Modeling Culturally-Influenced Decisions

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Abstract. This article proposes a model of culturally influenced decision processes. In particular, cultures influence individual motivation, jointly with human nature and personality. The use of this model is then illustrated by a simulation model of the impact of cultural differences on organizational performance (efficiency, flexibility and member satisfaction) in two organizational structures (bureaucracies and adhocracies). This model is validated against empirical evidence from social sciences.

Keywords: Social simulation · Simulation techniques · Tools and environments · Artificial societies

1 Introduction

"Leaders dictate, subordinates obey". Well, not the same everywhere. The acceptance of such a statement, which describes a collectively accepted social pattern, is shown to be highly correlated with culture. More generally, strong correlations between cultures and social patterns have been discovered. But, obviously, cultures do not directly influence societies. They influence individuals, whose collective action influences societies.

Sometimes, explaining how social phenomenon arise from the influence of culture on individuals is straightforward. For instance, the first sentence is easily explained by the individual sensitivity towards statuses, which is known to be culturally driven. Some other times, explaining correlations is far more complicated (e.g. determining the influence of culture on trading). Simple explanations may not be sufficient to cope with this complexity. So, more complex models such as agent based models (ABMs) are developed: by describing how cultures influence individuals, social patterns emerging from such a model can provide insights leading to new explanations.

Trivially, cultures influence individual practices (e.g. greeting in bowing or shaking hands). But, in cultures also influence inner motives, driving individual and collective action much more subtly while remaining quite strong. This article aims at producing the simplest possible agent decision model where individual motives are culturally-influenced, while not being only dependent on culture. Because culture is a very complex concept, we only use its core aspect, which can be seen as determining the preferences over a set of (fixed) values which influence motives.

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This model is then illustrated on a simple concrete case. This case reproduces social science observations, that individuals in cultures promoting openness to change are more satisfied in adhocracies, while those promoting conservatism are more satisfied in bureaucracies. This illustration, while not providing an explanation for a rather unknown social phenomena shows instead a concrete application of our model of culturally influenced motives in a well documented situation. Consequently, this illustration supports that our model allows to obtain results that are coherent with social science findings.

In Sect. 2, we present our culturally influenced motivation model jointly with their theoretical foundations. Then, our culturally influenced motivation model is applied to build a model of agents performing in organizations in Sect. 3 and finally the comparison between the output of this model and social science findings is described in Sect. 4.

2 Modeling Culturally-Influenced Motivated Decisions

2.1 Theoretical Foundations

Culture and Motives. Reference [7] suggests that motives are influenced by three sources: human nature (e.g. survival needs), shared by all humans; culture, shared within communities; personality which are unique. The distinction between these three sources is also related to Maslow's hierarchy of needs [7]: lowest levels are highly correlated with human nature while the order of highest levels is influenced by cultures and personalities.

As an important notice, motives, inspired by [2] are abstract drives or desires. All individuals have the motive to eat and the importance given to this motive can be culturally dependent. Then, these motives are turned in concrete goals or intentions: for instance, individuals can intend to have lunch. These intentions can be made concrete through plans (which can also be culturally dependent, like eating with sticks or forks and knives). In this article, we focus only on the abstract influence of culture on motives, leaving more concrete action for future work. To that extent, in our model, plans leading to concrete action are "predefined", but can of course be generated dynamically or make evolving.

Conceptualizing Cultures. Culture has been defined numerous times without reaching a consensus. Nonetheless, there is a general agreement that cultures are pieces of knowledge shared within communities. Reference [7] defines culture as the importance given to *values* (what is important for individuals, e.g. "being good" or "being rational") and *practices* (how to behave, e.g. shaking hands or bowing for greeting) shared within communities. Schwartz [9] proposes a set of values that is supposed to be fixed for all people: Self-Transcendence (Universalism, Benevolence), Conservation (Conformity, Tradition, Security), Self-Improvement (Achievement, Power) and Openness to Change (Stimulation, Self-direction). Values drives individuals towards reaching some type of situation. To that extent, values influence inner individual motives, while not influencing concrete plans pursued by agents.

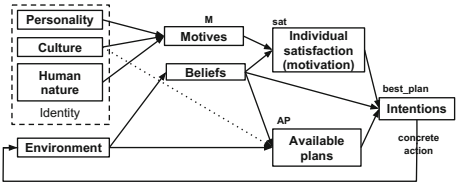

Fig. 1. Conceptual representation of the decision model

Cultural Dimensions. In spite of consensus on a formal definition, some research [6,7] empirically discovered the existence of cultural preferences, referred to as cultural dimensions, that can be measured via a cultural dimension score. As an example of such a dimension, Uncertainty Avoidance (UAI) measures the cultural sensitivity with regard to uncertainty. Cultures promoting high UAI tend to prefer regulated and stable environments while those promoting low UAI are likely to prefer trying out new solutions in less constrained environments. Note that these dimensions are related to national cultures: they do not necessarily reflect individual preferences, but rather indicate individual tendencies. Cultural dimensions can be related to values by indicating that they lead to preferences for certain types of values from the Schwartz values classification. Thus, UAI can be conceptually correlated with a preference for conservation (conformity, tradition) or openness to change (stimulation, self-direction).

Former ABMs. Reference [12] uses cultural dimensions to model inter-cultural trade. This model expands a former trade model in using culture to instantiate numerical parameters (e.g. an UAI variable influencing the tendency to double-check received products when dealing with unknowns). On a similar track, [3] investigates modeling the influence of culture on norm emergence, trying to provide explanations about why the European smoking ban is accepted in some countries but not all. Finally, [4] describes how cultural values influence the plan selection process in considering them constraints imposed to agents. Although some of this work already considers culture in terms of preferences over values, none of this work combines the influence of culture with that of other motivational sources directly, which is the aim of the present paper.

2.2 Model

In this model, we aim at enriching the representation of the influence of culture on decisions by going beyond using cultural dimensions to influence surface behavior. We want cultures to influence decisions from a deeper motivational aspect, by representing them as preferences towards values. In addition, we want that other aspects of individuals (namely, human nature and personality), play a role in motivation. A global depiction of this model is represented in Fig. 1.

Identity and Motives. As said before, we assume three sources of influence over motives, referred as identity: human nature, (cultural) values and individual preferences (personality). In the case study presented in this article, motives

represented by: m_s survival drive, only influenced by human nature; m_{otc} openness to change and m_c conservatism, both only influenced by culture. The set of motives is $M = \{m_s, m_{otc}, m_c\}$. For simplicity, each motive is influenced by only one part of the identity and the influence of personality over motives is discarded in this article.

Motive Satisfaction. Agent beliefs evaluate each motive satisfaction, modeled by the function $sat_a : M \rightarrow MS$ for each agent a from the set of agents A, where MS is a set of motive satisfaction. If MS is ordered, the lower $sat_a(m)$, the least m is satisfied. In the case study, MS is $[0, 1]$. *sat* allows modeling needs possibly independently satisfiable: agents can feel safe and bored at the same time.

Importance. Depending on their identity, agents can give more or less importance to different motives. This importance is represented by $imp_a : M \rightarrow I$, where I is the set of importance. Unlike *sat* which changes depending on agent beliefs, *imp* is expected to remain constant. In the illustration I is $[0, 1]$. In addition, *imp* is normalized: $\forall a \in A, \sum_{m \in M} imp_a(m) = 1$.

If I is partially ordered, the higher $imp_a(m)$, the more $m \in M$ is important for a. With such a representation, it becomes easy to model Maslow properties such as survival drives are more important than values. In addition, in this model, *cultures* are represented by changing the relative importance between values.

Desires. The inclination of an agent to act because of some motive is influenced both by the satisfaction and the importance of this motive. Desires are represented by $des_a : MS \times I \rightarrow D$, where D is the set of desires. If MS, I and D are ordered, des_a should be monotonically decreasing with regard to its first argument and increasing with regard to its second. In the illustration, I is $[0, 1]$. $des_a(ms, i) = (1 - ms) \times i$. An agent desire towards some motive is represented by $des_a : M \rightarrow D$ such that $des_a(m) = des_a(sat_a(m), imp_a(m))$.

This models capture the property that important or unsatisfied motives become more desirable for agents. Consequently, less important motives can become desirable if unsatisfied and more important motives are satisfied. In addition, lower level needs from the Maslow pyramid can be made are more easily desired than others. Idem for culturally important values.

Global Satisfaction. The global satisfaction of agents is determined by each motive satisfaction and importance. Formally, agent satisfaction is represented by: $Sat_a \in GS$, where GS represent the set of global satisfactions. If MS, I and GS are ordered, Sat_a should monotonically increase with regard to sat_a and des_a. In the illustration, $Sat_a = \sum_{m \in M} sat_a(m_s) \times imp_a(m_s)$. Since *imp* is normalized, this representation captures the property that more important motives have more impact on global satisfaction.

Plan Satisfaction. In order to select which action to perform, agents have to be capable of estimating how plans satisfy their motives. This estimation is represented by $sat_a : P \times M \rightarrow MS$, where P is the set of plans. sat_a can be expanded by $sat_a : P \rightarrow GS$ by determining global agent satisfaction from each motive estimated satisfaction. sat_a is just an estimation. Complex aspects, such as uncertainty are also part of the estimated satisfaction of a plan, represented by GS.

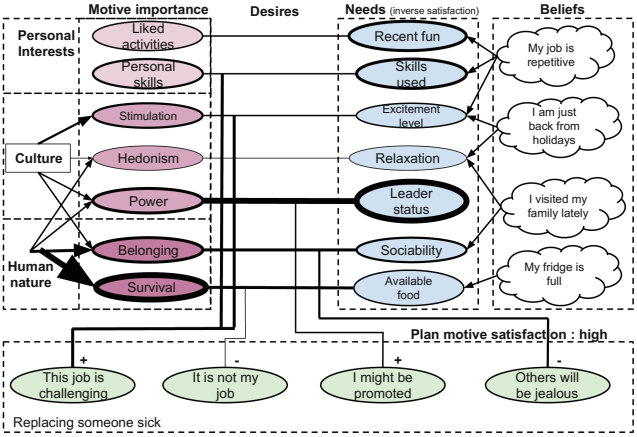

Fig. 2. Illustration of the evaluation of situations and plans (using line thickness). Human nature, culture and personality influence motive importance, beliefs influence motive satisfaction; importance and satisfaction influence desires; beliefs and desires influence estimation of plan satisfaction, influencing plan selection.

Plan selection. Finally, agents select the most satisfactory plan. Given the set of available plans AP, the selection is represented by $best\_plan_a \in AP$. If GS is partially ordered, then $best\_plan_a$ should belong to $(argmax_{p \in AP} sat_a(p))$. In the illustration, $best\_plan_a = argmax_{p \in AP} \sum_{m \in M} sat_p(m) \times des_a(m)$. This model represents the traditional utility function maximization. Note that $best\_plan_a$ is indirectly influenced by agent preferences and thus by culture.

Overview of Agent Decision Dynamics (Fig. 2)**.** Agents desires result from the combination of beliefs (obtained through perception) and their motives. Then, desires are combined with available plans (resulting from beliefs) to determine how satisfactory a plan can be. The output of this combination depends on the organization as well as on agent beliefs. Then, the most satisfactory plan is selected for the next agent action.

2.3 Modeling the Influence of Culture on Decisions

Cultural Importance. Our model integrates the influence of human nature, cultures and personalities on motivation via the imp function. Changing culture is done by modifying imp. While the signature of imp permit a wide range of functions, imp implementation is kept simple in the use case.

Human nature influence is represented by $hn \in [0, 1]$, culture by $c \in [0, 1]$ and personality by $p \in [0, 1]$ such that $hn + c + p = 1$. For our simulations p is set to 0 to prevent personalities to blur results, hn is set to 0.6 and c to 0.4. Human nature influences on the importance given to survival drives: $imp(m_s) = hn$ and cultures on values: $imp(m_{otc}) + imp(m_c) = c$.

Conform to cultural theories [7], our representation of cultures influence the relative importance given to values. In the use case, since *imp* is normalized, the relative preference towards conformity can be represented via $\alpha \in [0, 1]$. $imp(m_{otc}) = \alpha \times c$ and $imp(m_c) = \alpha \times (1 - c)$. So, if $\alpha = 0$, extreme cultural importance is given to openness to change. When α increases, cultural importance is increasingly given to conservation at the expense of openness to change. Note that this representation captures the property that cultures and human nature are differentiated (α does not influences hn).

Additional values can be used: in previous version we integrated self-enhancement (achievement, power) and self-transcendence (universalism, benevolence) Schwartz values. They are removed from the current model in order to keep experimentations simple and concise. If $V \subseteq M$ is the set of values, their importance should respect this property: $\sum_{v \in V} imp(v) = c$

Designing Cultural Importance. A few important properties have to be considered when designing *imp*. First, in order to match Maslow hierarchy of needs, human nature, which emphasize the importance of human drives, should be given more importance than cultural values or personal aspirations. Nonetheless, the model still captures scenario where culture can be more influential than nature (e.g. agents capable of self-sacrifice).

Another important design aspect is the differentiation between the three sources of motivation: human nature should be the same for everyone, while culture is shared within communities and personalities are unique.

Changing culture just by altering the single α parameter can appear to be overly simple. Actually, this very particular implementation is on purpose designed to be simple. It serves as demonstration that easy and simple representations can be sufficient to obtain coherent results when using our model. Of course, more values can be integrated. Plus, a lot of freedom is given on designing evaluators, such as sat_p, *des* (which relies on *imp*). For interested readers, an illustration of the design of complex decision processes influenced by preferences over values can be found in [10].

3 Case Study: Culture and Organizational Performance

This section serves as an illustration the motivational model described in Sect. 2. This illustration investigates the influence of cultures of individual satisfaction and on collective performance in various types of organizations. In particular, two cultures are studied: conservatism and open to change as well as two organizational patterns: bureaucracies and adhocracies.

This model purposefully investigates a research question which has a clear answer from social sciences. Namely, conservative cultures and bureaucracies combine well, as well as open to change cultures and adhocracies. Nonetheless, there is, up to our knowledge, no simulation model which emerges this collective behavior from individual cultures. The main aim of this model is *not* to provide an answer to a controversial social science question. Instead, we want to show that our motivation model can be used on a concrete case, by being capable of

observing expected collective properties from an expected cultural influence on individual behavior.

In addition, this illustration simplifies on purpose numerous aspects of the theory. While modeling in detail interactions occurring within organizations can be of great interest for providing explanations, going too far into detail would increase the model complexity while not better illustrating the motivation model. This simplification also avoids the risk for modelers to integrate culturally-driven bias into implementation details[1]. Second, culture seems to impact less on lowest-levels details, which are generally more environmentally constrained. In addition, abstracting away from lowest level details prevents results to be specific for a peculiar environmental or organizational detail. Finally, simplification avoids integrating very technical aspects which impact on organizational performance and sensitivity to culture are not yet extensively studied by former research. Instead, more importance can be given on clearly influencing aspects.

3.1 Previous Work

Organizations. Organizations have received a large amount of attention from social sciences. Reference [8] proposes a description of 5 typical organizational patterns (simple structure, machine bureaucracy, professional bureaucracy, divisionalized form and adhocracy). Each of these organizational pattern is fits for some type of environment (simple/complex, static/dynamic).

This article makes use of machine bureaucracies and adhocracies. While trying to define them is far out of the scope of this article, some key aspects are to be highlighted. Machine bureaucracies cooperation is promoted by standardization: behavior is restricted by procedures, which leads to repetition of action, allowing to improve individual efficiency and reducing necessary communication. In addition, a strong hierarchy is generally in place in order to centralize information and decision at various level of importance (e.g. team level, factory level, nation level). Adhocracies relies on informal structures. Individuals gather in working groups depending on tasks to be solved. Due to the volatile nature of these groups, rules of behavior tend to be rare and formal structure (such as leadership) have little benefits.

Reference [1] simulates of two organizational patterns (simple structure and adhocracy) in various environments. Each structure is in turn better than the other depending on the environmental conditions. Our illustration expands this idea in also integrating some cultural influence on individual behavior and thus on collective performance.

Culture and Organizations. Reference [7] links cultural dimensions and Mintzberg's archetypal organizations. The acceptance of some organizational patterns (and thus its coordination mechanism) depends on cultural preferences. For instance, bureaucracies, enforcing standardization are preferred in cultures which are sensitive to uncertainty. These preferences are summarized in Fig. 3. Our illustration model aims at providing explanations about how correlations

[1] Actually, the design of this model lead us to some culturally-motivated debates.

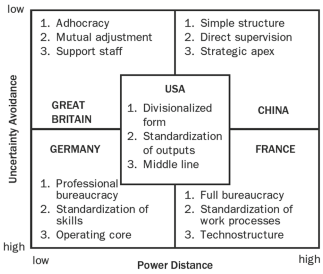

Fig. 3. Cultural dimension and preferred organizational form (conceptual)

between cultures and organizations emerge from the individual-based cultural influence, in the case of adhocracies and machine bureaucracies. Conceptually, conservatism is linked to high UAI and high PDI[2], while openness to change is linked to low UAI and low PDI. To that extent, adhocracies are expected to be preferred in open-to-change cultures while bureaucracies to be preferred in conservative cultures. On a similar track, [11] conceptualize the influence of culture on numerous organizational aspects such as coordination structure, communication processes, failure handling. This work was used to check whether aspects of the illustration model where coherent with theories.

3.2 Simulation Model

In order to ground investigated organizations and to give some meaning to numerical values, the model represents the functioning of an IT department. The department provides three kind of services: maintenance (e.g. keeping email servers running), user support (e.g. helpdesk) and software development (e.g. providing code for other organizations). This organization receives requests from users for each of those services. Each request is treated as an independent task, represented by the *task set* T. Tasks are solved by the intervention of a single agent for some amount of time. This amount of time is lowered if agents have the right expertise (represented by the *expertise set* E). Tasks have a deadline, hidden to agents, after which they are failed if not handled. Successfully resolving tasks influences organization success $OS \in [0, 1]$. Maintenance tasks are critical, making them more influential on organizational success than others.

Organizations can be either bureaucracies or adhocracies. In case of bureaucracies, a special entity, the leader, order subordinates to do some specific task (referred as t_l). Subordinates can still reject t_l for another task.

Agents either select tasks or work on them. This task selection is made using our motivation mechanism, depending on agent's environment (e.g. OS, t_l) and beliefs (domain of expertise).

Environment. The environment represents the set of requests made by users to the IT organization, treated as the set of tasks T and the organizational success, represented by OS.

[2] PDI refers to "power distance", the importance given by individuals to statuses.

Task Origin: Tasks originate from one of the three proposed services. Origins are represented by the set $O = \{o_m, o_s, o_d\}$, where o_m stands for maintenance tasks origin, o_s for support tasks and o_d for software development tasks. Task origins, represented by $origin : T \rightarrow O$, are randomly drawn from O.

The main distinction between task origins is that maintenance tasks have more impact on OS than others. The distinction between o_s and o_d is important for an extended version of the current model which includes Self-Transcendence and Self-Enhancement values (promoting cooperation and competition). For simplicity and space, these distinctions are removed from the current model.

Expertise: Tasks require some expertise in order to be resolved more efficiently. This expertise is represented by $exp : T \rightarrow E$, where E is the set of expertises. Task expertises are randomly drawn.

Task Deadline: Tasks can be failed if not being processed quickly enough. Deadlines, which are not visible by agents, is failed is represented by $dl : T \rightarrow \mathbb{N}$. In our simulations, deadlines occur 20 rounds after tasks are issued. This parameter is high enough for expert workers to easily resolve tasks but low enough for making not experts agents or maladapted resolutions to risk failures.

Task resolution: Tasks can be resolved in various ways: quickly r_q, procedurally r_p or creatively r_c. The set of task resolutions is $R = \{r_q, r_p, r_c\}$. This model simplifies reality: in practice not any resolution is allowed every time, but we assume that agents have always the choice.

Time to completion: Tasks require some time for being completed, which depends on several parameters: the task, resolver's expertise and the selected resolution. This time is represented by $ttc : T \times R \times E \rightarrow \mathbb{R}$ such that: $ttc(t, r, e) = btd(t) \times emf(t, e) \times rf(p, e)$ where $bdt : T \rightarrow \mathbb{R}$ represents the base task duration, $emf : T \times E \rightarrow \mathbb{R}$ represents the expertise match factor and $rf : T \times R \times E \rightarrow \mathbb{R}$ represents the influence of the type of resolution on the task resolution.

$\forall t \in T, bdt(t) = 3$, so tasks have the same base duration, which is set in relation with the task deadline. $emf(w, t) = 1$ if $exp(t) = e$, otherwise $emf(w, t) = 2$. This function represents the gain from performing a task the agent is expert at. rf represents the impact of the task resolution on the time required for solving tasks with the following formula: $rf(t, r, e) = 1$ iff $(r = r_q) \vee (r = r_p \wedge exp(t) = e$, otherwise $rf(t, r, e) = 3$ if $r = R_p \wedge exp(t) \neq e$ and $rf(t, r_c, e) = 1.5$. Quick resolution are more efficient. Procedural resolution can be as fast as a quick resolution if the agent is an expert, otherwise much less efficient. Finally, creative resolutions are slightly less efficient than quick resolutions but more efficient than an inexpert procedural resolutions.

Organizational success: represented by $OS \in [0, 1]$. Maintenance task are the main mission of the IT service and are thus more important for organizational success than others. When maintenance tasks are failed, OS is set to $OS \times 0.95$ and to $OS \times 0.99$ for other task origins. When a maintenance task is successfully performed OS is set to $OS + (1 - OS) \times 0.02$ and to $OS + (1 - OS) \times 0.01$ otherwise. The main property of this representation is that OS increases when workers perform well decrease otherwise, with a discounted memory over time.

Available Tasks: AT is the set of available tasks, which are issued but not yet done, failed or being processed.

Agents. Agents perform tasks received by the organization. The set of agents is A. In our experiments, $|A|$ is set to 15, creating a multi-worker setting while keeping reasonable computational complexity[3].

Expertise: Agents have expertise domains, represented by $exp : A \rightarrow E$. Agents are more efficient when solving tasks within their field of expertise. In our simulations, exp is uniformly drawn from E. This representation is a simplification of reality (e.g. expertises can be related), it captures capture the benefits of expertise on worker performance. Moreover, $|E|$ also models the fitness between agents and their environment: since task expertise are also uniformly drawn, the probability for a task-worker matching expertise between is $|E|^{-1}$.

Current task: The task on which an agent a is currently working is represented by $t_a \in T \cup \perp$. $\perp$ represents "no task" if no task is available.

Leader orders: Bureaucracies comprise leaders that propose tasks to subordinates. Proposed tasks are represented by $t_l : A \rightarrow \{T \cup \perp\}$. $t_l(a)$ is uniformly drawn from $\{t \in AT | exp(t) = exp(a)\}$ if this set is not empty. Otherwise, t_l is randomly drawn from AT. This model represents bureaucracy-like task allocation: experts are allocated tasks within their field of expertise if possible.

Implementation of Culturally-Influenced Decision Process. A few elements from the motivation decision process remain to be defined for this particular setting. Namely, how agents evaluate their satisfaction for each motive and how they estimate the satisfaction resulting from their actions.

Motive Satisfaction: The satisfaction of the survival drive m_s is represented by $sat_a(m_s) = \frac{1}{1+e^{-4(2OS-1)}}$. This formula links m_s to OS with a sigmoid function. Thus, $sat(w, m_s)$ is high for high OS values and decreases quickly when OS decreases below a threshold (around 0.7). This formula represents that satisfaction of survival needs is high when the organization performs well and depletes quickly when organizational success decreases too much.

Conservatism drives are satisfied in following standards, being obedient and acting like others, while open to change drives are satisfied when acting creatively. Openness to change and conservatism values satisfaction depends on two beliefs variables e_c and e_p recording past activity evaluation. e_c records the amount of creatively action in the past and e_p records the time spent acting conform to procedures. At the end of every round, e_c increases by $0.05 \times (1 - e_c)$ when acting creatively and $e_c \leftarrow 0.99 \times e_c$ otherwise. Similarly for e_p. These update functions discount with time the importance of oldest actions. Motive satisfactions of m_{otc} and m_c are represented by $sat_a(m_{otc}) = e_c$ and $sat(w, m_c) = e_p$. These formula have the property to increase when doing appropriate behavior and decrease over time. The importance of events is discounted over time.

[3] The simulation complexity is proportional to $|A|$, times the amount of rounds per simulation and the number of simulations to run. To that extent, $|A|$ is set to a reasonable value.

Plans: Agent plans is a task and its desired resolution, represented by the set $P = T \times R$. The set of available plans is $AP = \{(t, r) | t \in AT, r \in R\}$.

Estimated Plan Satisfaction: The organizational structure influences the way individuals satisfy their motives. Organizational archetypes, in addition to their impact on formal coordination structures, also influence on how individuals satisfy their drives. In both organizations, openness to change is satisfied by creative task resolution. But, the satisfaction of conservatism motives is more sensitive to the organization. Since adhocracies have no leader, thus conservatism motives cannot be satisfied via obedience. Instead, these motives can be satisfied by satisfying conformity and tradition, that is, performing similar tasks as others and following professional standards. In machine bureaucracies, instead of preferring performing similar tasks as others, conformity is satisfied by obeying leaders. Concerning survival needs, in adhocracies one's job is directly correlated to organizational survival. Thus, survival drives are satisfied in performing critical (maintenance) tasks. Conversely, machine bureaucracies tend to empower leaders. Thus, obedience is a better solution to satisfy survival drives.

Formally, for survival drive m_s, $sat_p((t, r), m_s) = 1$ if $t = t_l$ (the agent obeys the leader) in machine bureaucracies or if t is a maintenance task in adhocracies. Otherwise $sat_p((t, r), m_s) = 0$. For openness to change drive m_{otc}, $sat_p((t, r_c), m_{otc}) = 1$. $sat_p((t, r), m_{otc}) = 0$ if $r \neq r_c$. For conservatism drive m_c, $sat_p((t, r), m_c) = 1$ if r is a standardized resolution and if $t = t_l$ in a hierarchical organization or if the origin of t is the most frequently performed by other workers. Otherwise, $sat_p((t, r), m_c) = 0$.

Then, rewards are discounted by the estimated time to completion for this task, that is divided by $ttc(t, r, exp(a))$ for plan (t, r) and agent a.

Simulation Loop. The model iterates over a loop, where each round corresponds to one hour. Each round, incoming requests are added as tasks; agents work on their allocated task t_a; finished and failed tasks are removed; task-less agents decide on picking an available and how to resolve it.

Each time step, some new tasks are processed by the organization by the organization. In our simulations 5 tasks are issued each turn. This parameter is correlated to organizational processing capacity (depending on the number of agents). This value is high enough for workers to be busy but low enough for workers to be confronted to tasks they are not expert at.

3.3 Key Dynamics of the Model

Dilemmas: The environment forces agents into dilemmas: shall they botch a task with a quick resolution, with high efficiency, avoiding discounting expected survival reward over too long? Or shall they prefer to be creative, costing more time but allowing to satisfy their self-direction motives? Or to follow procedures, at any cost? What makes a decision change from one to another?

Since culture influences on individual preferences towards openness to change and conformism, agents are more likely to favor one decision over another. This lead to various patterns at the individual and collective level.

Maslow Hierarchy of Needs: These dilemmas happen only when survival needs are satisfied. Since human nature motives are more important than higher level cultural aspects, survival, when not satisfied, is always given more importance than higher levels, more influenced by culture.

Agent Satisfaction and Organizational Structure: A core mechanism of this model is that individual motives are satisfied differently depending on organizational structure. Thus, this structure influences individual decisions. For instance, agents tend to obey leaders in bureaucracies because that is the way their survival motive are satisfied. In adhocracies, this motive is satisfied in instead in performing maintenance tasks.

Organizational structure influences in turn satisfaction influences collective patterns. In bureaucracies, subordinates are allocated tasks they are expert at if available. In this case, workers can generally satisfy their conservation motives "for free". Conversely, openness to change, requiring creative solutions[4] are slightly less efficient than procedural resolutions unless workers are not experts. In case of high survival desire and not expert tasks, workers can prefer a quick resolutions, reducing the time to completion. In adhocracies, in spite of being given more freedom, agents are driven to perform maintenance tasks when OS is low. Thus, opportunities to perform tasks they are expert at can be lost, potentially leading to performance loss.

Environmental Complexity: Finally, in altering $|E|$ (which represents environmental complexity), tasks and agent expertise can be more or less in accordance. Since procedural resolution efficiency suffers the most from lack of expertise, conservation is likely to be less efficient (and thus less satisfied) than openness to change in complex environments.

4 Experiments

4.1 Setup

Experimental Variables and Measures. Experiments investigate the impact of culture on collective organizational performance (efficiency, flexibility, member's satisfaction), depending on organizational structure (adhocracy or bureaucracy) and environmental complexity. Cultural preferences are determined by $\alpha \in [0, 1]$, the relative preference towards conservation and openness to change from Schwartz values. The higher α the more workers prefer conservatism on openness to change. Environmental complexity represents the fitness of the organization with regard to its environment, here represented by $|E|$, lowering the probability of having a matching expertise between agent expertise and task requirements. The higher $|E|$ the more complex is the environment.

Efficiency is measured by the organizational success OS at the endrun. Flexibility correspond to the degree to which the organizational efficiency decreases

[4] In a former version, some "original" tasks could satisfy creativity. Open to change workers were occasionally insubordinated in well-doing organizations.

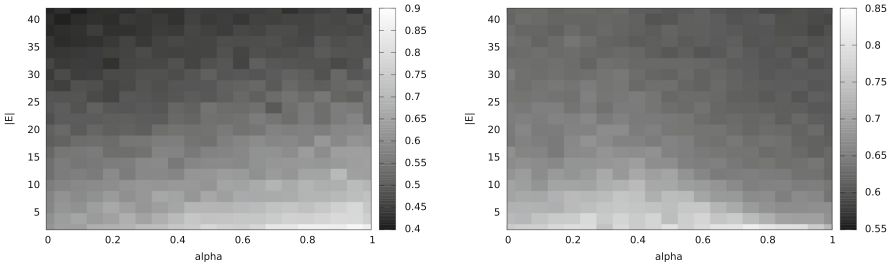

Fig. 4. Efficiency in bureaucracies (left) and adhocracies (right) depending on culture and environmental complexity

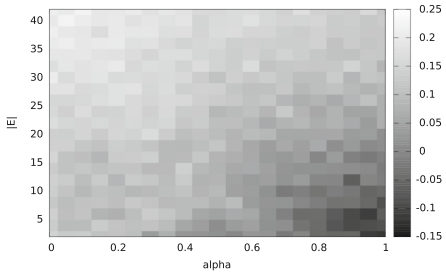

Fig. 5. Differences in OS between performance of bureaucracies and adhocracies in similar environmental setups

when the environment gets more complex. It is measured by $OS_{n+2} - OS_n$ where OS_i is the organizational success (and thus efficiency) when $|E| = i$. Individual satisfaction is measured by the average over Sat of agents. Each result is the average of 20 runs of 150 rounds each. Organizations contain 15 workers.

Studied Hypotheses. These experiments are conducted in order to test the conformity of our model of culturally influenced motivations with regard to well-studied social science observations. These observations provide a stable and well-studied "benchmark" to show the dynamics of our model of culturally-influenced motives. Consequently, if the output is not conform to expectations (and a stable theory provides a lot of expectations), then the only reason is that our model is faulty: we cannot hide behind subjective interpretation of theories. While not providing new answers about social sciences, we reinforce the As suggested by theories in Fig. 3, positive correlations are expected between efficiency and satisfaction in bureaucracies and conservative cultures. Idem, positive correlations are expected with adhocracies and open to change cultures. In addition, for both organizations, positive correlations between flexibility and openness to change are expected. Finally, Mintzberg's culturally-independent property that adhocracies are fitter for complex environment while bureaucracies are fitter for simpler ones is also expected to be retrieved.

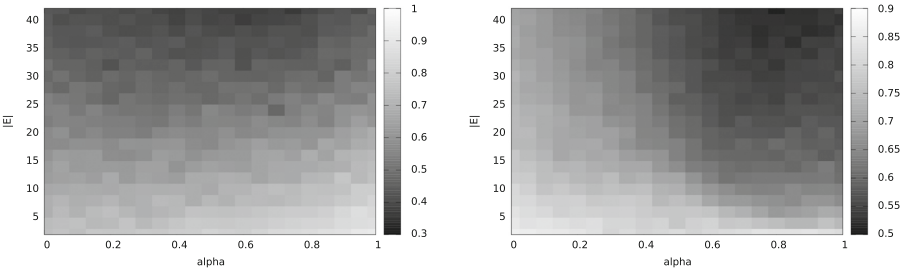

Fig. 6. Individual satisfaction in bureaucracies (left) and adhocracies (right)

4.2 Results

Culture, Organizational Structure and Efficiency. Figure 4 presents the relationship between culture (α), environmental complexity ($|E|$), organizational structure and organizational efficiency measured by the organizational success variable OS. In this figure, lighter cells represent higher efficiency. A horizontal polarization for bureaucracies can be seen: given any environmental complexity, higher conservatism leads to higher performance. For adhocracies, moderate level of conservation leads to higher efficiency for lowest complexity. The positive influence of conservation decreases when the complexity increases. This result is explained by the low cost of following standards in low complexity. In both cases, efficiency is correlated to conservation in bureaucracies and openness to change in adhocracies. This observation underlies a correlation between culture and preferred organizational structure.

Reference [5] shows evidence that "power distance moderated the relationship between empowerment practices and performance, such that there was lower performance for countries assumed to be high in power distance". In order to investigate if our model replicates this observation, bureaucracy and adhocracy efficiency are compared in Fig. 5. Lighter cells mean that adhocracies are more efficient than bureaucracies. For any given environmental complexity level, higher preference towards conservation leads to darker zones. So, adhocracies are less and less efficient than bureaucracies when preference towards conservation (higher power distance) increases, which correlate with the aforementioned evidence.

Culture, Organizational Structure and Satisfaction. Figure 6 depicts individual satisfaction in adhocracies and bureaucracies depending on culture and environmental complexity. Lighter cells represent higher satisfaction. Both figures display a horizontal polarization. In bureaucracies, satisfaction is correlated with conservatism while in adhocracies, satisfaction is correlated with openness to change. Once again, a correlation between satisfaction, organizational pattern and culture is observed. This observation also matches with [5]: "the relationship between empowerment and satisfaction differed across levels of power distance, such that empowerment was negatively associated with satisfaction in high power distance samples". In our model, satisfaction is negatively

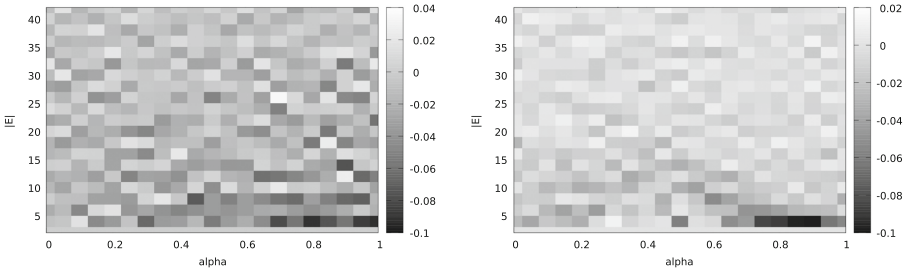

Fig. 7. Gradient of OS along $|E|$ in bureaucracies (left) and adhocracies (right)

associated with power distance (conformism) when individuals are empowered (in adhocracies).

Note the particular case of low environmental complexity and openness to change preference: individuals are more satisfied with in spite of lower efficiency (so, lower survival satisfaction). This case correspond to organizations confronted to a friendly environment: since survival is mostly satisfied, agents gain more satisfaction in value satisfaction.

Flexibility. Figure 7 represents the derivation of efficiency of organizations along increasing level of environmental complexity. Dark zones represent important performance drop due to environmental complexity increase. Both organizational structures display a similar pattern. Darkest zones are darker or more frequent in higher conformity. So, in conservative cultures, performance drops due complexity increases are more frequent and important. Consequently, organizations in conservative cultures are less flexible than organizations in more open to change cultures. This correlation suggested in [7,11], which describe that PDI and UAI have a negative impact on flexibility.

Mintzberg's Properties. Our model also replicates culturally independent phenomena described by Mintzberg [8]. Figure 5 replicates that, yet slightly influenced by culture, machine bureaucracies have higher organizational success (OS) than adhocracies in simple environments but less success in complex environments.

5 Conclusion

This article presents an agent decision model which explicitly links the influence of culture on motivation. Motivation is also non-cultural influenced by human nature and personality. Human nature, culture and personality influence the relative importance between motives. This importance, combined with need satisfaction, determines agent desires. These desires are influence in turn plan to be selected. Then, this model is illustrated by replicating the influence of culture on organizations as observed by social sciences.

Our decision model differs from the conceptual approach of recent social simulation cultural models such as [12]. Instead of representing culture using cultural dimension scores, which correspond to a cultural tendency to display some

type of behavioral response, we represent cultures by the relative importance given to values. This model, which is directly inspired by theories of culture [7], allows to go beyond altering surface level behaviors, but rather uses cultures as a factor of agent motivation thus influencing fundamental motives. This makes our approach more generally applicable and independent of specific applications.

By treating culture as preferences over values, our model can capture interesting properties of cultures. For instance, power distance and collectivism are empirically shown to be related. Since, in our model, cultural dimensions are to be inferred from individual behavior[5], correlations between these dimensions can easily be reproduced by our model: these two dimensions are related by some shared (or at least closely related) underlying cultural values.

The current paper shows a first step towards building computational models of culture that are conceptually closer to the theory of culture: a culture made of values and practices influencing individuals from their desires to their actions, while not discarding the influence of their own personalities and survival drives. Our model opens the way towards more elaborated and complex models of individual decision processes which integrate cultural aspects.

More complex models can enrich our simple model of culturally-driven motivations. As tracks for future work, we propose to integrate culturally-driven practices into agent decision (e.g. how to greet, how to eat), which provides immediately observable aspects of culture. In addition, ABMs appear to be a suitable tool for modeling dynamic aspects of culture, for instance how culture is acquired when entering into a new social environment, but also how individuals "switch" cultures when they change social context. Finally, we also propose to investigate the case where agents are heterogeneous, capable or representing different personalities, but also to acquire different aspects of culture.

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