with 10 possible traits each and a single control feature with 5 possible traits. As is expected from the previous description of the model, all homogeneous or heterogeneous such systems converge to intermediate affinity values, irrespective of other factors (fig. 5).

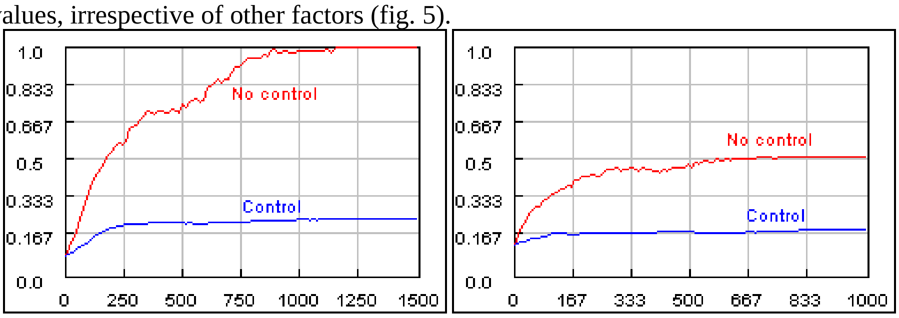

Fig. 5. An experiment with the Axelrod model with or without control features. (Left) Homogeneous model with or without control features. (Right) Heterogeneous model with or without control features (x: time in 100s of cycles, y: affinities). As theoretically expected, systems with non shared and non imitatable control features stabilize very fast to very low actual affinities.

Let us investigate what can happen in the case when the otherwise hidden cultural control features may be imitated as well. It is reasonable to assume that when this happens the imitation dynamics at the control level will be significantly slower. This adaptation or meta-imitation process is modeled as follows: when interaction occurs with a cultural feature controlled by an unknown control feature or by a control feature of unknown trait value, then this pair {control feature, control trait} is added to a short table (memory) of default size 4. Additionally, foreach such pair the number of encounters is maintained, thus each newly encountered pair replaces the weakest pair in the table. Whenever the number of encounters exceeds a threshold value, by default 10, then this pair is learnt as the control information for the corresponding cultural feature that is finally imitated. Figure 6 shows the effect of the additional adaptation mechanism to the cultural imitation process in a population of Axelrod-type agents having 15 cultural features with 10 possible traits each and two independent control features with 5 possible traits each (each regular feature is controlled by one of the two control features, randomly selected at start). Adaptation, or meta-imitation allows the population to attain affinity levels possible without cultural controls. This is only theoretical, though, because normally we don't expect all or even most of the cultural controls to be directly accessible to the outside and therefore imitatable, thus the actual affinity levels reached are expected to be lower than the theoretical ones without controls.

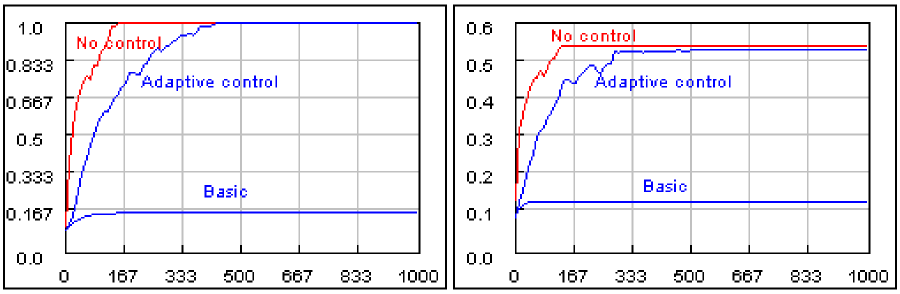

Fig. 6. An experiment with the Axelrod model with meta-features and with imitation at the meta level. (Left) Homogeneous model. (Right) Heterogeneous model (x: time in 100s of cycles, y: affinities). In both cases, adaptation allows the system to almost restore its final affinity levels, which is 1 in the homogeneous case and markedly lower in the heterogeneous case.

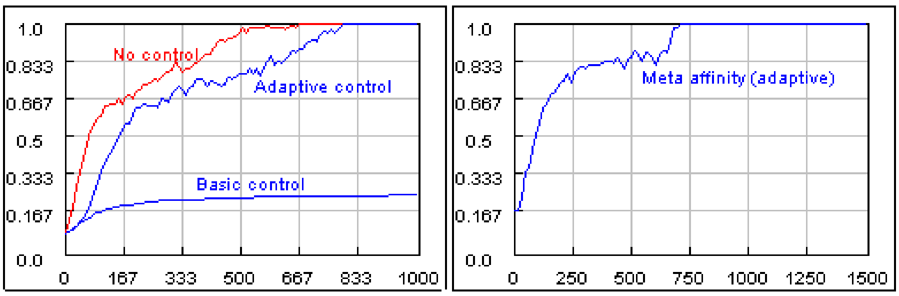

Fig. 7. An experiment with the Axelrod model with or without control features and with adaptation. Homogeneous model. (Left) Actual affinities. (Right) Meta affinities (control values) in the adaptive case (x: time in 200s of cycles, y: affinities). The cultural system shows a punctuated equilibrium at the meta level.

Figure 7 shows the results of the experiment of fig. 6 in the homogeneous case but with slower adaptation dynamics (memory size = 2 and an additional forgetting rate of 0.2 or 20%, which is the decrement of the encounter value foreach pair {control feature, control trait} that exists in memory, whenever another pair is encountered). As theoretically expected, the system develops final full affinity at a slower pace. Moreover, it shows a punctuated equilibrium at the meta level, i.e. a long period of stasis followed by an abrupt jump to a different plateau (full affinity). The stasis is due to control features of initially unknown type. Once the new feature types are imitated, their trait values immediate follow and regular cultural imitation starts. This experiment demonstrates the enabling role of the cultural control features and may partly explain why cultural systems, that look apparently calm and stable, suddenly move to a different equilibrium. Next, figure 8 shows the results of the same experiment as in fig. 7 but with an extremely high forgetting rate of 0.5 or 50%. With such slow adaptation processes, the final affinities at the meta level may stabilize at partial values (less than 1). It has been even verified that in most cases very fast forgetting combined with very short memory does not allow agents to adapt at all and thus shows no difference from the non-adaptive case. Finally, fig. 9 shows the result of the same experiment of fig. 7 but with the space initially divided in two halves with homogeneous cultures different from one another. Once more, the cultural system converges to the theoretically expected affinity value without control features (avg. affinity=1), but to a partial meta affinity value (less than 1).

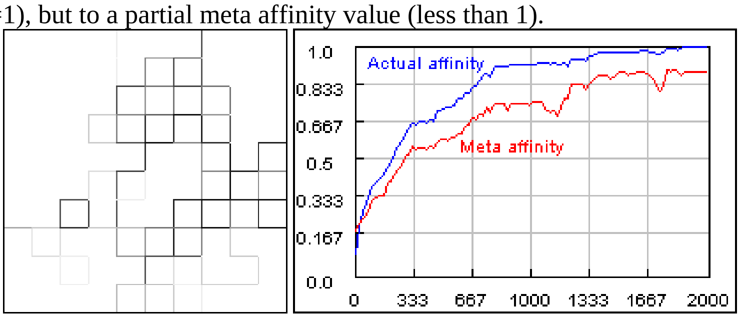

Fig. 8. An experiment with the Axelrod model with control features and adaptation. Homogeneous model. (Left) An intermediate state of the system. Large homogeneous cultural areas slowly absorb smaller differentiated areas and fight with each other before arriving to larger consensus configurations. (Left) Actual and meta affinities (control values) (x: time in 1000s of cycles, y: affinities). The cultural system converges to imperfect affinity at the meta level.

The same qualitative results may be obtained for the personalized and complex models as well, namely that populations with control features will converge to lower actual affinities and that the introduction of adaptation at the meta level may lead the system at most to the theoretical levels without controls. The general conclusion is that the final results obtained qualitatively are independent of the very presence of control features and meta adaptation, and depend exclusively on the type of initial cultural agent model(s) adopted. The role of the meta behavior is to allow or disallow cultural change and has only adaptive value, but it does not really characterize the possibilities of the cultural system and the type of final outcomes expected. The transitive phenomena and especially the speed of convergence may differ in different environments, though, depending on the details of the control or meta system of the agents. The final quantitative results in the stable situation can be accurately predicted in the case of non-adaptive agents, where in the end all agents will converge to the same traits for all common features, while the non shared features will remain distinct –the latter will account for partial actual and/or perceived affinities. In the case of adaptive agents, the presence of the adaptation mechanism results in fairly diversified results in accordance with the interaction history of the system. Finally, preliminary experiments with various localized interactions across the populations (such as parapatric environments as in fig. 9 or social networks of at least medium connectivity) diversify quickly the population on top of any intrinsic diversity generated by change mechanisms such as the adaptation or the meta mechanism.

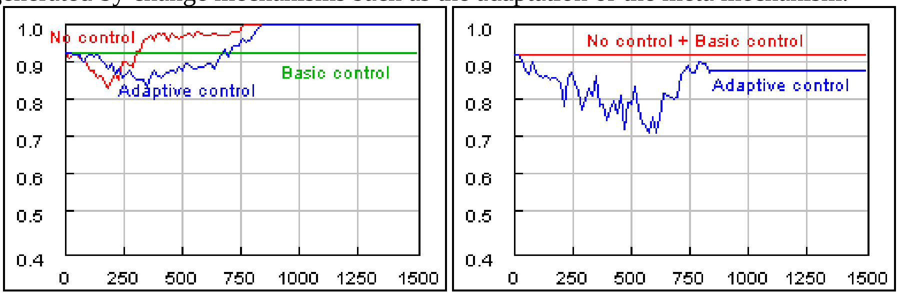

Fig. 9. An experiment with the Axelrod model with and without control features and with and without adaptation. The initial population is composed of two different culturally homogeneous populations that occupy each one half of the environment. (Right) Actual affinities (Left) Meta affinities (control values) (x: time in 1000s of cycles, y: affinities). The cultural system converges to imperfect affinity at the control level, that is lower than in the no control case. The initial destabilization and decline of meta affinities is due to the abrupt contact of the two populations where changes propagate from their borders toward the inner space of each area.

Therefore, it is the original structural diversity of the cultural systems and not the additional meta behavior that is responsible for the final configurations obtained. The cultural past constrains and defines the cultural future, whereas the meta mechanisms are only responsible for transitive behaviors of the system. Because, however, the world is in constant change, we may assume that final cultural convergence is rare and that the cultural identities are in constant transition; in this case, it makes sense to examine the exact meta possibilities available to the people. In further work of ours, we will experiment with ways to develop new cultural features from scratch and innovate independently of the sociocultural environment. The important thing to remember is that the psychological mechanisms that come into play are developed throughout the individual's life, therefore in an individualistic manner, and are hardly, if ever, exposed or detectable from the outside, i.e. from a different cultural perspective. This gives open room for modeling emergent dynamics and correlating with biological or linguistic speciation [17][18][19]. It should be also taken into account that the exact psychological tendencies or mechanisms that allow these hidden features to develop and evolve constrain the possible social evolutionary pathways that are available. One very significant issue is to deduce these tendencies from the actual pathways that are present in our historical past.

4 Discussion

In this paper we have studied the meta behavior of a modified Axelrod model of cultural simulation, where the agents have heterogeneous cultural features of different structure (different number of traits per feature). This configuration corresponds to heterogeneous populations where many agents of different social and evolutionary origins have to co-exist, as is for example the case of places that have received many different immigrant populations. In this case, and unlike what may be commonly thought, initial diversity does not disappear and the population does neither become monocultural, nor does it stabilize to well-delimited cultural groups; rather cultural affinity between adjacent agents is large enough but not perfect. The first set of meta models concerns personalized or individualistic behaviors of the agents that perceive each other differently (these individual differences may at first be attributed to personality differences). Such behaviors further diversify the interactions between agents and lead to multi-cultural environments, where no compact cultures emerge, but rather some cultural features may take a number of trait values across the population. The second meta-cultural mechanism is an explicit control model of cultural features, where otherwise regular control features are controlled by other “hidden” cultural features. This mechanism has been shown to lead by default to very diverse systems. Additional adaptation possibilities, whereby control features may themselves be slowly imitated have been shown to direct the system to its theoretical limit without control mechanisms. Finally, a paradigmatic experiment with two solid homogeneous populations demonstrates stabilization to final configurations that depend qualitatively only on the initial cultures and not on the types of meta behavior and contact between the initial populations. The general conclusion is that the cultural divide between populations or agents may not fully disappear. Cultural diversity is maintained by individualistic behaviors at a meta level, that act not on cultural content (traits) but on cultural structure (features). The main innovation in comparison with other cultural models lies in the presence of individually perceived affinities, either directly at the cultural feature level or indirectly at a control level, that do not necessarily coincide with one another or with an externally observable view. Therefore an intrinsically stable environment may be perceived from the outside as a rich, potentially explosive environment (cf. fig. 7). For this reason, such an environment shows a high degree of autonomy from a systemic point of view and cannot be easily externally manipulated, because the underlying causal factors are not exposed to the outside.

An immediate envisaged extension to the cultural model is the design of a cultural features network, where a feature may not change trait value independently of others but according to some intricate inter-dependence relations, much in the same sense as a genetic regulatory network that controls biological behavior. At a later stage, we would like to tackle the question of where the initial diversity at the meta level comes from, i.e. from personality or social factors, and how such “hidden”, cultural control features may be acquired developmentally to account for what looks externally like homogeneous populations in the first place. Practical constraints of cultural imitation are also interesting to explore, such as exposure to common environmental, social or linguistic factors, at first glance unrelated to culture. This future work aims at gaining more understanding of the factors and processes that generate, influence and maintain cultural diversity within a population of any origin.

References

1. Laland, K.N., Janik, V.M.: The animal cultures debate. Trends in Ecology and Evolution, 21(10), 542-547 (2006)
2. Gintis, H.: A framework for the unification of the behavioral sciences. Behavioral and Brain Sciences, 30(10), 1–61 (2007)
3. Lewin, R.: Human Evolution. Blackwell (1999)
4. Boyd, R., Richerson, P.J., Borgerhoff-Mulder, M., Durham, W.H.: Are cultural phylogenies possible? In Weingart, P., Richerson, P.J., Mitchell, S.D., Maassen, S. (eds.) Human by nature: Between biology and the social sciences, pp. 355-386, Lawrence Erlbaum (1997)
5. Mesoudi, A.: A Darwinian theory of cultural evolution can promote an evolutionary synthesis for the social sciences. Biological Theory, 2(3) 263-275 (2007)
6. Parpola, A., Carpelan, C.: The cultural counterparts to proto-indo-european, proto-uralic and proto-aryan: Matching the dispersal and contact patterns in the linguistic and archaeological record. In Bryant, E.F., Patton, L.L. (eds.) The Indo-Aruan controversy: Evidence and inference in Indian history", pp. 107-141 (2005)
7. Daniélou, A.: La civilisation des différences. Éditions Kailsh, Paris/Pondicherry (2004)
8. Hofstede, G.: Cultures consequences: Comparing values, behaviors, institutions and organizations across nations. Sage Publications (2001)
9. Axelrod, A.: The dissemination of culture: A model with local convergence and global polarization. The Journal of Conflict Resolution, 41(2), 203-226 (1997)
10. Shibanai, Y., Yasuno, S., Ishiguro, I.: Effects of global information feedback on diversity: Extensions to Axelrod's adaptive culture model. The Journal of Conflict Resolution, 45(1), 80-96 (2001)
11. San Miguel, M., Eguiluz, V.M., Toral, R., Klemm, K.: Binary and multivariate stochastic models pf consensus formation. IEEE Computing in Science and Engineering, 20-26 (2005)
12. Vitzthum, S.: Dissemination of culture in a networked world: The influence of network structure on the outcomes of the Axelrod cultural model. Proceedings Americaas Conference on Informarion Systems (AMCIS) (2007)
13. Trigg, A.B., Bertie, A.J., Himmelweit, S.F.: Modelling Bourdieu: An extension of the Axelrod cultural diffusion model".CRESC, Open University, Working Paper No. 49 (2008)
14. Peres, L.R., Fontanari, J.F.: The mass media destabilizes the cultural homogenous regime in Axelrod's model. Journal of Physics A; Mathematical and Theoretical, 43 (2010)
15. Lanchier, N.: The Axelrod model for the dissemination of culture revisited. arXiv:1004.0365v1, 2 Apr.2010
16. Tzafestas, E.: Cultural diversity dynamics, Proceedings IEEE ALIFE (2011)
17. Wilkins, J.: The dimensions, modes and definitions of species and speciation. Biology and Philosophy, 22, 247-266 (2007)
18. Dahl, Ö.: The growth and maintenance of linguistic complexity. John Benjamins (2004)
19. Henrich, J., McElreath, R.: The evolution of cultural evolution. Evolutionary Anthropology, 12, 123-135 (2003)