Modeling power distance and individualism/collectivism in negotiation team dynamics

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***Abstract*—It has been documented in the social sciences that cultural factors affect how people negotiate and behave in negotiations. Despite the importance of culture in the business world and politics, there is a lack of computational models that help to analyze how cultural factors affect negotiation. Moreover, while many negotiations take place between teams, there is a dearth of computational models for team negotiations. In this paper we present the first attempt to provide a computational model which takes into account cultural factors in a team negotiation setting. The model considers how two important cultural dimensions, power distance and individualism/collectivism, affect team negotiation dynamics and negotiation outcomes. We conducted experiments in high/low intra-team conflict scenarios. The results are compatible with social sciences findings from team decision making.**

***Keywords*-negotiation; multi-agent systems; cultural factors;**

I. Introduction

Prior research documented the influence of cultural factors on negotiation processes and outcomes [1], [2], [3], yet, research in computational modeling of negotiation [4], [5], [6] has not considered the effects of cultural factors on negotiation teams. Instead, research in this area and in social sciences have focused on negotiation between individuals [7]. Thompson et al. [8] define a negotiation team as a *a group of two or more interdependent persons, who are all present at the bargaining table, and join together as a single negotiating party because of their similar interests and objectives in the negotiation*. Negotiation teams face the problem of deciding which steps should be taken in the negotiation with the opponent, considering the different opinions and goals of the members. We argue that it is important to examine cultural influences in negotiation teams since (a) many real world negotiations, including business and politics, are conducted among teams [9], [8], [10], and (b) as interactions become increasingly global, the role of culture becomes drastically important in team decision making and interactions. Validated computational models of cultural negotiation teams will allow analysis and prediction of the parties' behaviors and could be used in applications such as training human negotiators, predict/simulate negotiation processes among humans, and provide negotiation support systems that help humans in real negotiations. Our long term research goal is providing a robust computational model for cultural negotiation teams that can be used to support the aforementioned applications.

This paper is the first attempt in addressing the influence of cultural factors in a negotiation team setting. We model the negotiation between one team and one other entity, and analyze how different cultural factors affect the negotiation process and outcomes. We focus on intra-team decision-making, i.e., how different members within a negotiation team make proposals or counter-proposals in response to the team's opponent. Team/group decision making in negotiation settings is challenging since it has elements of cooperative reasoning integrated with self-interested agent reasoning. Despite the fact that group members may have different viewpoints, they must form a consensus of how to act/react to opponents' offers and propose counteroffers. Our model not only considers heterogeneity of the team members' utility function, but also the influence of culture on team dynamics. Our model is motivated by Geert Hofstede's influential theory of five "cultural dimensions" [11] (individualism/collectivism, uncertainty avoidance, power distance, masculinity, and long-term orientation).

Even though, in real negotiations the five factors have a simultaneous effect on the negotiation process, we think that it is worth studying the different dimensions sequentially. The insights gained from simulations may serve as a stepping stone for a much more integrated model. In fact, initial simulations may present phenomenon that have already been documented in the social sciences literature. In that case, the model may be considered as an appropriate core element for a more complex model that integrates the

rest of the cultural dimensions. In this paper, we restrict our attention to two cultural dimensions: power distance and individualism/collectivism, since according to researchers, these two dimensions may be so intertwined that it is difficult to isolate their influence individually (usually being inversely related)[12]. Power distance measures the level of inequality within a society and how less powerful individuals accept the inequality; individualism (as opposed to collectivism), is the degree to which an individual derives his/her identity from self-reliance, low concern and distance from the group he/she belongs to [13]. For future research, we plan to incorporate and study the other three cultural dimensions of Geert Hofstede. The contributions of the paper are as follows: (a) We create a computational model of team decision making in negotiation situations, (b) we model the two cultural dimensions and their influence in team decision making, and (c) through experimentation we obtain results on how the two cultural dimensions affect team processes and outcomes which match with scenarios that have been documented in the social sciences. Thus, it validates our current proposal as an appropriate model for future extensions involving other cultural dimensions.

The paper is organized as follows. First, after situating our work in the related literature, we describe the general assumptions of our negotiation model. Second, we detail the negotiation protocol followed by the team. Third, we explain how cultural dimensions were modeled and introduced in the decision-making mechanisms employed by team members. Fourth, we present the simulation setting and analysis of our results. Finally we conclude and discuss future work.

II. Related Work

Velagapudi et al., [14] consider cost-effective policies for sharing information in large teams. Our paper, by contrast, models culture as a way to change beliefs and influence individual behaviors within a team.

As of today, the only work that has considered computational models for negotiation teams is [6]. They propose four different types of team dynamics for automated agents in a team vs. opponent scenario: a representative approach, a strategy based on similarity heuristics and majority voting, a strategy based on similarity heuristics and Borda count, and a unanimous mediated strategy which relies on an iterative process to build offers that are sent to the opponent. However, there are substantial differences between their work and the work presented in this paper. First, the work proposed in [6] aims to provide models for computational agents that act on behalf of humans in electronic markets. Thus, these agents interact directly with other software agents and human factors such as culture do not affect the negotiation process. Our present model aims to provide computational models that explain human factors in team negotiations. The goal of the work is then different: we aim to provide computational models that can be used to train real negotiators in cross-cultural negotiations; models that can be used to predict/simulate negotiation processes carried out by humans, and even provide negotiation tools that support humans in real negotiations. More specifically, in this paper we a) model power distance and individualism/collectivism cultural factors in decision making, and b) study how cultural factors affect the belief-changing processes among team members and hence affect the intra-team consensus formation in the negotiation.

Haim et al., [15] study the use of well known machine learning techniques to learn different cultures' decision-making in the colored trails game, where individuals engage in resource exchange negotiations with other individuals and computers. The key difference with our present work is that we focus on team dynamics in a negotiation team, where cultural dimensions such as power distance and individualism/collectivism may play a more important role due to the social and cultural implications provided by the team setting.

Perhaps, the most similar work to ours is Geert Jan Hofstede et al. [16], [17], [18], [19], [20]. They propose the modeling of Geert Hofstede's cultural dimensions (i.e., individualism/collectivism, power distance, long term orientation, uncertainty avoidance) in a trading and trust game. Bilateral negotiations are carried out between sellers and buyers to determine the price and quality of a certain commodity. The cultural dimensions are modeled as linear effects on negotiation parameters of the ABMP negotiation model [21]. In order to model the positive/negative effect of the different cultural dimensions on the negotiation parameters, expert knowledge was used. Different simulations were carried out using synthetic cultures to assess how different hypothetical cultures would behave in different scenarios. One of the main differences between Geert Jan Hofstede's work and the current study is the scenario that we aim to model: negotiation teams. In the scenario used by Geert Jan Hofstede, negotiations are carried out between individuals. Thus, the effect proposed for the cultural factors is only constrained to interactions between two individuals. It does not consider the effect of cultural factors such as individualism and power distance within a negotiation team, which may greatly affect the offers and decisions taken by the team. However, the research approach followed is similar to the work of Geert Jan Hofstede. We also base our modeling in expert knowledge, more specifically social sciences' results, to model the effect of individualism/collectivism and power distance in a team negotiation setting.

III. Negotiation Model

A. General Assumptions

- A group of humans has formed a team $A = \{a_1, a_2, ..., a_M\}$ whose goal is to negotiate a successful deal with an opponent party *op*. For the sake of simplicity, and since the focus of our study is on a negotiation team, we model the opponent as an individual.

- The negotiation domain is comprised of n real-valued attributes whose domain is $[0, 1]$.
- The team members and the opponent have their preferences represented by means of linear utility functions:

$$U(X) = w_1\ V_1(x_1) + w_2\ V_2(x_2) + ... + w_n\ V_n(x_n) \quad (1)$$

where X is a n-attributes offer, x_i is the value of the i-th attribute, $V_i(.)$ is a strictly monotonic function that transforms the attribute value to $[0, 1]$, and w_i is the weight or importance that is given by the agent to the i-th attribute. The reasons to use linear utility functions as a mechanism to represent agents' preferences were its uses in different decision domains, the availability of a wide range of elicitation methods, and its extended coverage in computational models [22], [23], [4], [21], [6]. Furthermore, linear utility functions corresponds with points schemes, which are widely used in behavioral experiments. We assume that team members have the same kind of valuation function (either monotonically increasing, or monotonically decreasing), whereas the opponent has exactly the opposite type of monotonic function. Even though the general form of the valuation function is known among team members, the specific weights that each agent assigns to each negotiation attribute is not common and shared knowledge. Thus, initially team members do not know what attributes are more important and how important is an attribute with respect to another attribute for another teammate. By assigning different weights to attributes we can introduce intra-team conflict within a negotiation team, which is a phenomenon not thoroughly studied in social sciences and agent research [24], [6].
- The negotiation process is bounded in time. The opponent has a private deadline T_{op}, whereas the team has a private joint deadline T_A which is common information for team members. Once a deadline has been reached, one of the parties will exit the negotiation process and the negotiation will end with failure.
- The opponent uses a time-based concession strategy $s_{op}(t)$ to act during the negotiation process [1] . This concession strategy depends on a parameter called the concession speed β_{op}. The opponent proposes offers to the team based on the utility value obtained by its concession strategy $s_{op}(t)$ and he/she accepts team's offer X at round t when $U_{op}(X) \geq s_{op}(t+1)$.
- Each team member has a parameter p_i which describes his social status with respect to other teammates, and where $\sum_{i=1}^{M} p_i = 1$. Social status suggests how respected is a person inside a group, and its roots may come from different factors such as the hierarchical role in an organization, education level, work experience, age, economic power, and so forth. Organizational negotiation teams where one or more members may have different social status clearly exist in the real world. For instance, when a negotiation team is formed in a human organization, usually one of the team members is appointed as leader due to several factors such as his position in the organizational hierarchy. Social status is known information by team members.

[1] $s(t) = 1 - (\frac{t}{T})^{\frac{1}{\beta}}$

B. Negotiation Protocol

The protocol followed by the team is divided into two phases: Pre-negotiation, and negotiation phase.

1) Pre-negotiation: In real life team negotiations, meetings are held amongst the members to discuss the negotiation strategy, and to identify preferences and the most important issues for the team. The negotiation strategy defines when concessions are to be made, and how much the team is going to concede at each round. In our case, we have modeled a scenario where negotiation processes are bounded in time. Thus, we decided to model the concession strategy as time-dependent such as the ones proposed in the literature [4]. In this family of concession strategies, the agents/humans have a certain aspiration level depending on the remaining negotiation time and the concession speed. In the pre-negotiation phase, the team of agents decides the private deadline T_A for the negotiation process and the concession speed β_A of their common negotiation strategy $s_A(t)$.

Ideally, at the end of the pre-negotiation phase a negotiation team should have formed an opinion about what the team prefers. Thus, the team members infer some kind of utility function for the team $U_A(.)$ (i.e., how team members perceive the preferences of the team). Nevertheless, we assume that, since humans have bounded cognitive capabilities, what the team members may infer at the end of the pre-negotiation may not reflect the real preferences of the team in an exact way. In this negotiation model, we assume that team members may be able to express correctly a ranking of attributes, but they are not able to express correctly the relative importance between negotiation attributes. Thus, when they discuss during the pre-negotiation, the team members are able to determine which attributes are more important for other teammates, but they are not able to detect the relative importance between those attributes. In a model where agents have their preferences represented by linear utility functions (and so do teams), this assumption would be translated into a mental model for $U_A(.)$ which has inaccurate weights w_i. Therefore, we decided to model the team utility function $U_A(.)$ was modeled as follows:

$$U_A(X) = \frac{\sum_{i=1}^{M} sc(i,1)}{\sum_{i=1}^{M}\sum_{j=1}^{N} sc(i,j)}\ V_1(x_1) + ... + \frac{\sum_{i=1}^{M} sc(i,N)}{\sum_{i=1}^{M}\sum_{j=1}^{N} sc(i,j)}\ V_N(x_N) \quad (2)$$

where $sc(i,j)$ is a score function that represents the importance that team member a_i gives to the attribute j. If j is the most important attribute (i.e., 1^{st} in the ranking) for a_i, then $sc(i,j) = N-1$ and if j is the less important attribute (i.e., N^{th} in the ranking) for a_i, then $sc(i,j) = N-N = 0$. The score function has an equivalent behavior to the score function used by agents in the classic Borda count. We acknowledge that this may not be the exact way in which team/group preferences are formed by humans. However, the main goal of this part of the model was to obtain a utility function representing team preferences approximately.

We argue that $U_A(.)$, the team utility function, influences the individual preferences of each team member according to how important is the team for the individual. More specifically, one of our hypotheses is that in collectivist cultures, team preferences are more important than in individualist cultures. The link between team preferences and culture will be further analyzed in the next subsection.

2) Negotiation: Once the pre-negotiation meetings have been held, the negotiation process with the opponent starts. The negotiation process has been modeled as a bilateral negotiation where each party is allowed to propose an offer/counteroffer to its opponent or accept/reject the offer proposed by the opponent in an alternate fashion. However, due to the fact that one of the parties is a team, we assume that team members are able to enter in a period of discussions between negotiation rounds. It is in this period that the team decides whether the opponent offer is accepted or not, and which counteroffer is going to be sent to the opponent. Therefore, during the discussions, two different decision-making processes are carried out: one process that decides the acceptance of the opponent offer, and a process that decides which counteroffer is sent back. Similar decision-making mechanisms, based on belief changing processes, are employed to model both processes:

- Opponent offer acceptance (OOA): Each team member states whether he/she would accept the opponent offer. The process is repeated until the opinion of team members has not changed with respect to their own opinion in the previous repetition, or until a maximum number of repetitions has been reached, so that the process is bounded in time. The final decision taken is the point of view of the majority of team members. How agents change their beliefs during this phase is described in the next subsection.
- Offer proposal (OP): First, each team member proposes an offer that he/she would send to the opponent as a counteroffer. Each team member states, for each offer proposed by teammates, whether the offer proposed is acceptable to be sent to the opponent. The offer sent to the opponent is the one which has received a higher number of acceptability votes. The considerations and role of culture of a team member when he/she proposes an offer is presented in the next subsection.

1) Start negotiation process with the opponent
2) Offer Proposal (OP)
   a) Each team member proposes to the team an offer to be sent to the opponent
   b) Each team member expresses his/her opinion about the acceptability of each offer proposed. If the opinion does not change with respect to what other team members have expressed, go to 2.c
   c) Send the most supported offer to the opponent
3) Opponent Offer Acceptance (OOA)
   a) Receive response/offer from the opponent. If the offer has been accepted, go to 5.
   b) Each team member expresses his/her opinion about the acceptability of the opponent's offer. If the opinion does not change with respect to what other team members have expressed, go to
   c) Accept the opponent's offer and go to 5 if it is supported by the majority of team members.
4) If deadline was reached, go to 5. Otherwise, go to 2.
5) End negotiation

Figure 1. Brief overview of the negotiation process from the point of view of the team members

Figures 1 and 2 show the negotiation process from the point of view of the team members. Figure 1 shows the overview of the process. Figure 2 shows the negotiation process in detail. The negotiation process, from the point of view of the team members can be observed in Figures 1 and 2. It should be noted that some of the terms that appear in Fig. 2 like AC_{a_i} and AC'_{a_i} refer to the decision making mechanisms employed by each team member, which are described in Section III-C

C. Cultural Dimensions in Team Members' Decision Making

Over the years, Hofstede's theory has grown to be almost a "*de facto standard*" among cross-cultural research practitioners. Nevertheless, some scholars have also criticized Hofstede's work as being simplistic, static, and restricted to a narrow experimental sample of subjects (IBM's workers). In fact, in [25] it is argued that Hofstede's work started as a consulting project for IBM. Therefore, the data came exclusively from IBM workers (narrow domain), and the questionnaires employed were tailored to IBM's needs and interests. Other scholars have criticized Hofstede's work arguing that culture and their associated behaviors are dynamic phenomena which change continuously along social relationships [26], [27]. Another weakness pointed out by some researchers is that cultural dimensions may be too simple to explain every real complex scenario [28], [27]. For instance, in [28], the results suggested that some cultures did not behave as it was expected according to Hofstede's initial study about cultural dimensions. Despite these criticisms, we decided to build our model based on Hofstede's

cultural dimensions. Cultural dimensions represent patterns of behavior that may be found, to a different extent, in every culture. They are independent of the initial categorization given to cultures by Hofstede. Data provided by human experiments can help models, such as the one presented in this paper, to be continuously re-adjusted to cope with the cultural dynamics. We acknowledge that Hofstede's cultural dimensions may not be the only factors that account for cultural behavior in complex scenarios. However, the topic of intercultural agent negotiation teams is novel and a model based on Hofstede's study regarding cultural dimensions can provide an interesting benchmark for more sophisticated theoretic and empirical research in the future.

Next, we describe how individualism/collectivism and power distance are modeled and the interaction with the decision-making processes presented in the previous subsection. Since both cultural dimensions coexist in a culture, our model integrates and considers the influence of both dimensions together on team's decision making in negotiations. The simulation of the negotiation phase from the point of view of the team is depicted in Fig. 2.

1) Individualism/Collectivism: Individualism is expressed as self-reliance, emphasizing economic goals over relational ones, and moderate or little identification of the individual's goals with societal goals. Collectivism, individualism's opposite, is usually found in societies where people are integrated into strong cohesive in-groups [13], [11]. They are expected to look after their in-groups' interests. Thus, we expect that, in a negotiation team, team members that belong to an individualist culture tend to support their own interests, whereas negotiation teams that belong to a collectivist culture try to support the interests of the group as a whole. This is consistent with social sciences literature, where individualism/collectivism has been found to determine whether personal goals are considered more or less important than the goals of the in-group [29], [13], [30]. In fact, individualists have been found to ignore group goals when there is conflict with individual goals, whereas collectivists may ignore personal goals to satisfy group preferences [31]. We model this cultural dimension as a $\delta_{a_i} \in [0,1]$ parameter which indicates the degree of individualism/collectivism in an agent a_i. Values closer to 1 represent highly individualist agents, whereas values closer to 0 represent highly collectivist individuals. For model simplicity, and since there is no evidence to the contrary, we assume that individualism/collectivism has a linear effect on the utility function (i.e., how the agent values different offers). The aforementioned effect was modeled as follows:

$$U'_{a_i}(X) = \delta_{a_i} \times U_{a_i}(X) + (1 - \delta_{a_i}) \times U_A(X) \quad (3)$$

where $U'_{a_i}(X)$ is the utility of the offer X for agent a_i, $U_{a_i}(X)$ is the utility of the offer X according to a_i personal interests, and $U_A(X)$ is the utility of the offer X according to the group's interests, which have been formed during the pre-negotiation phase. Therefore, on the one hand, when an agent from a highly individualist culture values a proposal, he/she will mainly consider his/her own personal interests and very little concern will be paid to team's interests. On the other hand, when the agent comes from a collectivist culture, the major focus of attention will be team's interests and personal interests will affect the valuation of proposals to a lesser extent. A team member a_i proposes offer X at round t whose utility $U'_{a_i}(X)$ is equal to $s_A(t)$.

2) Power Distance: Power distance is usually defined as the extent to which less powerful members of organizations and institutions accept and expect that power is distributed unequally. In a high power distance culture a society's level of inequality is endorsed by the followers as much as by the leaders [11]. A negotiation team is usually formed from a human organization or institution, and, thus, it is expected that power distance comes into play in a team setting. We posit that, in high power distance cultures, team members' social status influences the group decision making process. Opinions and comments of a high status member such as a team leader are likely to be endorsed by less powerful team members, even if they may not be totally aligned with personal or group interests. In fact, this hypothesis seems consistent with some social sciences studies that have found that members from high power distance cultures often do not question statements of empowered members and act as followers [32], [33], high power distance individuals are more receptive to top-down direction from their leaders [34], and high power distance groups are more likely to be influenced by high social status members' point of view and guidelines [35], [36]. In opposition to high power distance societies, teams which have members from low power distance cultures are more likely to be driven by personal opinions than by high social status members' opinions. We modeled power distance as an individual $\gamma_{a_i} \in [0,1]$ parameter which indicates the degree to which power distance influences agent's a_i decisions. In this case, two decisions are taken by the group and they are prone to be influenced by high status members: the acceptance of the opponent offer, and the offer that is sent to the opponent. We assume that both choices are affected by two different forces: the inertia to agree with members with higher social status and the actual utility of the available offers. It is assumed that the first force is more important in high power distance individuals, whereas the second force is likely to take a more important role in low power distance individuals. Thus, and since no evidence to the contrary is available, we assume a linear effect of the power distance on these two forces that influence the decisions of the team member. Next we depict how power distance was modeled in the various decisions of the team members, namely whether to accept the opponent offer (OOA),and what proposal to offer the opponent (OP):

- Opponent offer acceptance (OOA): Agents state whether they consider opponent's offer acceptable or

$t = 0$
while $t \leq T_A$ **do**
{**2) Offer Proposal (OP)**}
$OF_A = \emptyset$
{**2.a) Each team member proposes to the team one offer to be sent to the opponent**}
for $a_i \in A$ **do**
X_i =ProposeOfferWithUtility $(s_A(t))$
$OF_A = OF_A + X_{a_i}$
end for
$it = 0$; $YES = \emptyset$; $NO = \emptyset$
{**2.b) Each team member expresses his/her opinion about the acceptability of each offer proposed** }
while $it \leq IT \wedge YES_{it} \neq YES_{it-1}$ **do**
$it = it + 1$
$YES_{it} = YES_{it-1}$; $NO_{it} = NO_{it-1}$
for $a_i \in A \wedge X_j \in OF_A$ **do**
if $AC'_{a_i}(X_j, X_{a_i}) =$ accept **then**
$YES_{it}(X_j) = YES_{it}(X_j) + a_i$
$NO_{it}(X_j) = NO_{it}(X_j) - a_i$
else
$NO_{it}(X_j) = NO_{it}(X_j) + a_i$
$YES_{it}(X_j) = YES_{it}(X_j) - a_i$
end if
end for
end while
{**2.c) Send the most supported offer to the opponent**}
Send argmax$_{X_j}|YES_{it}(X_j)|$
{**3) Opponent offer acceptance (OOA)**}
{**3.a) Receive response/offer from the opponent**}
X_{op} = Receive Opponent Response/Offer
if opponent accepted the offer **then** break
$it = 0$; $YES = \emptyset$; $NO = \emptyset$
{**3.b) Each team team member expresses his/her opinion about the acceptability of the opponent's offer**}
while $it \leq IT \wedge YES_{it} \neq YES_{it-1}$ **do**
$it = it + 1$
$YES_{it} = YES_{it-1}$; $NO_{it} = NO_{it-1}$
for $a_i \in A$ **do**
if $AC_{a_i}(X_{op}) =$ accept **then**
$YES_{it} = YES_{it} + a_i$; $NO_{it} = NO_{it} - a_i$
else
$NO_{it} = NO_{it} + a_i$; $YES_{it} = YES_{it} - a_i$
end if
end for
end while
{**3.c) Accept the opponent's offer**}
if $|YES_{it}| \geq \frac{A}{2}$ **then**
accept X_{op}
end if
$t = t + 1$
end while

Figure 2. Algorithm that simulates team behavior during the negotiation

not. We considered that team members are influenced by other teammates' opinions. The following equations are used to determine whether agent a_i considers opponent's offer X acceptable or not at round t.

$$AC_{a_i}(X) = \begin{cases} \text{if } ac_{a_i}(X) \geq 0 & \text{then } accept \\ \text{if } ac_{a_i}(X) < 0 & \text{then } reject \end{cases}$$
$$ac_{a_i}(X) = \gamma_{a_i} \times (\max_{a_j \in YES} p_{a_j} - \max_{a_j \in NO} p_{a_j}) + (1 - \gamma_{a_i}) \times (U'_{a_i}(X) - s_A(t+1)) \quad (4)$$

where YES is the set of teammates that consider X as acceptable at round t, NO is the set of teammates that consider X as unacceptable at round t, and $s_A(t+1)$ is the utility of the offer that the team is going to send in the next round. We can observe that $AC_{a_i}(X)$ accepts X when the result of $ac_{a_i}(X)$ is positive and rejects X when $ac_{a_i}(X)$ is negative. The two forces are summed up to determine the value of $ac_{a_i}(X)$. The first term from left to right makes reference to the importance of other teammates' opinion given their social status. Thus, the importance of this term depends on the power distance cultural dimension in the individual p_{a_i}. When the higher social status member has supported X, the term will contribute to accept X, whereas the term contributes offer rejection when the higher social status member has not supported X. The degree of contribution towards any of the two options is determined depending on the difference in social status between both higher social status members in YES and NO respectively. The second term models the importance of the utility reported by the opponent offer $U'_{a_i}(X)$ according to agent's interests (which depends on its individualism level δ_{a_i}). The more important is power distance for the individual, the less importance will be given to this term. However, in low power distance cultures, this second term will have a great importance in the decision-making process. The term contributes to offer acceptance when the utility of the offer is greater than the utility of the offer which is going to be proposed to the team in the next negotiation round. Otherwise, it supports offer rejection.

- Offer proposal (OP): In this case, we consider that an agent a_i considers an offer X_j proposed by other teammate a_j as acceptable if it is more appealing compared to the offer that a_i proposed to the team X_i. The following equations model such phenomenon:

$$AC'_{a_i}(X_j) = \begin{cases} \text{if } ac'_{a_i}(X_j, X_i) \geq 0 & \text{then } accept \\ \text{if } ac'_{a_i}(X_j, X_i) < 0 & \text{then } reject \end{cases}$$
$$ac'_{a_i}(X_j, X_i) = \gamma_{a_i} \times (\max_{a_k \in YES} p_{a_k} - \max_{a_k \in NO} p_{a_k}) + (1 - \gamma_{a_i}) \times (U'_{a_i}(X_j) - U'_{a_i}(X_i)) \quad (5)$$

The general idea of this decision-making process in very similar to the one used to model opponent offer acceptance. The first term from left to right refers to

the importance of the power difference between a_j and oneself, and, thus it is weighted by the power distance level γ_{a_i}. The second term takes into account the difference in utility terms between X_j and X_i.

IV. Experiments and Results

We tested our model in extensive simulations to study the effects of these cultural dimensions. Next, we detail how these experiments were designed and we show their results.

A. Experimental Setting

- 60 different linear utility functions were randomly generated to represent possible preferences of potential team members for n=4 negotiation attributes. Each linear utility function assigns different sets of weights to the negotiation attributes. However, all of them share the same type of monotonicity (increasing for team members). Team size was set to M=$\{3,4,5\}$ members. Therefore, $\binom{60}{3}$ teams of 3 members, $\binom{60}{4}$ teams of 4 members, and $\binom{60}{5}$ teams of 5 members were generated. 60 linear utility functions were generated to represent the preferences of opponents. These utility functions were generated by taking potential team members' utility functions and using a reverse type of valuation function (monotonically decreasing). Therefore, if the most preferred value by team members for attribute i is 1, then the most preferred value by the opponent will be 0 (e.g., buyer-seller setting).
- In order to determine intra-team conflict, we compares team members' utility functions. Intra-team conflict was classified according to the method introduced in [6], which is based on the difference in utility between proposals. A dissimilarity measure based on the utility difference between offers is used. The dissimilarity between two teammates can be measured as follows:

$$D(U_{a_i}(.), U_{a_j}(.)) = \sum_{\forall X \in [0,1]^n} |U_{a_i}(X) - U_{a_j}(X)| \quad (6)$$

The number of sampled offers was limited to 1000 per dissimilarity measure. Since a team is composed by more than two members, it is necessary to provide a team dissimilarity measure. The team dissimilarity measure is defined as the average of the dissimilarity between all of the possible pairs of teammates. For all of the teams, we measured their dissimilarity and calculated the dissimilarity mean $\bar{dt}$ and standard deviation σ. This information is used to divide the spectrum of negotiation teams according to their diversity. We decided to consider those teams whose dissimilarity was greater than, or equal to $\bar{dt} + 1.5\sigma$ as very dissimilar, and those teams whose dissimilarity was lower than, or equal to $\bar{dt} - 1.5\sigma$ as very similar. For each team size, 100 random teams were selected to represent the very similar team case, and 100 random teams were selected to represent the very dissimilar team case. These teams participate in the different scenarios, where they are confronted with one random half of all of the possible individual opponents. Therefore, each negotiation scenario consisted in $100 \times 30 \times 4 = 12000$ different negotiations (negotiations are repeated 4 times).
- Similar negotiation strategies and conditions were generated for both team and opponent. T_{op}, T_A are selected randomly from a uniform distribution U[30,60]. Time-based concession strategies were randomly generated for both team and opponent. In this case, β_{op}, β_A are randomly set from a uniform distribution U[0.4,0.99]. Thus, both of them employ boulware strategies, which concede very slowly during the first negotiation rounds and start to concede faster as the deadline gets closer.
- Power distribution in a team is randomly generated.
- Different synthetic cultures were generated. Like previous work ([16], [17], [18], [19]), the first step to validate a computational model is to run simulations that use synthetic data for each culture. If simulations show realistic conclusions supported by other studies, the model may be a good basis for human experimentation to further validation. Synthetic cultural configurations try to mimic real societies: $\{\delta_{a_i} = U[0.1, 0.2], \gamma_{a_i} = U[0.8, 0.9]\}$, which according to our model corresponds to high collectivism and high power distance societies (*HCHP*), $\{\delta_{a_i} = U[0.8, 0.9], \gamma_{a_i} = U[0.1, 0.2]\}$, which corresponds to high individualism and low power distance societies (*HILP*), $\{\delta_{a_i} = U[0.4, 0.6], \gamma_{a_i} = U[0.4, 0.6]\}$, which corresponds to mild individualism and power distance societies (*MIP*), and $\{\delta_{a_i} = U[0.8, 0.9], \gamma_{a_i} = U[0.8, 0.9]\}$ which correspond to high individualism and high power distance (*HIHP*).

B. Results

We gathered several quality measures relevant to team performance in terms of the final agreement. However, due to space limitations, we only show the minimum utility of individual team members, the average team utility, the maximum utility of individual team members, the joint team utility (i.e., product of the utility of the team members), and the joint utility (considering team members and the opponent) of the final outcome (agreement). The results for our experiments can be observed in Table I (95% confidence intervals) and Fig. 3. We see that for all cultural configurations, the average team utility is higher for low team than for high team conflict (Fig. 3). In the high intra-team conflict scenario, our model suggests that there are clear statistical differences between high collectivism, high power distance (HCHP) and high individualism, low power distance (HILP) societies. These differences are bigger when comparing the minimum utility of individual team members, the maximum utility of individual team members, and the team joint utility. There is still a slight statistical difference

Number of team members $M = 3$										
	High Intra-team conflict					Low Intra-team conflict				
Culture	Min.	Ave.	Max.	TJoint.	Joint.	Min.	Ave.	Max.	TJoint.	Joint.
HCHP	[0.282-0.289]	[0.590-0.595]	[0.857-0.862]	[0.174-0.180]	[0.104-0.108]	[0.546-0.551]	[0.629-0.634]	[0.710-0.716]	[0.285-0.291]	[0.187-0.192]
MIP	[0.260-0.267]	[0.574-0.579]	[0.834-0.839]	[0.158-0.163]	[0.096-0.099]	[0.551-0.557]	[0.635-0.640]	[0.715-0.720]	[0.289-0.296]	[0.189-0.194]
HILP	[0.210-0.217]	[0.545-0.550]	[0.807-0.812]	[0.124-0.130]	[0.079-0.082]	[0.560-0.566]	[0.641-0.647]	[0.718-0.723]	[0.296-0.303]	[0.194-0.199]
HIHP	[0.184-0.191]	[0.498-0.503]	[0.786-0.791]	[0.097-0.101]	[0.062-0.065]	[0.542-0.547]	[0.625-0.630]	[0.706-0.711]	[0.280-0.286]	[0.186-0.191]

Number of team members $M = 4$										
	High Intra-team conflict					Low Intra-team conflict				
Culture	Min.	Ave.	Max.	TJoint.	Joint.	Min.	Ave.	Max.	TJoint.	Joint.
HCHP	[0.269-0.276]	[0.609-0.614]	[0.892-0.896]	[0.128-0.133]	[0.078-0.087]	[0.502-0.508]	[0.632-0.638]	[0.751-0.756]	[0.198-0.204]	[0.128-0.133]
MIP	[0.267-0.274]	[0.601-0.606]	[0.874-0.879]	[0.123-0.128]	[0.075-0.078]	[0.498-0.503]	[0.628-0.633]	[0.746-0.751]	[0.193-0.199]	[0.125-0.130]
HILP	[0.244-0.251]	[0.593-0.597]	[0.863-0.868]	[0.109-0.114]	[0.068-0.072]	[0.508-0.514]	[0.637-0.642]	[0.747-0.752]	[0.199-0.205]	[0.127-0.131]
HIHP	[0.184-0.190]	[0.522-0.528]	[0.841-0.846]	[0.073-0.078]	[0.047-0.050]	[0.469-0.475]	[0.606-0.611]	[0.731-0.736]	[0.173-0.179]	[0.114-0.118]

Number of team members $M = 5$										
	High Intra-team conflict					Low Intra-team conflict				
Culture	Min.	Ave.	Max.	TJoint.	Joint.	Min.	Ave.	Max.	TJoint.	Joint.
HCHP	[0.243-0.249]	[0.605-0.610]	[0.904-0.909]	[0.080-0.084]	[0.046-0.049]	[0.448-0.454]	[0.609-0.614]	[0.758-0.763]	[0.116-0.120]	[0.073-0.076]
MIP	[0.227-0.233]	[0.585-0.590]	[0.892-0.897]	[0.068-0.071]	[0.040-0.042]	[0.448-0.454]	[0.606-0.611]	[0.752-0.757]	[0.115-0.119]	[0.071-0.074]
HILP	[0.207-0.213]	[0.587-0.592]	[0.882-0.887]	[0.061-0.065]	[0.037-0.039]	[0.465-0.471]	[0.616-0.621]	[0.756-0.761]	[0.123-0.127]	[0.123-0.127]
HIHP	[0.144-0.149]	[0.494-0.500]	[0.862-0.867]	[0.034-0.037]	[0.021-0.023]	[0.422-0.428]	[0.587-0.592]	[0.740-0.745]	[0.102-0.106]	[0.065-0.067]

Table I

RESULTS FOR THE DIFFERENT SCENARIOS. EACH TABLE SHOWS CONFIDENCE INTERVALS (95% CONFIDENCE) FOR THE MINIMUM UTILITY OF INDIVIDUAL TEAM MEMBERS (MIN.), THE AVERAGE TEAM UTILITY (AVE.), THE MAXIMUM UTILITY OF INDIVIDUAL TEAM MEMBERS (MAX.), THE JOINT UTILITY IN THE TEAM (TJOINT.), AND THE JOINT UTILITY OF THE TEAM AND THE OPPONENT (JOINT.).

between both simulated societies in the case of the average utility and the joint utility. This pattern can be observed for all of the team sizes explored. Our model only showed a slight significant difference between mild individualism and power distance (MIP) and HCHP. In fact, confidence intervals are very close for all of the quality measures. HIHP obtained statistically worse results than the rest of configurations. According to the results, our model suggests that negotiation teams from a HCHP culture may perform better than negotiation teams from HILP societies in a high intra-team conflict situation. The reason for this higher performance in HCHP may be explained due to the fact that decisions are mostly influenced by members from higher social status (since it is a high power distance culture), who, in turn, seek to satisfy the desires of the team (including less powerful members). This kind of behavior resembles what has been termed in literature as *paternalistic leadership*, which guides subordinates to attain group's goals in HCHP societies [37], [38], [39], [40]. Another related explanation is that collectivist values lead to cooperative goals that result in open, effective conflict discussion (integrated decision), whereas individualist values reduce cooperative goals and, thus, undermine open, constructive discussion in cases of conflicts [41]. Other studies have also shown that individualism tends to hinder teamwork [30], [42], which may be more accentuated in a team setting where team members may have opposing preferences or viewpoints such as the scenario that we proposed for our study. We believe that the differences shown in the experiments between culture can be further increased if more intra-team conflict is introduced changing the shape of utility functions (e.g., team members that have opposing valuation functions). In the low intra-team conflict scenario, it can be observed that HCHP, MIP, and HILP perform similarly (HILP obtaining slightly better results). The three different cultural configurations are able to obtain similar results since team members' personal goals are aligned with those of their teammates. Thus, team members' goals are aligned even if they come from individualist cultures. However, HIHP obtains statistically worse results than other societies due to the high power distance level, which leads to situations where team decisions are governed by higher status members' individual preferences. It should be pointed out that HILP obtains slightly better results in the low intra-team conflict scenario than HCHP. This may be explained by the fact that decisions in HILP are not influenced/motivated by power distance but utility. When the preferences of the team members are not aligned (i.e., high intra-team conflict), HILP leads to each member proposing offers that may only satisfy one's own preferences. By contrast, the decisions of HCHP are mainly determined by the highest status member, who tries to satisfy the preferences of the team as a whole. That may explain why HCHP gets statistically better results than HILP in the high intra-team scenario. However, when the preferences of the team members are aligned (i.e., low intra-team conflict), HILP team members propose offers that are likely to satisfy many teammates (offers are probably close in the negotiation space). The low power distance component leads to offers being mainly compared in utility terms. Thus, from all of the offers, the one that has a better utility for all of the team members is the one that is most supported by team members' votes. On the other hand, the high power distance component in HCHP teams leads to the fact that usually the offer that is most supported is the one proposed by the highest status

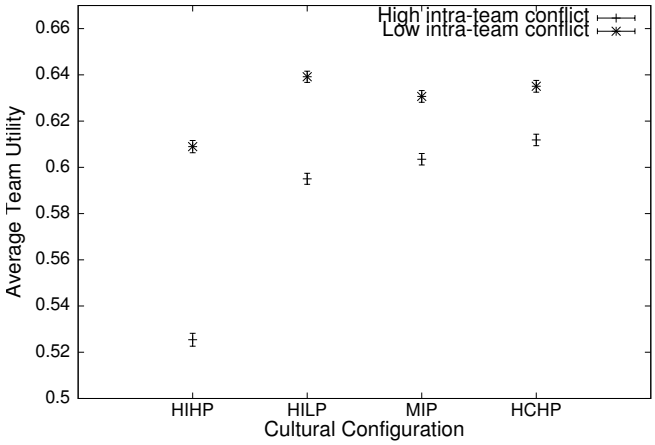

Figure 3. Average Team Utility for both conflict scenarios (M=4 team members). Graphic shows 95% confidence intervals

member. The utility of this offer is usually good since HCHP have high collectivism, but just the offer proposed by the highest status member is considered, even though there may be better options proposed by other teammates. Since in HILP teams all of the offers are really considered (i.e., more probabilities than a better offer is proposed), it may explain that HILP gets slightly better results than HCHP in low conflict scenarios. This particular result surprised us and we did not find any specific work studying this phenomenon. Therefore, it may be worth being tested with human subjects.

V. Conclusions & Future Work

In this work, we have presented the first attempt to provide a cultural computational model for negotiation teams. Our modeling focus is team dynamics before and during the negotiation process. Based on Hofstede's work, we introduced two cultural dimensions: individualism/collectivism, and power distance. Due to the lack of research in negotiation teams, we modeled cultural dimensions based on expert knowledge of social science studies in other decision making contexts. Simulations have been carried out in negotiation scenarios with different degrees of intra-team conflict between team members. Results suggest that teams from collectivist and high power distance cultures may perform better than teams from individualist and low power distance cultures due to the paternalistic leadership and the importance of group's goals in collectivist cultures. This result seems to be supported by several social sciences' findings, which validates our modeling for future extensions. We also found that individualist cultures may be able to outperform collectivist cultures in a low conflict scenario due to a joint exploration of the negotiation space by all of the team members. As far as we are concerned, this result has not been documented by social sciences and we think that it may be worthy of further study. As stated, we plan to include more cultural dimensions into our modeling (i.e., masculinity, uncertainty avoidance, long-term orientation). Additionally, we want to explore validation of the partial simulation results of this present paper by means of human experiments carried out in different cultures. A negotiation case has been designed where two different negotiation teams negotiate through a computer interface in order to reach an agreement. Conflict has been introduced in the utility functions (rewards point schemes) both between team members and between teams. Experiments will allow us to: (a) analyze the relationship between culture and negotiation outcome; (b) validate the effect of power distance and individualism/collectivism in negotiation team's dynamics; (c) observe which decision-making mechanisms are preferred by human teams of different cultures.

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