Available online at www.sciencedirect.com

ScienceDirect

EconomiA 21 (2020) 297–310

ECONOMIA

www.elsevier.com/locate/econ

The evolution of ethnocentrism revisited: an agent-based model with inductive reasoning

Pedro Vitor Ramos Halbout Carrão [*,1], Mariana Wik Atique [2]

Universidade Federal do Paraná - UFPR, Brazil

Received 30 June 2018; accepted 19 March 2019
Available online 24 March 2019

Abstract

Studies on the social behavior and cooperation decisions of individuals within and between different ethnic or cultural groups have gained increasing importance in economic sciences, especially in the field of behavioral economics. Axelrod and Hammond (2006) developed an agent-based simulation model to better understand the fundamentals of this phenomenon. Briefly, this model simulates a world with four different neighborhoods, based in a square toroidal lattice shape, where a cell can be inhabited or uninhabited by an agent. The simulation takes 3 stages, Interaction, Reproduction and Death and Placement and get as main result, an ethnocentric agents dominate population based on the path of the agents. The present study aims to broaden the model created by the authors by adding a process of inductive reasoning for the decision making of the agents from the perception of the actions of the others toward him. Our main result are that individuals who understand and interpret part of the environment that are inserted and react inductively to it tend to be more cooperative to the detriment of discriminatory and ethnocentric behavior found in the original model. We also analyze the importance of agent perception in the model and find that agents that perceive and interact with a larger number of other agents tend to be less ethnocentric.

JEL classification: C73; Z13

Keywords: Behavioral economics; Prisoner's dilemma; inductive reasoning; agent-based model

1. Introduction

Social division, often driven by ethnic and cultural characteristics, is a frequent phenomenon in the organization of human societies. The phenomenon of ethnocentrism is studied by Axelrod and Hammond (2006) using an agent-based model (ABM) to better understand this. Ethnocentrism is characterized by the authors as a behavior where discriminatory attitudes of a group that is considered with virtuous and superior values to that of other groups. Thus,

* Corresponding author.
E-mail addresses: pvcarrao@gmail.com (P.V. Ramos Halbout Carrão), marianatique@gmail.com (M.W. Atique).
[1] The author was supported by Fundação Araucaria.
[2] The author was supported by CAPES.

https://doi.org/10.1016/j.econ.2019.03.005

ethnocentric behavior is formed with higher intra-group cooperation rates while interactions with external groups are non-cooperative.

In addition to the work of Axelrod and Hammond, there are several others that address ethnocentric attitudes (Sumner (1906), Sumner et al. (1927), Brewer (1968, 1979), LeVine and Campbell (1972), Taylor and Jaggi (1974), Brewer and Campbell (1976), Perreault and Bourhis (1999), Cashdan (2001). ForSumner (1906), ethnocentrism is a ”syndrome” in the sense that it encompasses various (interrelated) attributes of social life, playing a universal role in group formation and intergroup competition. Therefore, positive feelings are shared about the inner group, with a sense of superiority, pride, and loyalty.

Kinder and Kam (2010) argue that ethnocentrism can be divided into 4 theoretical perspectives: as a consequence of conflicts between groups; unfolding authoritarian personalities; an expression of social identity and as a result of natural selection. In short, for the authors, ethnocentrism is a mental habit, a general predisposition. It is an inclination to divide the world into groups, presuming that members of the same group are friendly, cooperative, trustworthy and secure, while members of other groups are the opposite: hostile, uncooperative, unreliable, and dangerous.

Complementing the idea of ethnocentrism, Allport (1954) elaborated hypotheses on the behavior of individuals of the same group. They claim that contact can generate positive effects in some specific situations, such as equal group status within the situation; common goals; intergroup cooperation; and the support of authorities, law, or custom. In other words, the ethnocentric relations between different groups can be altered under a greater coexistence with each other.

Following on from this is the work of Powers and Ellison (1995) who conduct makes tests regarding the interracial relation and racial attitudes. The result is that interracial friendships lead to positive racial attitudes among black Americans. In Desforges et al. (1991) students had a cooperative learning experience with a ”study colleague” who was said to be a former mental patient. In circumstances that met most of the known preconditions for changing specific attitudes, these students liked the then-colleague more than expected and generalized their particular taste for less negative attitudes toward mental patients in general. Werth and Lord (1992), corroborating with the study of Desforges, developed a research in which he discovers that people who knew at least one member of a negatively stigmatized group are more likely than people that have never met to demystify the prejudices related to that group. The results gives support to the aforementioned ideas because they present positive attitudes with the group negatively stigmatized from the coexistence with at least one member of the same.

Pettigrew (1997) found that Europeans who had more friends of another race, nationality, religion, culture or social class were less prejudiced against minority groups in their country, while the opposite is also true. Masuda (2012) argues that individuals carry their own cores of reputation, which represent an evaluation of their past actions towards others. Individuals are motivated to cooperate to obtain good reputations, seeking to be rewarded and helped by others in the future, calling such an attitude of ”indirect reciprocity”. Emphasis should be given to Sherif et al. (1988) with a classic experiment developed where results show that cooperative interaction happens more intensely when those involved are subject to a common goal.

An important experiment was developed by Yamamoto and Araujo (2009), where they questioned whether religion would be an effective indicator for maintaining the coalition between individuals of the same religious group and whether cooperative behavior would be influenced by religion. They applied an experiment through an on-line game, in which Catholics, Evangelicals and atheists participated, with the winners receiving more chips, thus, sought to focus on reciprocity of the participants. The authors' expectation was that religious individuals were more cooperative, but they did not observe differences between the average percentage of donations when compared to atheists and evangelicals. However, the player's choice for donation was preferentially targeted to individuals in the same group. According to the authors, the relevance of the presented results does not depend on the identification of which elements are used to make an individual feel belonging to a certain group, but on the need that individuals present to categorize the world into groups of pertinence and external groups.

Reich and Purbhoo (1975), through an experiment with 11th grade Canadian students, tested the hypothesis that greater transcultural / cross-cultural contact would result in more favorable attitudes among other ethnic groups. The result found by the authors was positive, so that students who have greater contact with diversities presented greater tolerance to people from other groups. Complementing this, Pettigrew (1997) argues that intergroup friendship can often involve a reassessment of the inner group. Leading to a process of deprovinization, a closer contact can provide information about internal and external groups. Norms, traditions, and lifestyles are not the only ways to manage the social world. Thus, this new perspective makes it possible not only to ”humanize” the members from outside a group, but also to de-assimilate the individual from their own group. In addition, despite the broad debate on ethnocentrism, the definition that best fits the scope of this research is that used by Axelrod and Hammond (2006) of behavior defined as in-group favoritism.

Dawes and Thaler (1988) also present theories about human behavior and decision-making regarding cooperation with others. It is pointed out that inductive reasoning is the most common form of decision-making in human thought. Through it the individual is able to formulate hypotheses and from observed experiences and they determine directly the future actions of the others. Then new experiences generate new hypotheses and different actions in subsequent periods. The authors point out that inductive thinking is much more present than deductive reasoning.

The notorious research by Simon (1959) also points out that human reasoning is limited and that the ability to store and obtain information would not be complete. The individual would not be able to identify, process, store and conclude about all available information. In our modeling strategy we seek to incorporate this feature by limiting the information that the agent is able to perceive and store.

The modeling developed initially by Axelrod and Hammond (2006) to study the phenomenon of ethnocentrism is based on static agents whose behaviors are defined in their creation. It becomes interesting, therefore, to adapt the model developed by the authors according to the theories developed by the behavioral economy. In this way we would have behavior that changes over the life of the individual according to their past experiences, better suiting our reality and bringing more appropriate results.

This research seeks, then, through an agent-based simulation model, to find some insights about the coexistence between different social groups. We focus on understanding the possibility that greater coexistence between groups can increase tolerance and cooperation rates between groups. We also sought to incorporate more complex behavior in the original model by Axelrod and Hammond (2006) including the possibility of the moving agent in space, as suggested by De et al. (2015) and varying degrees of perception and interaction with other agents. The main theoretical bases of the work are in Dawes and Thaler (1988) because it is incorporated an inductive component in the rationality of the agents that will be explained with more detail in the next session. We also take inspiration from Simon (1959) by modifying the agents' perceptions, testing different constraints on the ability to interact. The empirical works cited also serve as reference for the agent-based model to be constructed from the original.

In the next session we present the methodology used, with a brief summary of the original model and the strategy used to model inductive reasoning. In the third session we make an exploratory analysis of the effects of model parameters and a local sensitivity analysis. In the fourth and final session we have the conclusions and insights that the model is able to present to us.

2. Methodology

We propose to build an agent-based simulation model where the units face decisions based on a game in the format of the prisoner's dilemma where they determine their chances of reproduction and, therefore, their survival in the simulated universe. The modeling strategy relies heavily on the model published by Axelrod and Hammond (2006) and on the book The Evolution of Cooperation (Axelrod (1984)). A fundamental modification will be made to the original model to represent an agent capable of making a new adaptive decision, where it reacts inductively to past interactions by modifying its initial interaction strategy. The idea is based on the argument that an agent's interpretation of other social groups can be formed and modified by interaction with these other groups throughout their life and is not a fixed characteristic determined at birth, as suggested by studied literature. We also incorporate the work of De et al. (2015) including a mobility function for the agents so they can move in space. Finally, inspired by Simon (1959), we add a parameter that can change the range of perception and interaction between the simulated units so we can better understand this effect on the model.

In The Evolution of Ethnocentrism (Axelrod and Hammond (2006)) they create a simulation with four main stages: immigration, interaction, reproduction and death. In the first step, the agents are generated according to a fixed immigration rate and randomly distributed in space. The group in which the agent belongs is also randomly determined among four possibilities and remains the same until his death. Another feature determined in the creation of the simulated elements is their interaction strategy, there are four possibilities formed by the combination of two traits: to help or not agents of the same group and to help or not agents from other groups. Then they interact in a game in the format of the prisoner's dilemma where they can choose between losing chances to reproduce to increase the chances of reproducing from the other player in greater proportion (helping others), these decisions are based on the strategy defined in the first step model. In the third step, the agents reproduce, given a probability defined by a fixed percentage (12% in the base model) added to the result established by the previous interaction. The descendants belong to the same group as their parents and have the same interaction strategy, with the exception of some that modify their characteristics according to a low and fixed mutation rate (0.5% in the base model). Finally, agents die at a fixed and low rate to make room for new ones in the next round of the simulation (5% in the base model). The perception and interaction range is set to 1 in the original model, which means that they interact with up to four other units in the four cardinal directions, depending only on whether the neighbors exist (they did not die in recent rounds). It is notable that the interaction space of the agents has the toroidal format of 50x50, that is, the maximum number of agents present simultaneously in the model is 2500. The pups of the units can appear randomly in all four cardinal directions because there is no limit to any direction.

2.1. Reaction

Our model's main contribution is made by adding an extra step in which units can react by modifying their initial interaction strategy. It is important to emphasize that the objective of the study is to complement the previous research by Axelrod and Hammond with a new addition in an inductive reaction strategy for the agents. While the original authors use a fixed strategy of interaction and focus on the results of these strategies, we try to analyze in more detail the formation of them and their viability and, mainly, to identify which ones have greater potential of survival in an environment where the agents modify their behavior and are not formed in a totally random manner.

We call the new stage proposed for the model "reaction", in which agents will have a probability of changing the interaction strategy defined in its creation. This characteristic corresponds to a probability based on the fact that the simulated element received help of elements of other groups. The probability of reaction will be given by a function based on the last interaction that the agent had with other groups. An agent who does not help foreigners is more likely to become willing to help other groups if they have had good relations with them in that round, ie. interacted with a unit and received help from it. The reverse also happens, an agent who has bad relationships with agents from other groups is more likely to change his strategy and become an agent that does not help foreigners.

We must therefore better detail the function that determines probability. It was modeled as a linear function that multiplies the "Reaction Chance" (RC) coefficient by the number of interactions performed in the round in which the agent received a different treatment from the choice made in the round.

$$p = RC * n \tag{1}$$

Where "p" corresponds to the probability of the agent changing his behavior; "RC" corresponds to the reaction chance coefficient; and "n" is the number of interactions the agent had in the last round with others who behaved differently.

That is, an agent whose strategy is not to help foreigners and interacts with two foreign agents who have helped him will have twice the probability times the RC coefficient to change his strategy and start to cooperate with foreigners. The reverse can also happen by making an agent who helps strangers pass on not helping them if they do not receive the same treatment. This way, the greater the number of neighbors influencing the agent the greater the chance of reacting by modifying its initial strategy. It is also interesting to note that this mechanism does not necessarily increase the amount of positive interactions where one agent helps the other. Non-helpfull interactions can also increase as agents who do not receive help tend to react in the same way, decreasing the total amount of aid and cooperation in the model.

2.2. Modeling strategy

Brian (1994) observes that, in complex situations, human deductive reasoning is limited and the presence of an inductive reasoning is more frequent. The human being would be extremely competent to see, recognize or combine patterns. With the proposed model we seek to bring an inductive reasoning to the agents, who would make their decisions based on information acquired throughout their existence and created hypotheses about which strategy is the most adequate. This process influences the decisions and actions of the individual, possibly making the change of strategy of interaction with other social groups.

Our model seeks to incorporate a strategy inspired by the notorious *tit-for-that* suggested by Dawes and Thaler (1988). In this behavior model the agent seeks to reciprocate an action in a repeated game in the same way that his opponent acted with him, ie. he would not help an agent who did not help him in the last period. In our model the individual would react to past interactions to decide which strategy to adopt. A social group that helps a lot of foreigners influences them to help other foreign groups, including their own, back. It is important to note that the strategy adopted is not perfectly tit-for-that since agents do not necessarily react to help with help in the next interaction. What happens is that aid increases the probability of agents forming a new hypothesis that can influence their decisions to help others in the future. With a high value for the RC parameter we have a near perfect *tit-for-that*.

Dawes and Thaler (1988) also point out that people tend to cooperate with one another when they believe that they belong to the same social group. Emphasis should be given to the fact that cooperation exists until the moment individuals interpret that they are being wronged, that is, when they are helping others and not receiving help in response. After that moment, they react and stop cooperating. We aim to incorporate this reaction into the model because it is possible that the strategy change occurs when individuals do not receive help from other groups and are not helping them. The situation where an individual helps other groups but does not receive help in return is unlikely to happen for long given the likelihood of modifying his strategy every round that this phenomenon happens.

Tesfatsion (2005) presents three definitions for complex adaptive systems, our article seeks to include in the third proposed definition. In this definition complex adaptive systems include agents that react and adapt according to units directed to objectives and that seek to have a certain control of their environment to reach the purposes traced in the process. We seek to model the elements so that they plan their actions to form alliances with the members the same or other social groups. The goal is to represent the fact that they would believe that they are more likely to thrive when they cooperate, that is, when they help each other, the agents would soon be taking their actions for the ultimate goal of survival. The modeled units also act according to the information perceived by them and have adaptive characteristics, since only the most suitable ones to the environment have a greater chance of reproducing because the probability of reproduction is a function of the aid received and, consequently, to thrive.

An important highlight should be given to the way modeled individuals perceive and store information in the model. Units are only aware of their interactions with neighbors. Neither know nor take into account the decisions and strategies of cooperation of the neighbors nor their actions with the other, only if the neighbor has helped or not in the last interaction. The agents' memory is limited and they can store information for a defined period. This modeling seeks to be consistent with Simon's theory of limited rationality (1959) because individuals only have information that is obtainable and do not have unlimited storage and processing of information. In the original model we have a set perception range, in our sensitivity analysis we can see the changes in the environment caused by different ranges of perception and interaction.

3. Simulations and parameter analysis

3.1. General parameter analysis

In order to analyze the results robustly we must adopt a strategy similar to that adopted in the literature on agent-based modeling. Therefore, the model was tested with variations in the fundamental parameters, being: variation in the cost in terms of the chances of reproducing to give aid, in the mutation rate of the units, in the immigration rate of the agents (how many agents are created per round), in the number of different ethnic groups represented, in the mortality rate, in mobility as presented in De et al. (2015), in the perception range and, mainly, in the RC parameter that represents the sensitivity of the agent to the interaction with other groups. We must point out that although varying the cost of aiding the structure of the game remain in the format of the prisoner's dilemma. The variation in the cost of aid also dispenses the variation in the benefits of the aided one since the interesting one is the proportion between these two parameters. Varying the size of the space where the agents interact is also not very interesting due to the toroidal characteristic of the same, always having spaces available for the interaction in the four directions for all the units of the model.

The basic parameters used are shown in Table 1 - Basic parameters. The value of each main coefficient was varied to test the trend of the model in different circumstances. For this, we also use the RC in the values 0 or 0.25, being the first model where there is no possibility of reaction of the agents (RC = 0) and the second one where it is high (RC = 0.25). The coefficient 0.25 was chosen because the agent can be influenced by up to 4 other neighbors in each round in the standard model and in this case the total influence would be 1. That is, in the case where four neighbors influence an agent to change strategy it would have 100% chances to do so, representing the maximum reaction or a

Table 1
Standard Parameters

Help cost	0.01%
Help benefit	0.03%
Mutation rate	0.005
Mortality rate	0.005
Immigration rate	1 p/ round
Perception distance	1 (up to 4 agents)
Mobility	0
Reaction Chance (RC)	0% or 0.25%

perfect *tit-for-that*. After analyzing the effects of the basic parameters and the general tendencies of the model we will investigate the effects of the RC parameter and the perception distance more thoroughly. Finally, we incorporate in the model the possibility of mobility in the space suggested by De et. to (2015). The basic parameter variation tests were all done with 10 simulations of 2000 periods and the proportions of the strategies of the simulated survivors were evaluated, we chose this number based on the original simulations based on Axelrod and Hammond. This amount was considered sufficient for the analysis due to the low values found for the standard deviations.

For this preliminary analysis of the parameters we ran the model with help cost, mutation rate and mortality rate with values equivalent to half of the standard value, the default value, one and a half times the default value and double the default value. For the immigration rate we tested the model for 1, 2, 3 and 4 immigrants per round. As mentioned previously it was not necessary to vary help benefit because the proportion of the same with help cost that is interesting for the tests. As far as reaction chance and perception distance will be analyzed in more detail in sections 3.2 and 3.3 respectively. The mean results and deviations between the simulated experiments for each of the variations of the simulated help cost, mutation rate, mortality rate and immigration rate are available in the appendix. For this first analysis we averaged between 10 simulations, for the subsequent analyzes we used a larger number of simulations, this number is in accordance with the one suggested by Railsback and Grimm (2012).

The results for the variation in help cost show a drastic decrease of the unrestricted cooperation strategy, ie the agents who helps others in the same and in other groups, when the cost of helping increases. The reduction is similar in relative terms for both the high reaction model and the original model with no reaction. This is a very intuitive result because with the rising cost of aid, while maintaining the paradigm of the prisoner's dilemma, the strategy of helping the neighbor is less likely to prosper. Highlight should be given to the ethnocentric behavior which is more sensible to the changes in the reaction model compared to the original model. One of the main arguments in Axelrod and Hammond (2006) is that this strategy is stable even when parameter variation exists. With the variation of the cost of helping between 0.005 and 0.01 the same reduces in a small proportion in the original model whereas in the model with reaction it more than doubles of value with the increase of the cost. This may be due to the fact that one of the evolutionary advantages of the ethnocentric strategy is to suppress individuals from different groups within their domain area. With the addition of the reaction, this advantage loses its force and consequently the strategy loses its stability in relation to the cost variations and behaves like the other strategies absorbing the negative variation of the unrestricted cooperation behavior. We must also show that the reaction model is much less stable than the original with the parameter variation.

Regarding the variation of the rate of mutation and the immigration rate. We can note that for higher values of both the stochastic character of the model increases, bringing the proportions closer to the uniform distribution among the strategies. For both models, with and without reaction, we have the initial highlight of a strategy that decreases by increasing the rate of mutation and immigration of agents, being they the ethnocentric strategy in the original model and the unrestricted cooperation in the model with reaction. It is noteworthy that, although in both models the dominant strategy loses prominence with increased mutation and immigration, in the reaction model this difference is slightly smaller in relative terms. One possible explanation is that the ethnocentric strategy depends on the ability of the agents to cooperate only with those of the group itself and a larger number of agents with random characteristics can generate more interactions between distinct groups, reducing the effectiveness of the strategy. The unrestricted cooperation strategy, dominant in the reaction model, is effective when a large part of the population adopts the

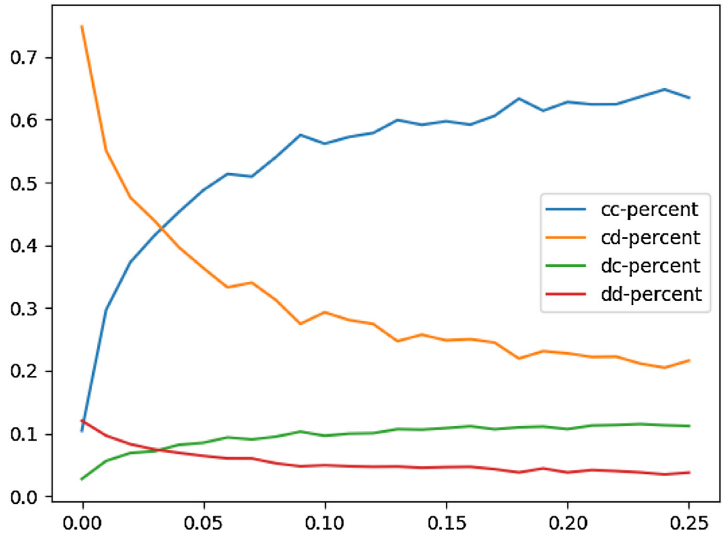

Fig. 1. Reaction chance variation. Note: The acronyms of the strategies correspond to the agent helping the group itself and other groups respectively. CC - help all, CD - help only the group itself, DC - help only other groups and DD - does not help.

same and consequently, many benefit from receiving help even though they also pay the costs of helping. When the randomness of the model increases the generalized presence of cooperative agents decreases causing the strategy to lose effectiveness.

The influence of the mortality rate, in turn, is very small in the proportions of the strategies in both models. It is notable that a higher mortality rate slightly increases the predominance of the ethnocentric strategy in the non-reactive model and the unrestricted cooperation strategy in the reaction model. We can argue that this happens due to the greater need for cooperation due to the smaller number of interactions that led to a decrease in the strategy of non-cooperation and an increase in the others for both situations.

3.2. Analysis of the Reaction Chance (RC) parameter

With the addition of the reaction step we have a change in the overall trend of the model. The model with high reaction chance brings a greater tendency towards the unrestricted cooperation strategy. This is due to two main reasons: the first is that the ability of a group to differentiate through the ethnocentric strategy decreases, since agents from other groups tend to reciprocate non-cooperation with non-cooperation and the ethnocentric group ends up receiving little cooperation out. Another possible motive is the fact that a group that helps foreigners gets more help from foreigners having a survival greater than that of ethnocentric groups. It is important to further study the influence of the RC parameter on this trend change.

In figure 1 the horizontal axis represents the variation of the coefficient RC between 0 and 0.25 and the vertical axis the average percentage of each strategy [3]. We can notice that the dynamics is sensitive to the RC parameter. The main difference is in the decision of the agents to help foreigners, which modifies the dominant strategy to the one of unrestricted cooperation in detriment of the ethnocentric strategy. We also have a decrease in the presence of the strategy of helping no one and an increase in the number of surviving agents that only help foreigners.

We can divide the strategies into two main groups, the intragroup helpers and the non-intragroup helpers. It is remarkable that the proportion of the same is maintained throughout the model, showing the evolutionary advantage of intra-group cooperation. The RC variation modifies only the decision of aid of the agent in relation to other groups increasing the aid to the detriment of the non-aid to foreigners. It is also noticed that for low values of the coefficient, below 0.05, the dynamics already modifies indicating a greater advantage for aiding members of other groups.

[3] To evaluate the percentage of each strategy was made the average of the participation of each one in the last 100 periods and we simulate the model 50 times for each of the 26 possibilities. Each simulation used 2000 rounds and the standard parameters.

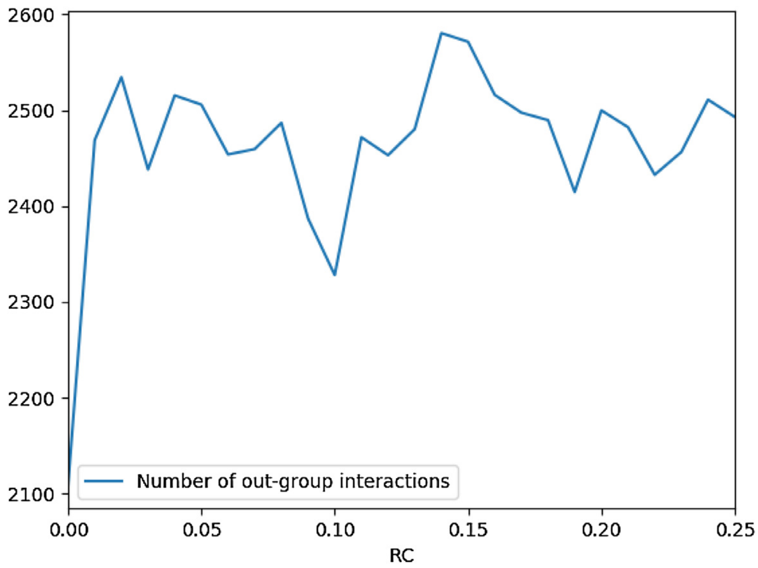

Fig. 2. Out-group interactions

This result is similar to the original model where the authors emphasize that cooperation is an evolutionary advantage. It is noted that they consider ethnocentric behavior as cooperative behavior because they help members of the group themselves. This result is closely related to the framework of the prisoner's dilemma adopted in the model because the benefits of receiving aid are necessarily greater than the costs of aiding, so in the long run, cooperation thrives.

It is also interesting that the results are according to recent research presented in the first session. The increase in the RC parameter implies a more intense reaction of the agents around it and a decrease in the ethnocentric behavior. It is also notable that with a larger RC parameter the diversity of simulated ambiance increases. Figure 2 shows the variation of the RC parameter in relation to the average number of interactions between individuals from different groups in the last round.[4]

It can be noticed that the parameter affects the amount of agents that interact with other social groups, specially at low values of RC. This is because the ethnocentric clusters are dismantled and there is a greater heterogeneity of simulated units in space due to the end of dominant ethnocentric behavior. This process is the cause of the increase in positive behavior towards foreigners but is also partly a result of the same because of the end of dominant ethnocentric groups. This type of result is expected since the end of large clusters of agents of the same group leads to greater interaction between distinct groups. It is noted that the total amount of interactions remains the same, what happens is a decrease in the amount of interactions within the same group and an increase in interactions with other groups.

3.3. Perception range

For a brief analysis of the effects of the perception range we vary the same as described in Table 2. It is important to say that the parameter indicates the radius of perception, that is, the radius of interaction of the agent with others. In this way we limit the information that the agent is able to perceive and the ability of the agent to respond to the actions of other individuals in the interaction stage of the model.

The variation of this parameter gives us a good insight into the importance of information and interaction with a different amount of agents in the process. We can observe that in a society where the agents have greater interaction between them the presence of cooperative strategies loses importance in the model without reaction and we have a much greater presence of individuals that do not help others. This parameter, which was not analyzed in the original model, shows that in the presence of agents that interact with others at very great distances make the ability to form ethnocentric clusters decreases drastically.

[4] To generate the data we use the standard parameters and 2000 time periods.

Table 2
Influence of perception distance

Perception distance	Strategy	RC = 0 Average	Standard deviation	RC = 0.25 Average	Standard deviation
1 (interact with up to 4 agents)	CC	0.10	0.02	0.64	0.06
1 (interact with up to 4 agents)	CD	0.75	0.03	0.21	0.06
1 (interact with up to 4 agents)	DC	0.03	0.01	0.11	0.03
1 (interact with up to 4 agents)	DD	0.12	0.03	0.04	0.01
2 (interact with up to 12 agents)	CC	0.03	0.01	0.38	0.02
2 (interact with up to 12 agents)	CD	0.57	0.06	0.28	0.02
2 (interact with up to 12 agents)	DC	0.02	0.01	0.21	0.03
2 (interact with up to 12 agents)	DD	0.37	0.06	0.13	0.01
4 (interact with up to 48 agents)	CC	0.01	0.00	0.09	0.02
4 (interact with up to 48 agents)	CD	0.19	0.07	0.04	0.01
4 (interact with up to 48 agents)	DC	0.02	0.01	0.65	0.04
4 (interact with up to 48 agents)	DD	0.79	0.07	0.22	0.00
6 (interact with up to 112 agents)	CC	0.01	0.00	0.07	0.03
6 (interact with up to 112 agents)	CD	0.13	0.09	0.05	0.02
6 (interact with up to 112 agents)	DC	0.01	0.01	0.49	0.03
6 (interact with up to 112 agents)	DD	0.85	0.10	0.39	0.02

Note: The acronyms of the strategies correspond to the agent helping the group itself and other groups respectively. CC - help all, CD - help only the group itself, DC - help only other groups and DD - does not help.

This result can bring us very interesting insights since the contact of people within an ethnocentric group who are capable of perceiving others outside their group and interacting with them is enough to de-structure the advantages of the ethnocentrism that the original model of Axelrod and Hammond (2006) suggested to us. There is also greater adherence to the researched literature that indicates that interaction between different groups is capable of discouraging ethnocentrism.

However, in the model with reaction to dynamics, we found different results. Since in this model the dominant strategy is unrestricted helping others, it is less sensitive to differences in the perception rate because it does not depend on the formation of clusters of agents of the same group with the same strategy. However, we have a decrease in strategies that help intragroup giving place to strategies that only help agents of other groups or do not help any other agent, which is a direct consequence of the additional reaction step that interferes only in the characteristics of the agent in relation to foreigners.

3.4. Mobility

De et al. (2015) present another variation of the original model. In it, the authors include an additional step at the end of each round where agents have a chance to migrate to any other random space in the universe given by an ”m” parameter. This relationship is modeled quite simply and intuitively, the agent has an ”m” probability of migrating at every time period. We incorporated this chance of migration into our model and presented the results in table 3.

We can observe that as migration increases the model reveals less advantage to us in strategies that aim at intragroup cooperation. In the model without reaction ethnocentric strategy loses space for an individualistic strategy, without cooperation between agents. A similar phenomenon occurs in the reactive model, where the strategy of unrestricted cooperation leaves room for a strategy of cooperation only with members of other groups. This is because greater agent mobility makes group identities less important due to the fact that groups are less able to focus on space and cooperate with each other.

Another interesting phenomenon that we can observe with migration are the proportions between social groups. When mobility is high the distribution of social groups in space moves away from a uniform distribution. This is due to the fact that mobility allows ethnocentric groups to spread throughout the universe and make the simulated environment an environment dominated only by a large ethnocentric group. For medium levels of mobility this event is more present, but for high levels of mobility the ethnocentric strategies lose their value and the ethnocentric group does not dominate the environment. This happens in a similar way in the reaction model, except that the dominant

Table 3
Influence of mobility rate

Mobility rate	Strategy	RC = 0 Average	Standard deviation	RC = 0.25 Average	Standard deviation
0	CC	0.11	0.03	0.63	0.07
0	CD	0.73	0.03	0.22	0.06
0	DC	0.03	0.01	0.11	0.02
0	DD	0.13	0.02	0.04	0.01
0.02	CC	0.05	0.01	0.67	0.07
0.02	CD	0.59	0.14	0.11	0.05
0.02	DC	0.04	0.03	0.19	0.04
0.02	DD	0.32	0.12	0.03	0.02
0.04	CC	0.04	0.01	0.58	0.07
0.04	CD	0.45	0.08	0.07	0.03
0.04	DC	0.05	0.01	0.30	0.07
0.04	DD	0.47	0.08	0.04	0.02
0.08	CC	0.03	0.01	0.48	0.06
0.08	CD	0.37	0.11	0.07	0.03
0.08	DC	0.06	0.03	0.40	0.09
0.08	DD	0.55	0.10	0.06	0.02

Note: The acronyms of the strategies correspond to the agent helping the group itself and other groups respectively. CC - help all, CD - help only the group itself, DC - help only other groups and DD - does not help.

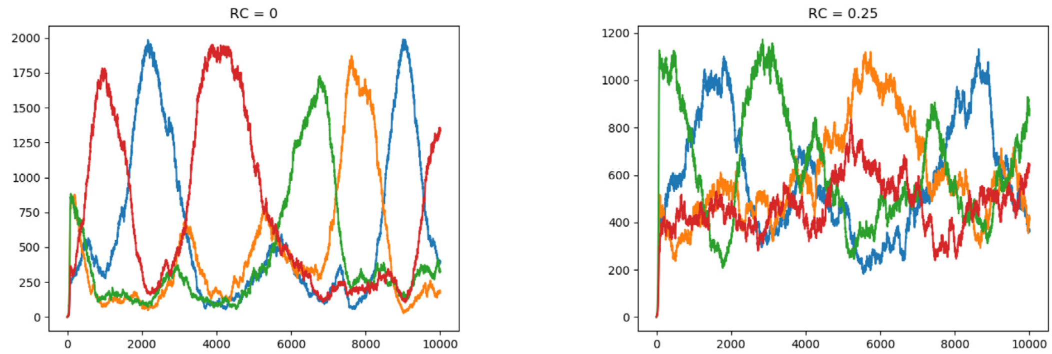

Fig. 3. Group proportions

group presents an unrestricted cooperation strategy instead of the ethnocentric strategy as evidenced in the previous section.

Figure 3 shows the number of individuals on the four social groups in the models with and without reaction for a median level of mobility [5] and helps us to better understand the event, on the horizontal axis we have 10000 rounds of the model and on the vertical axis the amounts of agents surviving in each group. We can observe in it a cyclical behavior among the proportions of the groups indicating that there is a kind of relay in the dominant group over time, showing that a group with more agents is more likely to thrive, however, due to the random characteristics internal to the group. this prosperity is not insurmountable and the dominant group can change over time.

Note that this dynamics is observed in both the RC = 0.25 model and the RC = 0 model. However, in the reactive model, due to the lower predominance of the ethnocentric strategy, the dominant group can not stand out as much. In the model with medium mobility and without reaction we have higher extreme values for the number of surviving agents in the dominant group, while in the model with reaction these values are smaller and the instability is greater.

[5] m = 0.4 was used to simulate this median level of mobility based on Dawes and Thaler (1988)

Table 4
Local Sensitivity Analisys

Variation = 25%	cc	cd	dc	dd
reaction.chance.min	-8,65	3,86	-5,32	8,40
reaction.chance.max	-0,07	-7,86	2,77	-2,29
move.rate.min	11,28	10,70	-2,12	-1,66
move.rate.max	-10,26	-10,70	2,25	1,26
perception.distance.min	49,23	85,75	-20,20	0,46
perception.distance.max	-29,83	-44,77	16,45	-7,15
cost.of.giving.min	47,79	58,08	-12,01	-5,24
cost.of.giving.max	-27,22	-34,46	9,37	-0,14
mutation.rate.min	-15,16	-16,60	2,99	2,43
mutation.rate.max	6,23	3,13	-0,65	-1,12
immigrants.per.day.min	-23,25	-24,45	4,58	3,57
immigrants.per.day.max	1,54	-0,04	-0,29	0,05
death.rate.min	1,51	-2,50	1,11	-1,39
death.rate.max	-2,15	-1,89	-0,64	1,67
Variation = 50%	cc	cd	dc	dd
reaction.chance.min	-14,51	14,90	-13,27	18,40
reaction.chance.max	5,06	-2,11	2,58	-4,23
move.rate.min	52,69	55,15	-10,57	-7,78
move.rate.max	-14,37	-16,89	3,22	2,00
perception.distance.min	227,78	356,21	-57,03	-39,25
perception.distance.max	-40,22	-54,07	22,28	-10,88
cost.of.giving.min	162,88	205,51	-36,63	-24,93
cost.of.giving.max	-43,21	-54,94	17,11	-3,16
mutation.rate.min	-13,97	-15,38	2,60	2,47
mutation.rate.max	15,78	13,46	-2,66	-2,47
immigrants.per.day.min	-23,25	-24,45	4,58	3,57
immigrants.per.day.max	26,79	26,87	-4,85	-4,44
death.rate.min	22,46	16,92	-1,55	-6,09
death.rate.max	11,87	16,56	-4,96	0,96

The acronyms of the strategies correspond to the agent helping the group itself and other groups respectively. CC - help all, CD - help only the group itself, DC - help only other groups and DD - does not help.

3.5. Sensitivity analysis

A local sensitivity analysis was developed as suggested by Thiele et al. (2014). We vary the parameters one by one and calculate a dimensionless index of the sensitivity of the results for each variation. In this way we can understand in a succinct and systematic way the importance of each parameter in the model. The main advantage of the methodology is to capture a comparable effect for positive and negative variations of the parameters.

Table 4 shows the results of the sensitivity analysis for variations of 25% and 50% of each parameter. For this simulations we used the following set of parameters: RC = 12.5%; move rate = 5%; perception-distance = 2 (up to 12 agents); help cost = 0.01%; mutation-rate = 0.5%; immigrants-per-day = 2 and mortality rate = 0.5%, 50 simulations were made for each combination of parameters. Each of these parameters was varied four times, increasing and decreasing their value by 25% and 50% while maintaining the initial value of the others, as suggested by the local sensitivity analisys methodology in Thiele et al. (2014). The basic initial parameter group was chosen based on the articles that suggested the first versions of the model in De et al. (2015) and Axelrod and Hammond (2006), they are also the same presented in the General parameter analysis section.

Table 5.

As we can observe the parameters that most influence the model are perception range and cost of help, especially when they reach lower values. Even small changes in these parameters can strongly affect the results of the model. It is interesting to note that the variation in the help cost parameter is not enough to make the model out of the prisoners' dilemma framework, it only increases the mutual aid benefits when its cost is reduced.

Table 5
General parameter analysis

	Strategy	RC = 0 Average	Standard deviation	RC = 0.25 Average	Standard deviation
Help cost					
0.005	CC	0.18	0.03	0.76	0.04
0.005	CD	0.73	0.03	0.16	0.04
0.005	DC	0.02	0.01	0.06	0.02
0.005	DD	0.06	0.01	0.01	0.01
0.01	CC	0.14	0.03	0.67	0.03
0.01	CD	0.75	0.03	0.23	0.04
0.01	DC	0.02	0.01	0.07	0.02
0.01	DD	0.08	0.01	0.03	0.01
0.015	CC	0.10	0.03	0.57	0.05
0.015	CD	0.74	0.04	0.28	0.05
0.015	DC	0.02	0.01	0.10	0.02
0.015	DD	0.13	0.02	0.05	0.01
0.02	CC	0.10	0.02	0.44	0.05
0.02	CD	0.65	0.05	0.34	0.05
0.02	DC	0.04	0.01	0.13	0.03
0.02	DD	0.21	0.05	0.10	0.02
Mutation rate					
0.0025	CC	0.11	0.03	0.74	0.08
0.0025	CD	0.83	0.04	0.19	0.09
0.0025	DC	0.01	0.00	0.06	0.01
0.0025	DD	0.05	0.01	0.02	0.01
0.005	CC	0.12	0.03	0.66	0.05
0.005	CD	0.77	0.02	0.24	0.04
0.005	DC	0.02	0.01	0.07	0.01
0.005	DD	0.09	0.02	0.03	0.01
0.0075	CC	0.18	0.03	0.65	0.06
0.0075	CD	0.68	0.04	0.21	0.06
0.0075	DC	0.03	0.01	0.11	0.03
0.0075	DD	0.10	0.02	0.03	0.01
0.01	CC	0.20	0.02	0.58	0.07
0.01	CD	0.63	0.02	0.27	0.06
0.01	DC	0.04	0.01	0.10	0.01
0.01	DD	0.12	0.03	0.05	0.01
Immigration rate					
1	CC	0.11	0.03	0.65	0.05
1	CD	0.83	0.04	0.20	0.04
1	DC	0.01	0.00	0.12	0.02
1	DD	0.05	0.01	0.04	0.01
2	CC	0.12	0.03	0.57	0.05
2	CD	0.77	0.02	0.24	0.04
2	DC	0.02	0.01	0.14	0.01
2	DD	0.09	0.02	0.06	0.01
3	CC	0.18	0.03	0.55	0.05
3	CD	0.68	0.04	0.23	0.04
3	DC	0.03	0.01	0.15	0.02
3	DD	0.10	0.02	0.06	0.01
4	CC	0.20	0.02	0.50	0.03
4	CD	0.63	0.02	0.23	0.03
4	DC	0.04	0.01	0.18	0.02
4	DD	0.12	0.03	0.09	0.02
Mortality rate					
0.025	CC	0.14	0.03	0.57	0.05
0.025	CD	0.66	0.05	0.22	0.05
0.025	DC	0.04	0.01	0.15	0.03
0.025	DD	0.15	0.03	0.06	0.02

Table 5 (*Continued*)

	Strategy	RC = 0 Average	Standard deviation	RC = 0.25 Average	Standard deviation
0.05	CC	0.11	0.02	0.63	0.04
0.05	CD	0.75	0.03	0.23	0.05
0.05	DC	0.03	0.01	0.11	0.02
0.05	DD	0.12	0.03	0.04	0.01
0.075	CC	0.12	0.03	0.70	0.04
0.075	CD	0.77	0.04	0.17	0.04
0.075	DC	0.02	0.01	0.10	0.02
0.075	DD	0.10	0.02	0.02	0.01
0.1	CC	0.15	0.04	0.66	0.07
0.1	CD	0.75	0.04	0.24	0.07
0.1	DC	0.02	0.01	0.07	0.01
0.1	DD	0.08	0.01	0.03	0.01

Note: The acronyms of the strategies correspond to the agent helping the group itself and other groups respectively. CC - help all, CD - help only the group itself, DC - help only other groups and DD - does not help.

The effect of the RC parameter is small because, as previously observed, after a certain minimum level the marginal differences in the parameter are not significant. We can note that the effect is slightly larger for the 50% negative change, at -14.51.

The importance of the effects of the perception of the agents is very interesting when one takes into account the analyzed literature. With a greater radius of perception the agent is able to interact with more other agents and, consequently, other social groups. The model suggests that this interaction is sufficient to de-structure the ethnocentric clusters and substantially decrease the advantages of this behavior. Agents capable of interacting with more other agents tend to become less ethnocentric as they receive and give help to others outside their group.

4. Concluding remarks

Our research has brought an addition to the social behavior model of Axelrod and Hammond (2006) introducing agents with an inductive reasoning. Due attention has been given not to model them in a way that does not increases or decreases by definition one of the strategies and for this we create an additional step where agents can become more or less cooperative. We call this ”reaction”, in which agents can increase or decrease the amount of help and, consequently, cooperation among themselves according to the actions of other agents in the environment that are inserted.

Due to the character of the prisoner’s dilemma game the unrestricted helping strategy has become dominant in the model. This was mainly due to the end of the ethnocentric strategy’s advantage in segregating other groups. This feature loses importance when the interaction between groups has a minimum degree of reaction where they reciprocate favorable actions in the same way. The prisoner’s dilemma game framework is a fundamental part of the new result and the reason for the cooperation to be dominant, as a result of which we have a model slightly more sensitive to variations in the game represented by variations in help costs.

Parameter variation and sensitivity analysis have brought us a better understanding of the phenomenon. In particular, the variation in the perception of the agents showed us that societies with greater interaction tend to be less ethnocentric. The contact with different groups diminishes the advantages generated by the ethnocentric strategy suggested by the authors of the original model. We also noticed that the variation in the number of interactions with different social groups has an interesting effect on the model. The more interaction with different groups, either by a higher value for the RC parameter or a greater perception of the agents, the less advantageous is the ethnocentric behavior.

The addition of only one new step in the original model was enough for a drastic change in results. The contribution made by De et al. (2015) was also significant in finding a new dynamic, in the article the authors propose a mobility rate of agents in the simulated system that changes the final results. We can argue that the stability of ethnocentric strategy as advantageous in evolutionary terms presented in the original research is questionable. It becomes interesting to analyze and compare the results found with empirical data to generate better interpretations of reality. We seek with this research to improve and better understand the model and to bring greater insight regarding the phenomenon of ethnocentrism. Future studies can calibrate the parameters from empirical databases and present new hypotheses for the behavior and distribution of social groups in order to bring a more accurate representation of social behavior and to better unveil the dynamics involved in the process.

References

Allport, G.W., 1979. The nature of prejudice. The Significance of Skin Color in Human Relations 1954.

Axelrod, R., Hammond, R.A., 2006. The evolution of ethnocentrism. The Journal of Conflict Resolution 50, 926–936.

Axelrod, R.M., 1984. The evolution of cooperation. Basic Books, New York.

Brewer, M.B., 1968. Determinants of social distance among east african tribal groups. Journal of Personality and Social Psychology, 10.

Brewer, M.B., 1979. The role of ethnocentrism in intergroup conflict. The Social Psychology of Intergroup Relations.

Brewer, M.B., Campbell, D.T., 1976. Ethnocentrism and intergroup attitudes: East african evidence. Sage.

Brian, A.W., 1994. Inductive reasoning and bounded rationality. American Economic Review 84, 406–411.

Cashdan, E., 2001. Ethnocentrism and xenophobia: A cross-cultural study. Current Anthropology, 42.

Dawes, R.M., Thaler, R., 1988. Anomalies: Cooperation. Journal of Economic Perspectives 2, 187–197.

De, S., Gelfand, J., Nau, D., Ross, P., 2015. The inevitability of ethnocentrism revistited: Ethnocentrism diminishes as mobility increases. Scientific Reports, 5.

Desforges, D. M., L., L. R. C. G. S., Mason, J. A., Van Leeunem, M. D., West, S., and R., L. M. 1991. Effects of structured cooperative contact on changing negative attitudes toward stigmatized social groups, Journal of Personality and Social Psychology.

Kinder, D.R., Kam, C.D., 2010. Us against them: Ethnocentric foundations of american opinion. University of Chicago Press.

LeVine, R.A., Campbell, D.T., 1972. Ethnocentrism: Theories of conflict, ethnic attitudes, and group behavior. The Journal of Politics 35, 1022–1024.

Masuda, N., 2012. Ingroup favoritism and intergroup cooperation under indirect reciprocity based on group reputation. Journal of Theoretical Biology, 311.

Perreault, S., Bourhis, R.Y., 1999. Ethnocentrism, social identification, and discrimination. Personality and Social Psychology Bulletin 25, 92–103.

Pettigrew, T.F., 1997. Generalized intergroup contact effects on prejudice. Personality and social psychology bulletin 23, 173–185.

Powers, D.A., Ellison, C.G., 1995. Interracial contact and black racial attitudes: The contact hypothesis and selectivity bias. Social forces 74, 205–226.

Railsback, S., Grimm, V., 2012. Agent-Based and Individual-Based Modeling: A Practical Introduction. Princeton University Press, Princeton.

Reich, C., Purbhoo, M., 1975. The effect of cross-cultural contact. Canadian Journal of Behavioural Science/Revue canadienne des sciences du comportement 7, 313.

Sherif, M., Harvey, O.J., White, B.J., Hood, W.R., Sherif, C.W., 1988. The robbers cave experiment, Intergroup conflict and cooperation.

Simon, H.A., 1959. Theories of decision-making in economics and behavioral science. American Economic Review 49, 253–283.

Sumner, W.G., 1906. Folkways. Ginn.

Sumner, W.G., Keller, A.G., Davie, M.R., 1927. The science of society. Yale University Press, pp. 4.

Taylor, D.M., Jaggi, V., 1974. Ethnocentrism and causal attribution in a south indian context. Journal of cross-cultural Psychology 5, 162–171.

Tesfatsion, L., 2005. Agent-based computational economics: A constructive approach to economic theory. Handbook of Computational Economics, 2.

Thiele, J.C., Kurth, W., Grimm, V., 2014. Facilitating parameter estimation and sensitivity analysis of agent-based models: A cookbook using netlogo and r. Journal of Artificial Societies and Social Simulation, DOI: 10.18564/jasss.2503.

Werth, J.L., Lord, C.G., 1992. Previous conceptions of the typical group member and the contact hypothesis. Basic and Applied Social Psychology 13, 351–369.

Yamamoto, M.E., Araujo, L.F., 2009. Coaliz oes e etnocentrismo: o ponto de vista da psicologia evolucionista. Oecologia brasiliensis, 201–208.