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Dealing with Agents' Behaviour in the Decision-Making Process

Diogo MARTINHO[a], João CARNEIRO[a,1], Goreti MARREIROS[a] and Paulo NOVAIS[b]
[a] *GECAD – Knowledge Engineering and Decision Support Group, Institute of Engineering – Polytechnic of Porto, Porto, Portugal*
[b] *CCTC – Computer Science and Technology Center, at University of Minho, Braga, Portugal*

Abstract. Gathering a group of managers or executives (decision-makers) in a same place and at a same time is not an easy task. In fact, the decision-makers' schedule is so tight that it becomes necessary to develop tools that will aid in the communication and in the decision-making process. The intelligent systems (IS) can be the solution to overcome these necessities. In literature, there have been appearing more and more IS that make use of multi agent systems (MAS) in order to represent real decision-makers in this type of systems. In our work we address the problem of how agents should behave during the decision-making process and what strategies they can follow to represent the interests of the decision-maker. We intend to define valid behaviours for agents in group decision-making context and to relate the theoretical behaviours definition with usual attitudes and acts that are relevant for this context. We define two dimensions and relate them with two facets based on the Five Factor Model. Then we propose the behaviours classification according three different levels (low, moderate and high) for each one of the dimensions. We use the value of the personality trait correspondent to each facet in order to classify our behaviours in the scale.

Keywords. Intelligent Systems, Ubiquitous Group Decision Support Systems, Multi-Agent Systems, Behaviours, Five Factor Model

1. Introduction

The number of studies related to Ambient Intelligence (AmI) has been increasing exponentially over the last decade. AmI can be considered as a relationship between several areas of computer science such as: Artificial Intelligence, Human Computer Interaction, Networks, Sensors and Pervasive Ubiquitous Computing [1; 2]. In order to coordinate AmI, specific systems known as Intelligent Systems (IS) are used [3]. These "intelligent" environments and systems, among other things, can: be pro-active, anticipate scenarios and act autonomously [4].

A recognizable application of intelligent environments is smart offices. In fact, smart offices are seen as the new trend of the traditional offices and decisions rooms [4]. A smart office is nothing more than an intelligent environment that aims to support the Decision-making process. Usually these types of environments are composed of physical components (e.g. sensors, controllers and smart devices) and software (e.g. intelligent agents). The software makes use of the information collected by its physical

[1] Corresponding Author. Email: jomrc@isep.ipp.pt

components to reason about the environment and trigger actions in order to change its state [5].

It has become more of a common feature for smart offices to be prepared to make the environment more intelligent and also to create an ubiquitous/pervasive computing platform, i.e. there is the necessity to collect and deal with both all the possible information about the environment as well as with the fact that not every decision-maker will be present at the same place [6]. Many of the intelligent systems that have been proposed for this type of environment include intelligent agents that, among other things, will represent real decision-makers [7-9]. In order to make this representation more intelligent, there have been suggested new strategies, that for example, can identify emotions through the use of sensors, analyse profiles, define personality models, etc. [10-12]. Most models that are used to define personality, strategies or behaviours of the agents, are adapted from scientific literature which is not entirely related to the area of computer science [13; 14].

Many approaches have been suggested in the literature which define/model agents with certain characteristics that differentiate them from each other and as result permit them to operate differently [8; 9; 15-18]. Specifically in the group decision-making context, some behaviour models have been used (conflict style, strategies or personality models) which intend to differentiate the agents according to certain interests. However, there is not one specific definition to really describe how each one of the behaviours should act in group decision-making context. Some appointments that can be used are just not enough, and in the case where the decision-makers perform the modelling of their agent by selecting one behaviour from a list of possible behaviours, it is not possible to know if the agent will act according to the decision-maker's expectations.

In this paper we purpose the inclusion of what we consider the most important dimensions to define agents' behaviours that should be considered in the group decision-making context. We present the adaption of the conflict styles identified by Rahim and Magner [19] to the group decision-making context and we propose 2 new dimensions (plus the adaptation of the 2 dimensions that were identified by Rahim and Magner [19]) to define and differentiate them. In order to be able to classify the different behaviours to each one of the dimensions we propose a correlation between the dimensions and some facets based on Five Factor Model [13]. We use the syntax used by Rahim and Magner (Low, Moderate and High) to classify the behaviour types.

The rest of the paper is organized as follows: in the next section is presented the literature review. Section 3 presents our methods, where we: identify the facets that are relevant to our context; propose 2 new dimensions and how we correlate them with the different behaviour types and present the different levels (low, moderate and high) for each one of the dimensions considering the behaviour types. Finally, some conclusions are taken in section 4, along with the work to be done hereafter.

2. Literature Review

The way different behaviour types can be adapted for an agent to use for a group decision-making context is closely related to how a person behaves in real life and also related to specific traits of personality of each individual. Therefore, it is important to understand which factors are responsible to affect the personality of an individual and how the personality can enhance one specific behaviour type in a situation and a different behaviour type in another.

The first relevant study in this area was made by Jung [20], in 1921 when he specified a model to study different psychological personality types based on four types of consciousness or functions (sensation, intuition, thinking, feeling):

- Sensation – How a person perceives a stimulus through the use of sense organs (smell, taste, touch, hearing, sight);
- Intuition – How a person is able to acquire knowledge without inferring or reasoning;
- Thinking – How a person arrange thought and ideas, and how a person makes sense of the world around him or her;
- Feeling – How a person experiences emotions.

Both thinking and feeling functions are related with one individuals rational side the same way both sensation and intuition functions make part of the irrational side of the individual. These functions can in turn be combined with two types of attitudes (extraversion and introversion) and that way identify eight primary psychological types (Extraverted sensation, introverted sensation, extraverted intuition, introverted intuition, extraverted thinking, introverted thinking, extraverted feeling and introverted feeling).

Following Jung's studies, there have been suggested and developed so many other models applied to several areas of psychology and sociology such as leadership [21], social conflict, which allows us to see the impact that Jung's contributions have had in modern psychology and sociology. With regard to social conflict, our area of study centers in conflict management which has always been an important area of decision-making, since it is very rare to find situations in group discussion where conflict is not present.

In 1975, Kilmann and Thomas [22], based on Jung's studies and a conflict-handling mode proposed by Blake and Mouton [23], suggested a model for interpersonal conflict-handling behaviour, defining five modes: competing, collaborating, compromising, avoiding and accommodating, according to two dimensions: assertiveness and cooperativeness.

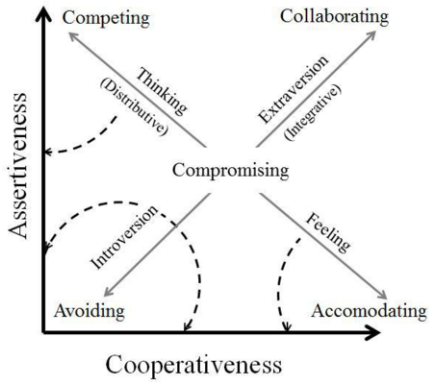

Figure 1. Thomas and Kilmann's model for interpersonal conflict-handling behavior, adapted from [22].

As seen in Figure 1, both assertiveness and cooperativeness dimensions are related to integrative and distributive dimensions which were discussed by Walton and McKersie [24] in 1965. Integrative dimensions refer to the overall satisfaction of the group involved in the discussion while distributive dimension refers to the individual

satisfaction within the group. It is possible to see that the thinking-feeling dimension maps onto the distributive dimension while the introversion-extraversion dimension maps onto the integrative dimension. It is easy to understand this association by looking at competitors as the ones who seek the highest individual satisfaction, collaborators as the ones who prefer the highest satisfaction of the entire group. On the other hand avoiders do not worry about group satisfaction and accommodators do not worry about individual satisfaction. They also concluded that the thinking-feeling dimension did not move towards the integrative dimension, and also that the introversion-extraversion did not move towards the distributive dimension.

In 1992, Costa and MacCrae [25] proposed a set thirty traits extending the five-factor model of personality (OCEAN model) which included six facets for each of the factors. These traits were used in a study made by Howard and Howard [13] in order to help them separate different kinds of behaviour styles and identify corresponding themes. A theme is defined as "a trait which is attributable to the combined effect of two or more separate traits". Those styles and themes are based on common sense and general research, and can be inferred such as the conflict styles that were proposed, (Negotiator, Aggressor, Submissive and Avoider), however it is also important to referrer other relevant styles that were suggested such as the Decision and Learning styles. Decision style includes the Autocratic, Bureaucratic, Diplomat and Consensus themes while Learning style includes the Classroom, Tutorial, Correspondence and Independent themes.

In 1995, Rahim and Magner [19] created a meta-model of styles for handling interpersonal conflict based on two dimensions: concern for self and concern for the other. This model was created in order to validate 5 subscales of the Rahim and Magner's Organizational Conflict Inventory (ROCI-II) which measure 5 styles of handling interpersonal conflict.

The styles defined by Rahim and Magner [19] are presented in Figure 2 and have been adapted to our problem. Rahim and Magner [19] reckons the existence of 5 types of conflict styles: integrating, obliging, dominating, avoiding e compromising. In his work, they suggested these styles in particular to describe different ways of behave in conflict situations. They define their styles according to the level of concern a person has for reaching its own goal and reaching other people's objectives.

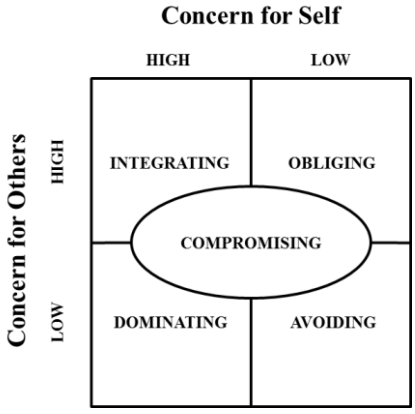

Figure 2. Conflict Style, adapted from [19].

Rahim and Magner's model relates to the themes identified by Howard and Howard [13] to a certain extent. The Aggressor theme resembles the Dominating style; the Negotiator theme resembles the Integrating style; the Avoiding theme resembles the Avoider style; and the Submissive theme resembles the Obliging style. The main difference is the existence of the Compromising style in Rahim and Magner's model which does not relate to a specific theme. In theory the Compromising style is an intermediate state between the other styles that were identified.

3. Methods

Before we introduce our proposal, there are a few, yet relevant questions that must be addressed in order to understand our point of view and how that will also has impact in the way we will develop it.

As mentioned before we have considered 5 main behaviour types, following Rahim and Magner's studies: Integrating, Dominating, Compromising, Obliging, Avoiding. These styles will be available during the agent's configuration process and will be responsible for instructing the agent on how to behave during the decision-making process in the system.

What is important to know is:

- What differentiates each behaviour type? It is obvious that each behaviour should be different, otherwise having agents with different behaviours and acting the same way in the system would just be completely useless;
- How will an agent behave after the configuration? Defining what the agent will do is the next step to take into account because even if we can distinguish one agent's behaviour from another, if we cannot transform that into actions to be performed in the system it will also be useless for our goal;
- How will the decision-making process work? Now that we have our agents well defined and differentiated we're ready to use them in a decision-making context, however it is necessary to know how the system will perform;
- How will the agents interact with each other? What information can be exchanged? How will that information be exchanged? If agents do not interact with each other and exchange information, the decision-making process ends with no decision at all. It is important to define how the agents will communicate with each other.

Considering Costa and MacCrae [25] 30 facets, we have identified those that are relevant and make sense in our context. From all the existing facets, we consider that the most relevant facets are: activity, altruism and compliance (Table 1).

Table 1. Facets that define specific behaviour types for decision-making context.

Facet	Low	Moderate	High
Activity	Leisurely	Average Pace	Vigorous
Altruism	Uninvolved	Willing to Help Others	Eager to Help
Compliance	Aggressive	Approachable	Defers

The activity facet is considered because it allows to differentiate participants that are more or less active during the discussion. It is easy to identify, during a group decision-making process, participants that play a more active role by openly inquiring other participants or making statements, and there are also participants that are less

active and usually only participate when asked to share their thoughts or opinions, without having the will to take initiative and try to solve things on their own. The altruism facet is important because it reveals the concern that one participant might have for other participants and their opinions. This will show to what extent the participant will be willing to understand other individual's point of view on the same matter or why they defend one opinion instead of another. Compliance is also a necessary facet in our context because it differentiates the level that each agent will have towards accepting or refusing to change opinion during the discussion. If all agents refuse to change their opinion it will be very difficult to reach an agreement. If all agents are willing to accept new opinions it will be easier to reach a consensus.

Just by looking at these facets' definition we begin to understand that it will be very important for a group decision-making context to have a mixture of all the possible levels for each facet (low, medium, high) spread through the different behaviour types, according to each behaviour's definition and that some of those behaviours may also share the same levels for one or more facets. However that does not mean that in practice, agents will behave exactly the same way. They might share some common characteristics but in the end, their behaviour will be distinguished by not what they do the same way, but by what they do in different ways.

For our work we considered Rahim and Magner's dimensions for concern for self and concern for others:

- Concern for others – This dimension is related to the altruism level of each agent and how much the agent will worry about other participant's opinions. This means that an agent with a high concern for others will ask more questions to try understanding other participant's point of view compared with an agent with low concern for others;
- Concern for self – This dimension is also related to the altruism level of each agent and the value given by an agent to its own opinion and how he will express his own opinion in the presence of others. An agent with a high concern for self is going to make more statements to justify and defend his opinion compared with an agent with low concern for self.

Looking at the definition of each behaviour type it becomes easy to understand how the dimensions will affect each behaviour type based our own definition of the group decision-making context where we consider two main areas of discussion (public and private). The concern for others dimension is related with elocutions that are the type of questions. An agent with high concern for others wants to know and understand other agent's point of view so he will ask more questions. An agent with low concern for others will ask fewer questions. The concern for self dimension is related with elocutions that are the type of statements. An agent with high concern for self wants to be heard and wants to share his opinion with other agents. An agent with low concern for self may not even have an opinion to share with others and therefore will make fewer statements.

The next step is to level each behaviour type for each of the dimensions considered. In Rahim and Magner's work they consider 2 levels for each dimension: high or low. However they point that the Compromising style of behaviour involves a "moderate concern for self as well as the other party involved in the conflict". This means that a third level could also be supposed which would be the moderate level. We use these 3 levels as a scale to classify each one of the behaviour type according to each dimension. We assume the classification of behaviour types presented in Table 2.

Table 2. Classification of conflict styles for each dimension proposed by Rahim and Magner [19].

Dimension	Low	Moderate	High
Concern for self	Obliging and Avoiding	Compromising	Dominating and Integrating
Concern for others	Dominating and Avoiding	Compromising	Integrating and Obliging

On one hand the obliging and avoiding behaviour types are placed at a lower level, the compromising type is placed at a moderate level, and the dominating and integrating types are placed at a higher level of concern for self. On the other hand the dominating and avoiding behaviour types are placed at a lower level, the compromising type is placed at a moderate level, and the integrating and obliging types are placed at a higher level of concern for others.

Like mentioned before we think that these two dimensions are related to the altruism facet and the distribution of each behaviour type in the levels that were considered could also be deduced just by looking at Costa and MacCrae [25] definition of altruism. In fact Rahim and Magner's analogy is very similar to the one used by Howard and Howard to classify each conflict theme. They consider that an aggressor has a low level of agreeableness (**-A**), meaning that an aggressor is someone that is unwilling to help others, and therefore has a low concern for others and their necessities and in return has a high concern for its own necessities. On the other hand a Submissive is someone with a high level of agreeableness (**A+**), meaning that is someone who is eager to help others, and therefore has a high concern for other necessities and a low concern for its own necessities. A Negotiator has a medium level of agreeableness (**A**) and therefore it is willing to help others but not as much as a submissive would because it still has a higher concern for its own necessities. For the avoider, he is not given an altruism level because an avoider does not care for others nor own necessities since he does not have any necessities and an avoider will not want to help others.

We then purpose 2 other dimensions of scope, based on the terminology of the remaining facets that were considered and that will be used to identify each behaviour. These dimensions are: resistance to change and activity:

- Resistance to change: This dimension is related to the compliance level of each agent, which means that an agent with a low "resistance to change" level will change his opinion easier compared with another with a higher level;
- Activity – This dimension is related to the activity level of each agent and how much effort he will put in the decision-making process, whether he will play a more active role and will take initiative to open discussion topics, ask questions and make statements in both public and private contexts and request to change opinions.

For the activity dimension, we associate this dimension with the areas of discussion as well as the agent's will to begin a new topic of discussion. This means that the more active an agent is then the more likely it will participate in both areas of discussion as well as want to create new topics of discussion. For the resistance to change dimension, we consider how agents will deal with other agent's requests. An agent with a high resistance to change will hardly ever change his opinion (unless the requested option can also provide a high satisfaction for that agent). On the other hand, an agent with a low resistance to change will accept other opinions more easily.

For the resistance to change and activity dimensions, like mentioned before, we based our scale with Costa and MacCrae [25] facets and therefore we consider three levels for each dimension: low, medium or moderate, and high.

The behaviour types for each dimension are classified as seen in Figure 3 and Figure 4.

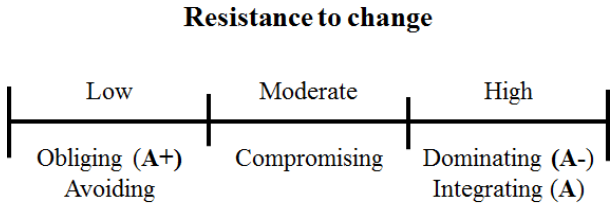

Figure 3. Classification of each behaviour type according to Resistance to Change Dimension.

Obliging and avoiding types are placed at a lower level, compromising type is placed at a moderate level, and dominating and integrating types are placed at a higher level for resistance to change.

Because we think resistance to change is related with the compliance facet there is a certain similarity with the concern for other and self dimensions since according to Costa and MacCrae [25] model, both altruism and compliance belong to the agreeableness factor. An individual with a low level of agreeableness (A-) is more aggressive and very hard to approach and convince. An individual with a medium level of agreeableness (A) is more approachable, and an individual with a high level of agreeableness (A+) is even easier to approach and to convince. Howard and Howard definition for each conflict theme also makes sense with the scale we have considered. An obliging individual because he has a high concern for others and their opinions is more likely to be convinced by others. On a medium level we find the integrating type with a medium level of compliance because he has a less concern for others compared with the obliging type; however it still is higher than the dominating's concern for others. The dominating is the type with the lowest compliance level and the hardest to approach and convince. The avoider does not have a compliance level because it does not possess its own opinion or interest and therefore is not even considered as a target that needs to be convinced or to be approached by others.

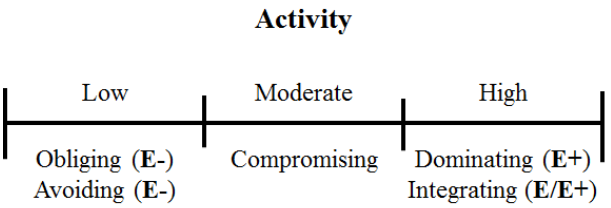

Figure 4. Classification of each behaviour type according to Activity Dimension.

Obliging and avoiding types are placed at a lower level, compromising type is placed at a moderate level, and dominating and integrating types are placed at a higher level for activity. This dimension is related to the Activity facet, with both obliging and avoiding types having the lowest extraversion which mean they will not be very active

in the system. On the other hand, dominating and integrating types have the highest extraversion, and therefore will be to most active in the system.

To sum up the final table for all behaviour types and the corresponding levels for each of the dimensions defined in Table 3:

Table 3. Numerical classification of each behaviour type according to each dimension.

Behaviour Type	Concern for Self	Concern for Others	Resistance to change	Activity
Dominating	3	1	3	3
Integrating	3	3	3	3
Compromising	2	2	2	2
Obliging	1	3	1	1
Avoiding	1	1	1	1

It is important to understand that these levels are not absolute, which means that there are situations where an agent might act in a way that is not theoretically expected. This is why these values must be looked as low to high and not as 0 to 100. And this makes sense if we think of any real life group decision-making meeting. We often find participants that might have entered the meeting with a certain strategy, for instance, a participant that decided the best approach for that meeting would be to stay quiet at first, understand other participant's opinion and then gather a final opinion on the matter. Will this individual, however, follow this plan flawlessly? In some situations it could actually work however there are also situations where he might be forced to intervene earlier than he expected, either because another participant said something that does not make sense and if he does not say anything other participants might actually end up believing in that. Another situation could be the one where every participant or at least the majorities of participants share the same behaviour. If we imagine a group of avoiders trying to reach a consensus and everyone is waiting for a proposal to be announced, if no-one talks then there will be made no decision at all. But even in those cases there is always someone who ends up throwing a wild guess or suggesting something, even if at random, and then everyone will likely agree with that.

Therefore our model takes into account these special aspects of decision-making and is never assumed that a behaviour type will restrict an agent from performing a specific action. This means that every agent in our system has the same capabilities even if each agent has a different behaviour type. The behaviour type will only affect the probability of an agent to perform a specific action inside the system.

4. Conclusions and Future Work

Smart offices are a topic of study in the area of Intelligent Environments. They can be seen as the new trend of the traditional offices and decisions rooms. In order to simplify the process of group decision-making, there have been studied specific types of intelligent systems that will act in this kind of environments. The concern for representing decision-makers in a way that can support them with more intelligence has been increasing throughout the last decades. One of the strategies revolves around using multi-agent systems where an agent that represents a decision-maker is modeled with characteristics that allow doing so. These characteristics can be conflict styles, strategies, behaviour types, emotions, personality, etc. However, even though there is already a considerable amount of work in literature about some of these topics it is still

hard to find models that can be correctly adapted to a context that requires the agents to represent and act accordingly to the style they have been modeled with. In this work we have identified as the main objective to define the most important dimensions that can differentiate the way agents act in the context of group decision-making and define for each behaviour type its level for all the dimensions considered.

We believe that the work here presented will open a new window towards the creation and the concrete definition of ways of acting for the agents that represent decision-makers through a conflict style. Firstly we adapted the conflict styles proposed by Rahim and Magner (integrating, compromising, dominating, avoiding and avoiding) to the group decision-making context and considered them as our behaviour types. Secondly we defined 2 dimensions which we consider important to define and differentiate the actuation mode of an agent modelled with each one of the different behaviour types (resistance to change and activity). We also adopted the 2 dimensions already proposed by Rahim and Magner (concern for self and concern of others) and the implicit classification in their work to classify each one of the behaviour type to each one of the dimensions (low, moderate and high). Thirdly, in order to classify each one of the behaviour type with each one of our new 2 dimensions we used the existing analogy between Rahim and Magner's work and the Howard and Howard's work. Then we used 2 facets from the Five Factor Model (activity and compliance) in order to be possible to correctly classify each one of the behaviour type in our scale.

We think that our future work can be very promising. Although the work here presented is based on deductions about scientifically proven studies, it is essential to notice if the future users (decision-makers) of this type of approach can understand what each behaviour style means whenever they select one to use. This way, our future work revolves around undertaking an in-depth study to observe how users perceive these conflict styles and if they are perceived according to their specification. This means that it is necessary to understand if when a decision-maker selects a conflict style, the agent acts according to his expectations. Besides that we also intend to define for each dimension (in case that our hypothesis can be validated) what will be the probability of occurrence as well its coefficient of variation. We also intend to connect each conflict style with certain elocutions to learn if there is homogeneity in the answers and that way draw valuable conclusions that can be applied to the definition of the behaviours.

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