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EFFECTS OF PARTNER SELECTION ON THE EMERGENCE OF CULTURAL DIVIDES IN MIXED POPULATIONS

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Abstract. In this work, we are exploring spatial dynamics and clashes in cultural simulations involving multicultural populations with partner selection. We are using as basis an Axelrod model [1][2][3][4] extended with a Moore neighborhood, heterogeneous sets of cultural features per agent and a number of psychologically realistic, basic and more advanced, conceptual models of cultural affinity perception and imitation [5]. Elsewhere we have shown that in many cases the population stabilizes to multi-cultural configurations and that in cases of population clashes where two or more culturally contiguous populations meet the cultural divide may persist, albeit in a relatively weaker form [5] [6]. In this paper we repeat our previous experiments to investigate the effects of partner selection on these configurations.

Keywords. Cultural simulation; Axelrod model; Selfishness; Indifference; Cultural clash; Social network; Partner selection.

1 Models

First, we are briefly summarizing the extended models that we are using (for an in-depth account, see [5]). Our models have been inspired by the observation (also put forward by other authors, for instance [4]) that the original Axelrod result, where cultural grouping and polarization emerges in an initially diverse society, 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.

Heterogeneous Axelrod model: It is an Axelrod model, where each agent may have a variable number of cultural features, that are initially ordered. For example, agent-i may have (the first) five features whil agent-j may have (the first) nine features etc. This way, some features are widespread within the population and others are not.

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Selfish model: Each agent has a feature vector, defining a trait value for a feature or none (absence of the corresponding feature). 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 will perceive affinity as [–,aff,–,–,aff,–,aff,–,–,aff], where aff denotes the regular Axelrod affinity for the corresponding trait and is computed only on common features and any feature perceived as not shared by an agent does not count. A **second selfish model** more psychologically realistic is to allow an agent A to compute affinity with agent B only on As features (and affinity will be 0 if B does not possess the corresponding feature), while B will compute affinity with agent A only on Bs features. In the previous example, the perceived affinity vector for the two agents will become respectively [0,aff,–,–,aff,–,aff,–,0,aff] and [–,aff,0,–,aff,–, aff,0,–,aff]. Both models have been found to lead to a single value for shared features within the population (affinity for shared traits is called actual affinity), while the latter model results in lower perceived affinities by agents.

Indifferent model: It 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 and dontcare 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, whereas 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.

Complex model: A 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 $\sum w_i \text{aff}_i / \sum w_i$, while the actual affinity is defined as usually. Apparently, with this model it is very common to have agents that perceive each other very differently due to their different weight vectors.

2 Experiments

We have performed a series of experiments with and without partner selection to understand the effect, if any, of partner selection. Partner selection uses a simple probabilistic preference scheme, previously introduced in [7], where each agent maintains a set of probabilities of interaction with each one of its eight neighbours. All partners are equiprobable in the beginning and the corresponding preferences develop after each interaction according to the following reinforcement algorithm:

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Let aff be the affinity against partner i
   (with whom interaction just occurred)
   and avg be the average affinity
   with all neighbours.
If (s > avg) then increase preference
   for partner i,
Else decrease preference for partner i.
Re-normalize all preferences so that
   they express probabilities
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Experiment 1. Modified Axelrod model (homogeneous) results with an initially diverse population (fig. 1). Partner selection does not change the final outcome which is full monoculture in the population, but it substantially retards the cultural contagion process. On the other hand, partner selection induces extremely fast local polarization as is depicted in fig. 1(left) where an intermediate configuration is shown, that is not possible without partner selection in this model. Fig. 1(right) shows the large speed of local convergence in the beginning of the experiment that slows down in what follows compared to the convergence speed without partner selection.

Experiment 2. Modified Axelrod model (homogeneous) with two initial populations where a cultural clash is expected. Again, partner selection does not change the final outcome which is full monoculture in the population, but it substantially retards the cultural contagion process. This is due to the border agents between the two populations that create individualistic partnerships and thus hinder the fast spreading of cultural information.

Experiment 3. Modified Axelrod model (heterogeneous) results with an initially diverse population. Partner selection leads generally to fairly lower final affinities and is slower as well, as in previous cases. However, as in experiment 1, partner selection induces extremely fast initial development as shown in fig. 3(middle). Fig. 3(right) shows how the average preference bias (preference bias = maximum preference minimum preference for a neighbour within an agent) develops. As expected, the bias rises quickly to a high value, whereas it remains random in the case without partner selection. The unstable nature of the latter measure is due to the presence of intrinsic noise to the agent preferences.

Experiment 4. Heterogeneous selfish 2 vs. indifferent model results with an initially diverse population. As before, partner selection does not change substantially the final outcomes (it may lead to slightly lower affinities), but is faster in the beginning and overall slower (fig. 4).

Experiment 5. Heterogeneous selfish 2 vs. indifferent model results with two initial populations where a cultural clash is expected, but border agents may form individualistic partnerships, as in experiment 2. As in previous experimens, partner selection does not change the final outcomes. In the case of two selfish 2 populations that meet, affinity with partner selection develops higher values on its way to final convergence (fig. 5 left), while in the case of two indifferent populations that meet, affinity with partner selection develops much slower showing a final avalanche effect (fig. 5 right).

Experiment 6. Heterogeneous complex model results with an initially diverse population or with two initial populations where a cultural clash is expected. In the case of the mixed population, as before, partner selection does not change the final outcomes but cultural convergence slows down (fig. 6 left). In the case of two complex populations that meet, stabilisation is almost immediate to substantially lower affinity levels, because of the potential of agents to quickly build and maintain individualistic partnerships with some of their neighbours (fig. 6 right). The disturbances found in the graphs with partner selection are due to the intrinsic noise to the agent preferences.

3 Conclusion

Overall, partner selection has been found not to alter substantially final expected outcomes without partner selection, but to slow down cultural convergence because of the initial construction of partnerships that constrain further development. From an evolutionary point of view, a partner selection mechanism would be promoted by evolution, because real biological and social systems generally do not have all the time needed to develop final, stable configurations, but operate in response to newly encountered situations. In such cases, it makes sense to dispose of

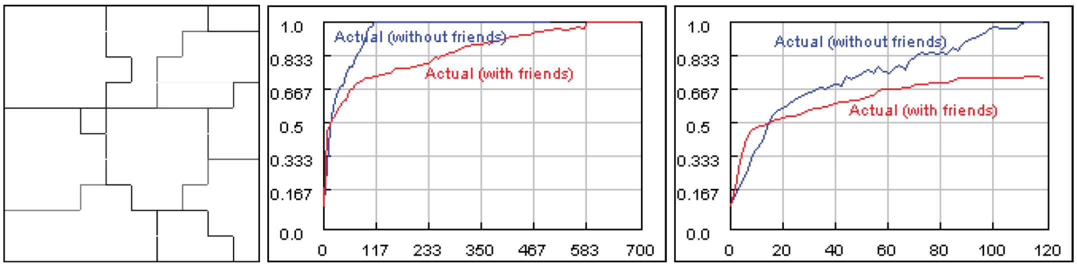

Figure 1: **Experiment 1 -** (x: time in 1000s of cycles, y: actual affinities) Typical outcome for a modified homogeneous Axelrod model. (Left) An intermediate configuration in the case of partner selection. (Middle) Actual affinities with and without friends (partner selection). (Right) Zoom to the first part of the previous graph (first 120 cycles).

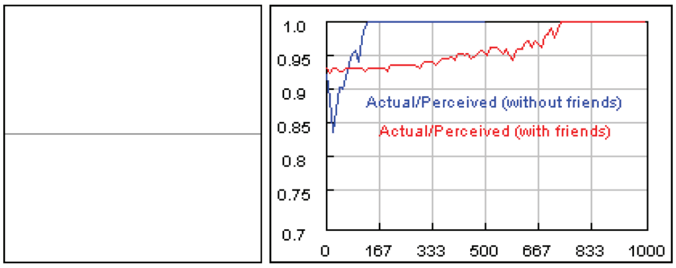

Figure 2: **Experiment 2 -** (x: time in 500s of cycles, y: actual affinities) Typical outcome for a modified homogeneous Axelrod model. (Left) The initial configurations, with two homogenous populations occupying each half of the space. (Right) Actual affinities with and without friends (partner selection).

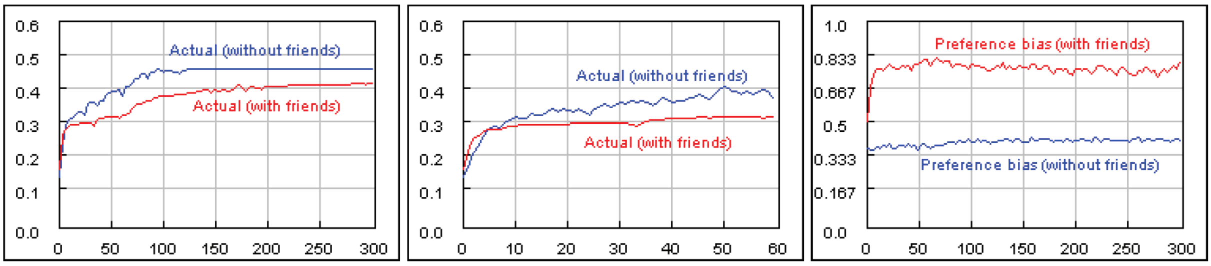

Figure 3: **Experiment 3 -** (x: time in 1000s of cycles, y: actual affinities) Typical outcome for a modified heterogeneous Axelrod model. (Left) Actual affinities with and without friends (partner selection). (Middle) Zoom to the first part of the previous graph (first 60 cycles). (Right) Preference bias with and without friends (partner selection).

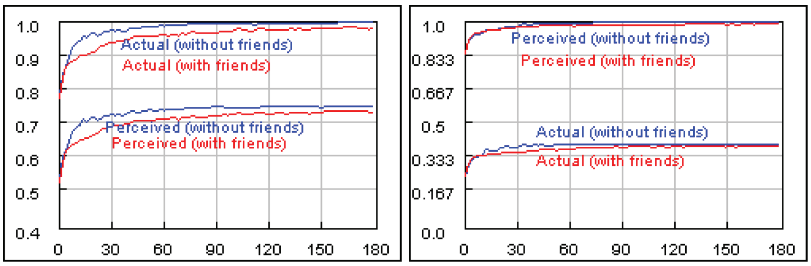

Figure 4: **Experiment 4 -** (x: time in 1000s of cycles, y: actual affinities) Typical outcome for an heterogeneous selfish 2 or indifferent model. (Left) Actual and perceived affinities for the selfish 2 model with and without friends (partner selection). (Right) Actual and perceived affinities for the indifferent model with and without friends (partner selection).

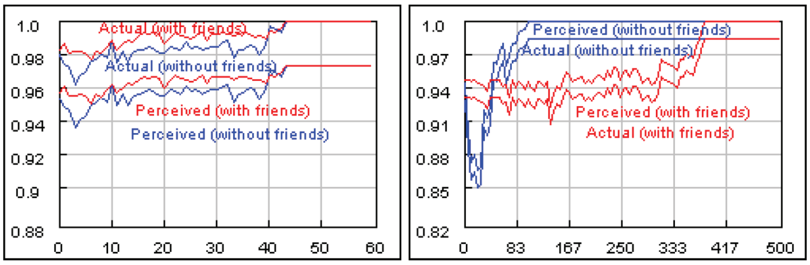

Figure 5: **Experiment 5** - (x: time in 500s of cycles, y: actual affinities) Typical outcome for a selfish 2 and a indifferent model starting from an initial configuration as depicted in fig. 2 left. (Left) Actual and perceived affinities for two selfish 2 populations with and without friends (partner selection). (Right) Actual and perceived affinities for two indifferent populations with and without friends (partner selection).

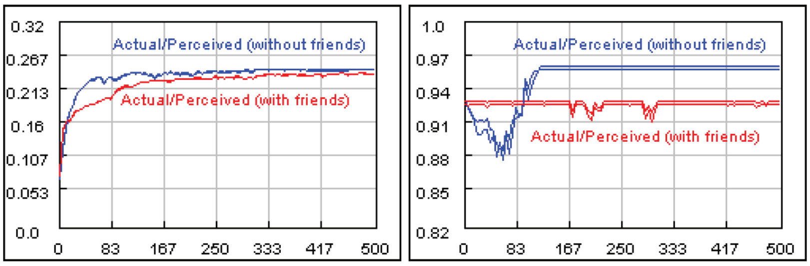

Figure 6: **Experiment 6** - Typical outcome for a complex model. (Left) (x: time in 1000s of cycles, y: actual affinities) Actual and perceived affinities in an initially mixed population with and without friends (partner selection). (Right) (x: time in 500s of cycles, y: actual affinities) Actual and perceived affinities starting from an initial configuration as depicted in fig. 2 left with and without friends (partner selection).

means to find quick, working solutions to problems, and partner selection appears to be exactly such a means to form quickly small groups of high affinity, although unstable in the longer term.

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