Title

Predicting Satisfaction: Perceived Decision Quality by Decision-Makers in Web-based Group Decision Support Systems

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Abstract

In future, the organizations' likelihood to endure and succeed will depend greatly on the quality of every decision made. It is known that most decisions in organizations are made in group. With the purpose of supporting decision-makers anytime and anywhere, Web-based Group Decision Support Systems (GDSS) have been studied. The amount of Web-based GDSS incorporating automatic negotiation mechanisms such as argumentation has been steadily increasing. Usually, these systems/models are evaluated through mathematical proofs, number of rounds or seconds to propose (reach) a solution. However, those techniques are not very informative in terms of the decision quality. Here, we propose a model that intends to predict the decision-makers' satisfaction (perception of the decision quality), specifically designed to deal with multi-criteria problems. Our model considers aspects such as: meeting's outcomes, decision-maker's intentions, expectations and emotional cost. To validate the proposed model in terms of its ability to predict decision-makers' satisfaction, we developed a prototype of a Web-based GDSS to be used in a case study where the participant had to make a joint decision. The decision process consisted in a set of 5 rounds, where the participant could (re)configure his/her preferences along the process. The satisfaction model ascertained its ability to predict the participants' satisfaction and allowed to understand that (as is stated in the literature) the inclusion of cognitive and emotional variables is essential to evaluate satisfaction more accurately.

Keywords

Group Decision Support Systems, Decision Satisfaction, Decision Quality, Outcomes, Affective Computing

1. Introduction

It is known that most decisions in organizations are made in group (Lunenburg, 2011). Group Decision Support Systems (GDSS) have been widely studied throughout the last decades to support this type of decisions (DeSanctis & Gallupe, 1984; Desanctis & Gallupe, 1987). However, in the last ten/twenty years, we have seen a remarkable change in the context where the decision-making process happens, especially in large organizations (Grudin, 2002). With the emergence of global markets, the growth of multinational organizations and a global vision of the planet, we easily find decision-makers (chief executive officers, managers and other members of global virtual teams) spread around the world, in countries with different time zones (Shum, Cannavacciuolo, De Liddo, Iandoli, & Quinto, 2013). However, to support the group decision-making process in this context is particularly complex, due to the fact that decision-makers are geographically dispersed. To provide an answer and operate correctly in this type of scenarios, the traditional GDSS have evolved to what we identify today as Web-based GDSS (Alonso, Herrera-Viedma, Chiclana, & Herrera, 2010; Kwon, Yoo, & Suh, 2005). The idea behind the Web-based GDSS is to support the decision-making process "anytime" and "anywhere" (Grudin, 2002). The automatic negotiation mechanisms can be used (in Web-based GDSS) to help overcome the lack of interaction inherent to the context described before (Rahwan et al., 2003). Usually, these systems/models are evaluated through mathematical proofs, number of rounds or seconds to propose (reach) a solution (Marreiros, Santos, Ramos, & Neves, 2010). However, those techniques do not say much in terms of decision quality. In fact, the decision quality is impossible to measure in the end of a group decision-making process. What is possible to measure, or what can be valuable to know in the end of a group decision-making process is the perception of the decision quality of each of the decision-makers (or their satisfaction) (Carneiro, Marreiros, & Novais, 2015). Satisfaction is therefore a strong indicator, not only of the results, but also of the whole decision process (Higgins, 2000). When someone is questioned about the quality of a decision, the answer does not reflect only the assessment of outcomes, but also, albeit unconsciously, includes the evaluation process necessary to reach the decision (Higgins, 2000). Satisfaction as a metric has been applied in the literature to many different issues: life satisfaction (Schimmack, Oishi, Furr, & Funder, 2004), job satisfaction (Judge, Heller, & Mount, 2002), etc. Satisfaction has also been applied in the GDSS topic. However, the existing proposals are not concerned with the perception of the decision quality but instead with decision-maker's satisfaction regarding the GDSS performance, usability, among others (Briggs, de Vreede, & Reinig, 2003; Paul, Seetharaman, & Ramamurthy, 2004; Tian, Hou, & Yuan, 2008).

The ability to predict the quality of the decision through the perception of quality by each decision-maker may bring countless new possibilities, such as: to evaluate different systems and models (and to compare their ability to potentiate satisfaction); to use it in new algorithms to predict the decision-maker's satisfaction, and also as a metric to potentiate satisfaction, as a variable that we can try to maximize. Besides, it also allows that organizations may use this metric as an important indicator of the degree of trust associated with a particular decision.

In this work, we study satisfaction as a metric to understand the decision-maker's perception of the decision quality. Our proposal is defined based in the assumptions and premises previously published in Carneiro, Marreiros, et al. (2015), which contemplate different approaches from researchers of a wide range of areas in this thematic (computer sciences, psychology, economy, etc.). It intends to allow automatic assessment of the participants' satisfaction in a meeting supported by a Web-based GDSS. To evaluate decision-maker's satisfaction, we consider the alternatives comparison, style of behavior, emotions, mood and expectations. Our research

hypotheses are: (h1) it is possible to formulate a decision satisfaction model that correctly (mathematically) expresses the assumptions and premises identified in Carneiro, Marreiros, et al. (2015); and (h2) it is possible to predict the decision-makers' perception of the decision quality with a high degree of accuracy. In order to study h1, we performed a large set of simulations in a prototype (previously developed) that uses a negotiation architecture based on social networks (Carneiro, Martinho, Marreiros, & Novais, 2016) and implements the argumentation-based dialogue model proposed in Carneiro, Martinho, Marreiros, Jimenez, and Novais (2017). All the simulations performed consisted of inserting a set of previously defined inputs in order to see if the obtained satisfaction varied according to what was expected. To study h2, we carried out a case study with 43 participants which consisted in a group decision-making process using a Web-based GDSS. To do so, we developed a prototype of a Web-based GDSS to support participants in reaching a decision. The proposed satisfaction model asserted its ability to predict the participants' satisfaction with a high degree of accuracy, showing that in some scenarios it can even evaluate the perception of the decision quality by some participants in a more correct/precise level than themselves.

The rest of the paper is organized in the following order: in the next Section, we present the literature review. In Section 3, we introduce the proposed satisfaction model. In Section 4 we present our Study 1, where we verify if the proposed satisfaction model respects the assumptions and premises published in Carneiro, Marreiros, et al. (2015). Section 5 consists in our Study 2, where it will be presented a case study with real participants, in order to test if the model is able to predict the satisfaction of decision-makers (participants) with a high degree of accuracy. In Section 6 the discussion is presented. Finally, some conclusions are put forward in Section 7, alongside with suggestions of work to be done hereafter.

2. Literature Review

There is a moment, between the time when a decision is made and the time when that decision is put into practice, during which it is not possible to measure the quality of the decision, since we do not know what the practical consequences of such decision will be. A football player who decides to score a penalty to the right, a company that decides to open a new branch in New York, a worker who decides to return home from work using the highway in order to arrive as fast as possible or a group of friends who choose a restaurant to celebrate a special occasion, are examples of decisions that allow us to easily understand that it is only possible to perceive the quality of the decision that was made after the penalty is beaten, the branch open, the worker gets home and the group of friends are served dinner. However, this does not mean that the quality of a decision has completely random assumptions, quite the opposite is true. It is known that factors such as the level of expertise of decision-makers (Klein, 1997), intellectual and emotional abilities (Van Kleef, De Dreu, & Manstead, 2010) also have a great influence on the quality of decisions. It is the ability to anticipate situations and predict what will happen that allows humans to make better decisions and improve their decision-making abilities (Agor, 1986). As such, the period immediately after the decision-making process provides an important indicator of what the consequences of the decision may be: satisfaction with the decision or the perception of the decision quality from the decision-maker's point of view. However, in order to be able to measure this satisfaction/perception first of all, we need to know what factors influence the perception of the quality of the decision. Literature is not very rich in this domain. However, Higgins (2000) presents very interesting work on what is considered to be a good decision.

Higgins (2000) says that "a good decision has high outcome benefits (it is worthwhile) and low outcome costs (it is worth it)", and that "independent of outcomes or value from worth, people experience a regulatory fit when they use goal pursuit means that fit their regulatory orientation, and this regulatory fit increases the value of what they are doing". Decision satisfaction is

therefore a strong indicator, not only of the results, but also of the whole decision process. When someone is questioned about the quality of a decision, the answer does not reflect only the assessment of outcomes, but also, even unconsciously, the evaluation process necessary to reach the decision. To understand how suitable a decision is, it is necessary to understand and analyze the means by which that decision is reached (Beach, 1990; March, 1994). Thus, one should give prominence to the process when drawing conclusions about the results. Satisfaction with a decision resulting from a decision process needs a complex analysis and involves multiple variables. Obviously, satisfaction is related to what we think a good decision is. But what is a good decision? As previously referred, according to common sense, a decision is considered good because of the analogy made with the obtained results. However, psychologically, the results are not enough to make a participant consider a decision as good. Higgins (2000) says that "psychologically, then, a decision is perceived as good when its expected value or utility of outcomes is judged to be more beneficial than the alternatives. The benefits include the social benefits of a decision, such as those received from a 'politically correct' or ingratiating decision. The costs of attaining the outcomes can also influence whether a decision is perceived as good. The outcome benefits have to be weighed against the costs of attaining the outcomes. The costs include not only the goods or services one must give in exchange for receiving the benefits but also the costs of the decision-making process itself. The decision-making process that would optimize outcomes might not be used because the costs in cognitive effort or time are too high". Therefore, it is clear that there is much more than knowing if the chosen alternative is the participant's favorite in order to evaluate his satisfaction with the decision. It has been suggested that a purely cognitive approach may be inadequate in the modeling of satisfaction ratings, so it is particularly important to include emotional variables (Liljander & Strandvik, 1997; Oliver, Rust, & Varki, 1997; Wirtz & Bateson, 1999). The research made in the field of satisfaction has recognized that there is a need to incorporate the emotional and affective components in regulating the consumer's satisfaction (Wirtz, Mattila, & Tan, 2000). Therefore, the final results and the decisions made are not the only responsible for determining the quality and the satisfaction of the decision. In his work, Higgins (2000) says: "We are all familiar with the idea expressed in the maxim of the late-19th-century British statesman John Morley, 'It is not enough to do good; one must do it the right way' or the coaching classic, 'What counts is not whether you win or lose but how you play the game'. Such maxims reflect a moral position: Achievements should be evaluated not only in terms of outcomes but also in terms of the means by which they were attained. 'The ends do not justify the means.'". Using the reasoning present in this approach and the moral objective of these famous maxims, the process relevance in performing a certain action is easily understood. We can also conclude that the impact of the decision-making process can drastically change the participant's satisfaction regardless of the results. Higgins (2000) also refers that "this insight concerns how the goodness of a decision depends not only on its relation to ends or outcomes but also on whether the means used to make it were suitable. Suitability here refers only to what is morally proper. By considering proper the more general meaning of suitable as 'fit', a new perspective on what makes good decisions good is possible". The consideration of several factors is therefore necessary to obtain a correct approach in the decision-maker's satisfaction analysis regarding the decision made.

In this Section we review a set of topics that influence the way by which the quality of the decision is perceived. This literature review reflects the existing knowledge in each of the topics, as well as, if they exist, of models that allow to manipulate and implement this type of knowledge.

2.1. Expectation

The expectation levels are the reason why two organizations in the same sector can offer such distinct levels of service while keeping consumers equally satisfied (Zeithaml, Berry, & Parasuraman, 1993). That is why McDonald's can enlarge an industrialized service of excellence, with few employees per consumer, while an expensive restaurant with employees dressed in tuxedos may not do it so well from the costumer's perspective (Davidow & Uttal, 1989). A costumer's expectations are pre-conceived beliefs about a particular product (Olson & Dover, 1979) that serve as benchmarks against which the product is evaluated. Parasuraman, Zeithaml, and Berry (2002) state that the evaluation of the service quality made by the customer results from comparing the existing expectations with the actual performance. Anyway, despite the importance of expectations being recognized in several works as the service quality (Gronroos, 1983) and customer satisfaction (Oliver, 1985), many questions related to the role of expectations have been considered in research and need to be answered. Consumer expectations have been studied in several research environments (Oliver & Winer, 1987), with a greater emphasis in the analysis of the consumer's satisfaction/dissatisfaction and service quality. In literature, there is a consensus on expectations to serve as standards against which subsequent experiences are compared, resulting in assessments of satisfaction and quality. Consensus on other issues such as: the expectation's specific nature, the number of standards used, and the sources or antecedents of expectations, have not yet been met. Research under the topic of expectations is mostly related to the service quality, but the principles addressed are perfectly applicable in decision group processes. Naturally, decision-makers create expectations regarding the process (for instance, if it will be more or less litigious) and the possibility of reaching their objectives. Several expectations patterns have been proposed: expectations as standard predictions (Oliver, 1985), expectations as the ideal pattern (Miller, 1977), expectations of experience based on standards (Woodruff, Cadotte, & Jenkins, 1983), tolerable minimum expectations (Miller, 1977), among others (deserved expectations (Miller, 1977) and comparative expectations (Prakash, 1984)).

2.2. Emotion

Emotion, in a general definition, is a neural impulse that moves an organism towards action. Emotions are caused by the interaction of a human-being with the environment and the others, affecting the decisions and actions. There are several types of emotions, being the cognitive emotion the most important for this work. Cognitive emotion is related to knowledge, being actions such as: learning, memorizing, motivating and planning, considered cognitive processes. It is possible to learn to control a certain emotion through cognitive evaluation. An individual is under the effect of a certain emotion during a short period. It is well known and considered for a long time that emotions play a fundamental role in humans, and only recently psychologists began studying emotions as a component that positively affects intelligence and cognitive aspects (Ekman, 1992). A great set of evidences has demonstrated that emotions have impact on reasoning, memory and judging (Li, Qiu, Yue, & Zhong, 2007). Damasio (2006) showed that people with deficiencies at the level of the emotional response, generally adopt weak decisions, severely limiting their interpersonal relationships and their place in society. Gardner (1987) proposed the concept of "multiple intelligences", considering personal intelligence as a specific kind of intelligence that deals with the interaction and emotions. Later, Goleman (1995) used the term "emotional intelligence", recognizing the current point of view that emotion is really an important part of the human intelligence. Lately, the modelling of emotions has had a very strong growth with respect to their computational representation. The incorporation of emotions in games and applications enables a more natural interaction with the user. Nass, Moon, Fogg, Reeves, and Dryer (1995) showed in their work that humans like to communicate with computers in a similar way to that used to interact with other people. With respect to the application area of emotions, Kessler et al. (2008) identified three:

- Artificial emotions: can be used to improve problem solving in complex environments;
- Emotional models: can be used to perform experiments of psychological theories using controlled scenarios;
- Emotions: are fundamental to make computer agents more credible. Emotional models that are able to synthetize and express emotions are needed to make artificial intelligence characters look more human.

Many psychologists have proposed models to describe emotional processes. One of the most popular is the OCC model, developed by Ortony, Clore and Collins, deriving its name from their initials, a model that is widely used to analyze emotions (Ortony, Clore, & Collins, 1990). According to this model, an emotion is triggered as a reaction to: consequences of events, actions of agents, or aspects of objects. Thus, emotional perceptions appear related to the objectives, patterns and preferences of an individual. To calculate the intensity of an emotion, global variables are considered, such as the sense of reality and proximity, as well as local variables, such as the probability of an event to occur, the effort to achieve a goal and the possibility to fulfill an objective. The OCC model also evaluates the preferences and patterns of the agent. The emotions are generated by the interpretation of the agent to the reactions to the consequences of the events, actions of other agents and aspects of the objects. Agents can be people, animals, inanimate objects, or abstractions as institutions. Events are how agents perceive what happens. There are three kinds of value structures underlying the perception of goodness and badness: objectives, norms and attitudes. Patterns are used to assess the actions of an agent. The actions of an agent are evaluated according to his obedience to social norms, morals, or behaviors. Finally, the objects are evaluated as attractive, depending on the compatibility with taste and attitudes of their attributes. One of the many practical implementations of the OCC model was developed by Staller and Petta (1998), who constructed a virtual agent whose emotional architecture related categories of discrete emotions to 14 categories of action-response, covering a wide range of individual actions. The OCC model is also partially congruent with the renowned theory of Frijda (1986).

Another important emotional model was proposed by Roseman, Spindel, and Jose (1990). According to this model, emotions are generated based on an event association procedure. Events are divided into events with consistent motifs and events with inconsistent motifs. The former is defined as being consistent with the objectives of the individual, while the latter, the inconsistent, are events that threaten one of the objectives that the individual proposes to achieve. Events are further classified according to the cause of the event, and can be caused by third parties, by the own individual or by circumstance. Another way to differentiate emotions is that an event was motivated because the subject wanted a reward or wanted to avoid a punishment. A certainty measure was also used as another way to classify events: an event may be declared in an unexpected, certain, or uncertain manner, i.e., subject to a valuation.

2.3. Mood

Mood is a psychological state of an individual that indicates the degree of his mood and well-being Mehrabian (1996), being a way of representing the emotions felt and the individual's personality. A mood is maintained over a period of time until something, such as the emotions felt, give rise to a new mood. A person's mood influences his/her decisions and is important in the way he/she analyzes the received information. There are several models developed to analyze an individual's mood, being PAD (Pleasure, Arousal and Dominance), developed by Mehrabian (1995), one of the most popular. PAD is a model that allows the integration of personality and emotions in order to know the generated mood Mehrabian (1996). This model defines three dimensions which describe the emotional state (mood/temperament) of an individual: pleasant, arousable and dominant (Mehrabian & O'reilly, 1980). These three

dimensions define a three-dimensional space where individuals are represented as points, personality types as regions and personality scales as straight lines that cross the intersection point of the three axes. By using +P, +A, and +D, Mehrabian (1995) refers to pleasure, arousable, and dominant temperament, respectively, and -P, -A, and –D, to unpleasant, unarousable, and submissive temperament.

Another model also well cited is PANAS, developed by Watson, Clark, and Tellegen (1988) is a model often mentioned in literature capable of measuring mood, and is used in many research works. Positive Affect (PA) and Negative Affect (NA) are the scales used in this model. It is composed by two of ten items of psychometric scales that measure positive affect (the extent to which individual feels attentive, interested, alert, excited, enthusiastic, inspired, proud, determined, strong, and active) and negative affect (the extent to which individual feels anguished, angry, hostile, irritated, scared, afraid, ashamed, guilty, nervous, and easily perturbable). PANAS has been demonstrated to be very reliable and easy to apply (Watson et al., 1988), being an instrument frequently used in psychology and other areas (Crawford & Henry, 2004; Mackinnon et al., 1999). Numerical answers are given on a 5-point Likert scale for the ten items of Positive Affect and for the ten items of Negative Affect, which are added to obtain a single score for PA and NA, comprised between 10 and 50.

2.4. Models to define conflict and behavior styles

In this Subsection, we put forward some models that can be used by computer scientists to model anthropomorphic agents. A current problem in the humanization of agents is related to the lack of knowledge that still exists about human psychological functioning, and perhaps even more so regarding the formalization of such knowledge. This problem often leaves computer scientists prone to devise strategies that still lack solid scientific validation. In this regard, a greater investment in multidisciplinary teams becomes of uppermost importance. Next, we advance/put forward some models that, in our view, show the potential of the adaptation to computational systems, regardless of whether they are simulators or real systems.

Kilmann and Thomas (1975) suggested a model for interpersonal conflict-handling behavior, based on Jung's studies and a conflict handling mode proposed by Blake and Mouton (1964), that defines five modes: competing, collaborating, compromising, avoiding and accommodating, according to two dimensions: assertiveness and cooperativeness. As seen in Figure 1, both the dimensions of assertiveness and cooperativeness are related to the integrative and distributive dimensions as discussed by Walton and McKersie (1965). Integrative dimension refers to the overall satisfaction of the group involved in the discussion while the distributive dimension refers to the individual's 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. This association becomes more evident if we conceive competitors as the ones who seek the highest individual satisfaction and 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 that the introversion-extraversion did not overlap with the distributive dimension.

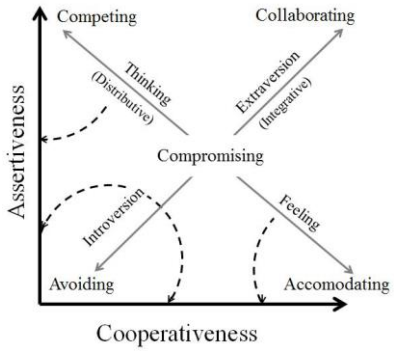


Figure 1. Thomas and Kilmann's model for interpersonal conflict-handling behavior (adapted from Kilmann and Thomas (1975)).

McCrae and John (1992) proposed a set of thirty traits extending the five-factor model of personality which included six facets for each of the factors. These traits were used in a study made by Howard and Howard (1995) in order to help them separate different kinds of behavior styles and identify corresponding themes. They defined a theme as "a trait which is attributable to the combined effect of two or more separate traits" (Howard & Howard, 1995). Those styles and themes are based on common sense and general research, and can be inferred as the conflict styles that were proposed, (Negotiator, Aggressor, Submissive and Avoider). It is also important to refer other suggested relevant styles, 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.

Rahim (1983) created a meta-model of possible styles for handling interpersonal conflict based on two dimensions: concern for self and concern for the other. Later, Rahim and Magner (1995) performed a study to assess the construct validity of the five subscales of the Rahim Organizational Conflict Inventory (Rahim, 1983). The styles defined by Rahim (1983) are presented in Figure 2. He acknowledges the existence of 5 types of conflict styles: integrating, obliging, dominating, avoiding and compromising. In this work, he suggested these styles as means to describe different possible ways of behaving in conflicting situations. The proposed styles are defined according to the level of concern an individual demonstrates for achieving one's own goal or following through on other people's objectives.

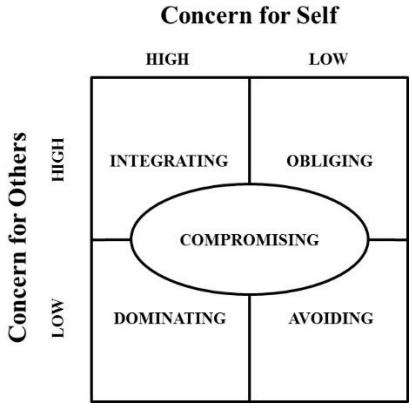


Figure 2. Rahim's proposal of conflict styles (adapted from Rahim and Magner (1995)).

The model proposed by Rahim (1983) also relates to the themes identified by Howard and Howard (1995) 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 the model proposed by Rahim (1983) which does not

relate to a specific theme. In theory, the Compromising style is an intermediate state between the other styles that were identified.

Previously, we proposed a model (Carneiro, Saraiva, Martinho, Marreiros, & Novais, 2018) that intends to allow agents to represent the decision-makers' intentions. We consider the decision-makers' intentions to be what they: intend (a purpose), plan, desire and/or aspire. To reach the decision-maker's intentions the agent should behave accordingly. We adopted the conflict styles proposed by Rahim and Magner (1995), and redefined them to be more adequate to the context of group decision-making. We called them styles of behavior and defined them as follows:

- Dominating: A dominating individual believes that he owns the key to solve the problem. He plays a very active role during the decision-making process and tries to force his opinions on other participants;
- Integrating: An integrating individual favors a collaborative style. He aims to achieve consensual decisions and greatly values his and others' opinions. He prefers to manage assiduously the entire decision-making process;
- Compromising: A compromising individual favors a collaborative style. He aims to achieve consensual decisions and values his and others' opinions. He plays a moderately active role during the decision-making process;
- Obliging: An obliging individual tends to give up on his opinions in favor of the group interests. He prefers to follow others' opinions rather than sharing his owns;
- Avoiding: An avoiding individual prefers to be freed from responsibility. Fundamentally, he prefers to not be involved in the decision-making process and devalues both the process and the opinions of other participants.

Using a correlation between the work proposed by Rahim and Magner (1995) and the facets identified by Costa and MacCrae (1992) we proposed 4 dimensions suitable to the context of group decision-making: activity level, resistance to change, concern for self and concern for others. These dimensions represent:

- Activity level: High activity levels reflect leadership and vigorousness. Low activity levels reflect leisurely and low need for thrills;
- Resistance to change: High resistance to change reflect humble, eager to help and easily moved. Low resistance to change reflect aggressive, superior and skeptical;
- Concern for self: High or low interests to satisfy his or her concerns;
- Concern for others: High or low interests to satisfy the concerns of others.

The information available in the literature only allows to define each style of behavior in these dimensions using classifications as low, mid and high. However, to computerize this model and to make agents represent the intentions as well/accurately as possible, we needed to transform this classifications into numerical values. Moreover, let us suppose that an existent model considers a Dominating behavior as having a low concern for others. How can we know if whenever a decision-maker selects the dominating behavior style to model his agent, he is expecting this "low concern for others"? To deal with these issues, we ran a survey to understand if it was possible to find homogeneous answers to define each style of behavior in each dimension (numerically). The objective was to verify if the behavior styles are perceived in the same way and if that can be expressed numerically. The study involved 64 participants, 39 men and 25 women, aged between 19 and 68 years old (M=33,56; SD=10,84) all of which either had higher education degrees or were undergraduate students (10%). In respect to their fields of expertise, respondents were professionals from a wide variety of backgrounds, ranging from technology to social sciences. Basically, we asked them to classify the five proposed behavior styles in four dimensions: Concern for self; Concern for others; Resistance to change;

and Activity level in a questionnaire ranging from 0-10 (by means of a visual analogic scale). All respondents were asked to fill out the questionnaire in the researcher's presence to ensure engagement in the task and/or to provide assistance in the clarification of concepts or modes of signaling the answers. We used the Intraclass Correlation Coefficient to study the agreement level. For all dimensions results were above ,900, more precisely between ,915 and ,941, with highly significant results (p<,001).

The values obtained in this study helped us to define the actuation levels for each style of behavior in each dimension as can be consulted in Table 1 (the values were normalized to the [0; 1] range). This behavior style model plays an important role in the work proposed in this paper.

Table 1. Behavior style measures for each dimension.

Style of behavior	Activity Level	Resistance to Change	Concern for self	Concern for others
Dominating	0,94	0,92	0,95	0,17
Integrating	0,90	0,54	0,78	0,85
Compromising	0,58	0,42	0,55	0,62
Obliging	0,23	0,12	0,20	0,87
Avoiding	0,05	0,10	0,11	0,09

An interest finding of this work was that none of the proposed styles of behavior is always more advantageous/beneficial over others regardless of context. This is an incentive for decision-makers to choose the style of behavior that better fits to their intentions.

2.5. Satisfaction models

The literature is very poor in terms of satisfaction analysis as an indicator of the perceived decision's quality. The results related to the evaluation of the satisfaction of the decision-makers with the decision made (in group), with the perception of the quality of the decision or with the quality of the decision obtained with the use of a GDSS are practically nonexistent. There are works that study the satisfaction with the use of a GDSS (or of a software in general) and the satisfaction of the decision-maker in the decision process using surveys.

Briggs et al. (2003) presented a theory of meeting satisfaction, which explains the causes of conflicting research results on meeting satisfaction, as these results have never been fully explained in the group support systems literature. Therefore, their theory tries to contribute to a possible development of systems and methodologies that increase group efficiency and group effectiveness, without decreasing meeting satisfaction. The authors proposed and tested the Satisfaction Attainment Theory (SAT) – a causal model of meeting satisfaction. Taking into account the SAT assumptions, satisfaction, i.e., the affective arousal with a positive valance a participant felt after a meeting, would be a function of the perception that, balancing conflicting and mutually exclusive goals, the value of one's goals increased, or the likelihood of their success increased because of the meeting. Meetings that produce positive Perceived Net Goal Attainment (PNGA) should also produce high levels of meeting satisfaction, and meetings that produce negative PNGA should also produce low levels of meeting satisfaction. However, other researchers may choose to define meeting satisfaction according to other factors, such as the degree to which a meeting has fulfilled certain requirements. The difficulty to provide a clear definition of meeting satisfaction reduces the degree to which research on meeting satisfaction can be generalized.

In their work, Paul et al. (2004) explore how the performance of a GDSS affects the different satisfaction dimensions. They focus on three indicators of group performance, namely: the decision time, the efficiency in decision-making and the number of iterations in the group

decision-making process. For each one of these indicators hypotheses that affect satisfaction were created. Example: “H1a – In a GDSS-supported group decision, the higher the decision time, the lower is the satisfaction of a group with the system used by its members.” This model is based on hypotheses and is illustrated in Figure 3.

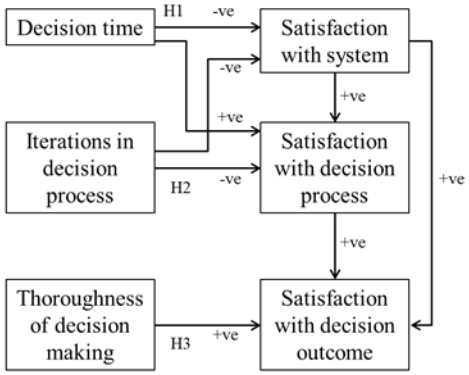


Figure 3. Paul et al. (2004) research model based on hypotheses.

Some of the conclusions obtained from this work demonstrated that the performance of GDSS influences the group members’ satisfaction. When decision time increases, the system appears to be unproductive and the group members’ satisfaction with the system decreases. However, when GDSS meetings end quickly, members may perceive that they are rushed through the process and different alternatives of the decision situation are not adequately evaluated. This is evidenced in the positive relationship between decision time and the members’ satisfaction with the process. The authors found a positive relationship between the thoroughness of decision-making and the group members’ satisfaction with the decision outcome.

Tian et al. (2008) conducted a study on how to measure satisfaction based on the emotional space. The satisfaction measured sought to understand the users’ acceptance of a product by testing its usability. In order to analyze the emotional space, they used the PAD (Pleasure, Arousal and Dominance) model proposed by Mehrabian (1995). To find out his initial emotional state the user must answer to the Big Five Inventory questionnaire, and with the obtained personality he is given a standard emotional state. The emotions generated during the test are detected by observing the user’s behavior. His emotions decay through the process, getting closer to the initial state, as can be seen in Figure 4.

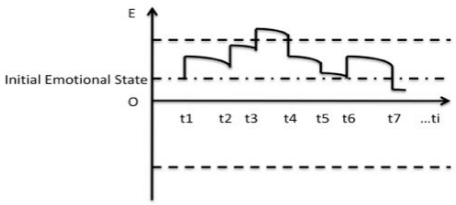


Figure 4. Changes of single dimension in PAD model (adapted from Tian et al. (2008)).

After performing the test and building the emotional map, the emotional changes are registered and their sum is calculated. With emotional values, interesting conclusions are attained. The authors claim that “with a good pleasure emotional state, users can have a smooth thinking and judgment to choose the most effective method to finish the task, so the pleasure state of the users can reflect the affinity and usability of the product in the testing. The arousal degree has a positive effect on usability, but the high level of arousal means that users are in a highly concentrated spirit and get tired easily; on the other hand, also means that users may be thinking about a way to solve the problems. So, a lower level of positive arousal degree reflects the usability of the software operations. The improvement of the user domination means that users

are in an intense state, and that has a negative effect on usability. High usability products should be consistent with the users' traditional habits, without the need to consider the controllable process and solutions of the product. Therefore, the domination degree indirectly reflects the extent of the ease of using the product."

Husain (2012) presented a paper where he included a satisfaction tool to help solve problems in GDSS. The tool is based on linear goal programming (GP) in order to assist GDSS participants in performing group decision-making for problems that have multiple and conflicting alternatives. His objective is to achieve a higher satisfaction for the group using this technique. Some theoretical ideas in this paper are very similar to the ideas described in this paper: (1) the consideration of satisfaction in group decision-making process, (2) the use of satisfaction to achieve better results and (3) the consideration of the classification of the alternatives by the decision-makers to find the optimal solution. The author claims that with this approach it is possible to improve the participants' satisfaction by reducing the deviation by 29%. However, this work does not include all the necessary variables to measure satisfaction, as is possible to verify in the literature (for instance, decision-makers' expectations and the consideration of decision process). In addition, the decision-making process faces some limitations when using the GP strategy, such as: reconfiguration of the problem, impossibility of the decision-maker to add new information during the process, and some limitations related to human-interaction and psychological issues.

3. Proposed Decision Satisfaction Model

The decision satisfaction model presented in this paper follows the assumptions and premises defined in Carneiro, Marreiros, et al. (2015). To evaluate the decision-maker's satisfaction four main points are considered: meeting's outcomes, decision-maker's expectations, decision-maker's intentions and decision-maker's emotional cost. Our proposal deals with these points making use of the typical data configured by the decision-makers in a Web-based GDSS (to support disperse meetings (Bjørn, Esbensen, Jensen, & Matthiesen, 2014)).

3.1. Outcomes

The alternative chosen by the group has an impact in the decision-maker's satisfaction. This is an inescapable fact, since achieving the outcomes is the reason why decision-making process happens. The satisfaction or the perception of the decision quality is related to the outcomes (Carneiro, Marreiros, et al., 2015). However, to understand the impact of the outcomes in the decision-makers, it is necessary to see the big picture. As we have seen in the Section 2 "a decision is perceived as good when its expected value or utility of outcomes is judged to be more beneficial than the alternatives" (Higgins, 2000). Thus, whereas the preferred alternative is the best in the decision-maker's perspective, the distance between the preferred alternative and the chosen one means a loss of the decision-maker's satisfaction. The loss of satisfaction comprises the difference in the assessment made by the decision-maker for each of the alternatives, as well as the one by the participant who did not achieve the final decision. In this work, we consider the participant's assessment of each alternative varying in a [0; 1] range, where 0 means "I do not like at all" and 1 means "I like very much" (see our proposal of a practical implementation based on this in Carneiro, Martinho, Marreiros, and Novais (2015)). To understand the satisfaction considering alternatives comparison, we suggest the following formulas:

$$D_{Lost} = Alt_F - Alt_P \quad (1)$$

$$A_{Conversion} = 2Alt_F - 1 \quad (2)$$

$$D_{Outcomes} = (1 - |A_{Conversion}|) * D_{Lost} + A_{Conversion} \quad (3)$$

Where:

- D_{Lost} is the loss of decision-maker's satisfaction based in the difference between the assessments made for the alternative chosen by the group (Alt_F) and for his preferred alternative (Alt_P). The loss is zero when the chosen alternative is the same as his preferred alternative;
- Alt_F is the assessment made by the participant for the final alternative, alternative chosen by the group;
- Alt_P is the assessment made by the participant for his preferred alternative;
- $A_{Conversion}$ is the conversion of the assessment made by the participant into our scale of dissatisfaction/satisfaction;
- $D_{Outcomes}$ is the participant's satisfaction concerning the outcomes. Intends to evaluate the satisfaction based in the assessment made by the participant to the alternatives, including the loss of satisfaction in the case where his preferred alternative is not chosen by the group.

We assume the $D_{Outcomes}$ is the purely analytical evaluation of the decision-maker's satisfaction. All other remaining points (presented below) have impact in $D_{Outcomes}$. The other points will depend on the context.

3.2. Expectations

In order to study the impact of expectations in decision-maker's satisfaction (and considering the knowledge expressed in previous work (Carneiro, Marreiros, et al., 2015)) we assume the following rules.

$If\ Participant\ achieves\ goals == True$
$Then\ expectations\ impact = Positive\ or\ Neutral$
$If\ Participant\ achieves\ goals == False$
$Then\ expectations\ impact = Negative\ or\ Neutral$

In this work, we consider the Web-based Group Decision Support System as the only existent mechanism for the decision-makers to communicate. Thus, we assume that decision-makers can create expectations (consciously or unconsciously) regarding the chances in attaining their objectives (meeting's outcomes) and the decision process (the set of events that may or may not happen during the period of time in which the decision process occurs). In this Subsection only the former is considered, the latter will be included in the Subsection 3.4.

In a real scenario, decision-makers are creating expectations all the time: "Is he going to accept my request?"; "Will he help me support my idea?", etc. However, when automated negotiation techniques are used, the decision-makers only create expectations about issues from what they can expect something from and which they can interact with. We consider that expectations can influence satisfaction in three different ways:

- Positive impact: When the results exceed the expectations;
- Negative impact: When the expectations are not achieved;
- Without impact: When the expectations are achieved.

We defined that decision-maker's expectation is represented by a numerical value within the range [0; 1]. To evaluate expectation in this context, approaches as the ones proposed in Carneiro, Martinho, et al. (2015) can be used. The calculus of satisfaction including expectations is divided in 2 different conditions. Firstly, we address the situation where expectations are matched. This means, the expectations have a positive impact in satisfaction.

Secondly, we address the situation where expectations are not matched, i.e., the expectations have a negative impact in satisfaction.

Positive Impact. This type of impact occurs when the chosen alternative is the one preferred/supported by the participant. In this case, the impact of the expectation will be positive or neutral (in case the expectation is 1). The following formula is used to calculate the positive impact:

$$P_{Impact} = (1 - E) * Alt_S \quad (4)$$

Where:

- E is the participant's expectation regarding the possibility of his preferred/supported alternative being chosen by the group;
- Alt_S is the assessment made by the participant regarding the supported alternative.

For a better understanding of the proposed formula, let us consider the scenarios where the impact should have the maximum and minimum values (extreme cases):

- The positive impact should be 1 (maximum impact) when the participant's expectation regarding the preferred/supported alternative being chosen by the group is 0 and the value of alternative assessment is 1;
- The positive impact should be 0 (no impact) when the participant's expectation regarding the preferred/supported alternative being chosen by the group is 1. This means that the decision-maker is taking it for granted. The maximum expectation on a positive situation does not bring any increased satisfaction as a form as impact.

We can include now the expectations in the satisfaction calculation. $D_{Outcomes}$ can be recalculated using the following formula:

$$D_{Outcomes} = D_{Outcomes} + (1 - |D_{Outcomes}|) * P_{Impact} \quad (5)$$

The most important point of this formulation is the possibility to recalculate the $D_{Outcomes}$ satisfaction using the impact in a form of a variable.

In our proposal, we first understand which impact the expectation has (according to the different situations) and use the correct impact next (calculated according to the context). The use of $(1 - E)$ in our formula intends to reflect the difference between the maximum expectation (which would be 1) and the participant's expectation.

Negative Impact. This type of impact occurs when the chosen alternative is not the one preferred/supported by the participant. In this case the impact of the expectation will be negative or neutral (in case the expectation is 0). The following formula is used to calculate the negative impact:

$$N_{Impact} = (Alt_S - Alt_F) * E \quad (6)$$

In the case of a negative impact, we propose a different formula because in this situation the impact represents an expectation that has not been met, symbolizing a loss. Moreover, in this situation, to truly understand the expectation impact, we need to analyze the relation between this loss and the difference between the assessments of his preferred alternative and the one chosen by the group. As we have done before, let us consider the scenarios where the impact should have the maximum and minimum values (extreme cases):

- The negative impact should be 1 (total impact) when the participant's expectation regarding the preferred/supported alternative being chosen by the group is 1, the

assessment of the alternative chosen by the group is 0 and the assessment of his preferred/supported alternative is 1;
- The negative impact should be 0 (no impact) when the expectation is 0.

We can include now the expectations in the satisfaction calculation. $D_{Outcomes}$ can be recalculated using the following formula:

$$D_{Outcomes} = D_{Outcomes} + \big((1 - |D_{Outcomes}|) * (-1)\big) * N_{Impact} \quad (7)$$

3.3. Intentions

Previously (Carneiro et al., 2018), we proposed a model to define styles of behavior in agents to represent the decision-makers' intentions. In this proposal, we consider those styles of behavior to formulate the satisfaction model. However, this proposal can be easily adapted to situations where aspects such as personality and conflict styles are used. In this satisfaction model, we aim to assess the decision-maker's satisfaction, so we use behavior to understand the impact of the process in the decision-maker. The process impact will vary according to the decision-maker's intentions. For instance, let us consider a situation where the participant defined his conflict style as "Dominating". If he notices that the most of other decision-makers do not like his preferred alternative, we can associate to him emotions as: distress and fear. On the other hand, if the participant defined his conflict style as "Obliging", he may not feel the same emotions (or at least with same intensity) because his main intention is not to achieve is preferred alternative but to please some other/s decision-maker/s. This is a simple example to demonstrate that the impact will vary according to how the decision-maker experiences the process.

We consider a set of events that decision-makers experience using a GDSS and correlate them with styles of behavior (using the OCC model (Ortony et al., 1990)). Ortony et al. (1990) proposed a global structure of emotion types where they defined "valenced reaction to": consequences of events, actions of agents and aspects of objects. For our purpose, we only use the consequences of events. Into the consequences of events they distinguish between the consequences for other and consequences for self, what means a remarkable correlation with the classification of conflict styles proposed by Rahim and Magner (1995) where they defined the conflict styles according to the concern for self and the concern for others. We use the concern for self and concern for others' dimensions to calculate the appropriate events' impact according to the decision-maker's intentions.

The considered set of events are expressed in the Table 2. (CO is consequences for other and CS is consequences for self). "Concern for self" type events refer to situations that the decision-maker identifies as "consequences for self", on the other hand, "Concern for others" type events relate to situations that the decision-maker identifies as "consequences for others". This means that if a decision-maker encounters, for example, event 4, this event (which presents "consequences for self") will have a greater impact on decision-makers with a behavior style that has a higher "Concern for Self" value. In other words, when a decision-maker experiences a "Concern for Self" type event, the emotions associated with that event are weighted with the value that the decision-maker's style of behavior has in concern for self dimension. The same is obviously applied to the "Concern for Others" type events.

Table 2. Considered events and respective description.

#	Event	CS	CO	Emotions
1	Participant's preferred alternative was chosen by the group	✓	×	Joy
2	Participant's preferred alternative was not chosen by the group	✓	×	Distress
3	Participant changed his preference to another alternative	✓	×	Hope (+ rules)
4	The majority prefers the participant's preferred alternative	✓	×	Joy, Hope (+ rules)

5	A few or none decision-maker prefers the participant's preferred alternative	✓	×	Distress, Fear (+ rules)
6	The preferred alternative of the decision-maker/s that the participant considers credible/important was chosen by the group	×	✓	Happy-for
7	The preferred alternative of the decision-maker/s that the participant considers credible/important was not chosen by the group	×	✓	Pity
8	The majority prefers the participant's preferred criterion	✓	×	Joy, Hope (+ rules)
9	A few or none decision-maker prefers the participant's preferred criterion	✓	×	Distress, Fear (+ rules)

According to Ortony et al. (1990) special rules must be applied when the decision-maker experiences hope and fear:

$If\ Participant\ experience\ hope\ and\ it\ is\ confirmed$
$Then\ Participant\ will\ experience\ satisfaction$
$If\ Participant\ experience\ hope\ and\ it\ is\ not\ confirmed$
$Then\ Participant\ will\ experience\ disappointment$
$If\ Participant\ experience\ fear\ and\ it\ is\ confirmed$
$Then\ Participant\ will\ experience\ fears-confirmed$
$If\ Participant\ experience\ fear\ and\ it\ is\ not\ confirmed$
$Then\ Participant\ will\ experience\ relief$

3.4. Emotional changes and mood variation

Due to the brilliant work proposed by Gebhard (2005) where he correlates the PAD and the OCC model, many works appeared using the triggered emotions in order to update the mood state (including ourselves). For this model, we propose a correlation between the events defined in Subsection 3.3 with a set of triggered emotions for each of the situations. We used the work proposed in Ortony et al. (1990) to define a set of emotions for each of events and analyze the emotions triggered during the process to understand the emotional cost.

In Table 2, we presented the set of considered events and the emotions associated to each event. As we can see, all the events are in some way related to the alternatives and criteria. These events describe the scenarios the decision-makers face every time they interact with the system (GDSS). However, it is also important to define the impact of each event. The impact of "Participant's preferred alternative was not chosen by the group", should be different if previously the participant faces an event of "A few or none decision-maker prefers the participant's preferred alternative" or an event of "The majority prefers the participant's preferred alternative". That's why it is crucial to include in our math the expectations created by the decision-maker throughout the process (already introduced in Subsection 3.2.) to better understand the event impact.

Thus, we consider the process expectations:

$$P_{Expectations} = N_p/N_t \quad (8)$$

Where:

- N_p is the number of decision-makers supporting the participant's preferred alternative or some other decision-maker/s that the participant considers credible/important;
- N_t is the total number of decision-makers.

The $P_{Expectations}$ calculated in each event will have impact in the emotions calculated in the next interaction because every time a decision-maker faces a new situation, he will be affected

by the new information plus the expectations that he created based in previous information. Next, we will describe how to process the emotions created in each situation:

Let Emo_S be a set of emotions of one situation:

$$Emo_S = \{(P_1, A_1, D_1), \ldots, (P_n, A_n, D_n)\} \quad (9)$$

Where:

- n is the number of created emotions;
- P_i, A_i, D_i are the values of Pleasure, Arousal and Dominance for emotion i (based in [27]).

Let Emo_T be the sum of emotions in Emo_S:

$$Emo_T = \sum_{i=1}^{n}(P_i, A_i, D_i) \quad (10)$$

Where:

- n is the number of created emotions;
- $P_i, A_i, D_i \in Emo_S$.

Let Int_{Emo_T} be the intensity of Emo_T considering the value of the style of behavior being used by the decision-maker in the "Concern for self" or "Concern for others" dimension:

$$Int_{Emo_T} = \frac{\sqrt{(P)^2+(A)^2+(D)^2}}{\sqrt{3}} * \beta_{Dim} \quad (11)$$

Let $Exp_{Int_{Emo_T}}$ be the Int_{Emo_T} considering $P_{Expectations}$:

$$Exp_{Int_{Emo_T}} = Int_{Emo_T} * P_{Expectations} \quad (12)$$

Let $Pos_{Emotions}$ be the sum of intensities of all positive emotions (joy, hope, happy-for, satisfaction and relief) created in each situation along the process:

$$Pos_{Emotions} = \sum_{i=1}^{n}\left(Exp_{Int_{Emo_{T_i}}}\right), Emo_S \; is \; a \; set \; of \; positive \; emotions \quad (13)$$

Let $Cons_{Emotions}$ be the sum of intensities of all negative emotions (distress, fear, pity, disappointment and fears-confirmed) created in each situation along the process:

$$Cons_{Emotions} = \sum_{i=1}^{n}\left(Exp_{Int_{Emo_{T_i}}}\right), Emo_S \; is \; a \; set \; of \; negative \; emotions \quad (14)$$

After calculating $Pos_{Emotions}$ and $Cons_{Emotions}$, we compare the two intensities to understand the emotional cost. According to that, we propose the following simple rules:

$If \; Pos_{Emotions} == Cons_{Emotions}$
$Then \; Emotional_{Cost} = Neutral$

$If \; Pos_{Emotions} > Cons_{Emotions}$
$Then \; Emotional_{Cost} = Positive$

$If \; Pos_{Emotions} < Cons_{Emotions}$
$Then \; Emotional_{Cost} = Negative$

Now, we normalize the $Pos_{Emotions}$ and $Cons_{Emotions}$, such that $Pos_{Emotions} + Cons_{Emotions} = 1$:

$$Norm_{Pos_{Emotions}} = Pos_{Emotions}/(Pos_{Emotions} + Cons_{Emotions}) \quad (15)$$

$$Norm_{Cons_{Emotions}} = Cons_{Emotions}/(Pos_{Emotions} + Cons_{Emotions}) \quad (16)$$

The difference of intensities will then be considered as a gain or a loss (or neutral in case of no emotional cost). Let us assume this value as $Cost$:

$$Cost = Norm_{Pos_{Emotions}} - Norm_{Cons_{Emotions}} \quad (17)$$

Finally, with the objective of considering the emotional impact according to the importance of the process for the decision-maker, we defined that:

$If\ Emotional_{Cost} == Positive\ or\ Emotional_{Cost} == Neutral$
$Then\ Cost = Cost * Alt_P$
$Else\ Cost = Cost * (Alt_P - Alt_F)$

3.5. Final satisfaction calculation

Considering the value of participant's satisfaction concerning the alternative chosen by the group and the value of his mood (both contemplating the expectations), now we are going to join them to do our final calculation of satisfaction:

$$Satisfaction = D_{Outcomes} + (1 - |D_{Outcomes}|) * Cost \quad (18)$$

The end result of satisfaction will belong to the interval [-1; 1].

The scale of satisfaction presented in Table 3, developed and inspired from the work of Babin and Griffin (1998), reflects the satisfaction with the final result obtained by the model here introduced.

Table 3. Scale of satisfaction.

Designation	Interval
Extremely Satisfied	[0,75; 1]
Much Satisfaction	[0,5; 0,75[
Satisfaction	[0,25; 0,5[
Some Satisfaction	[0; 0,25[
Some Dissatisfaction	[-0,25; 0[
Dissatisfied	[-0,5; -0,25[
Very Dissatisfied	[-0,75; -0,5[
Extremely Dissatisfied	[-1; -0,75[

4. Study 1

The first hypothesis we planned to study (h1) was to understand how the proposed satisfaction model can correctly (mathematically) express the assumptions and premises defined in Carneiro, Marreiros, et al. (2015). For this, several tests were carried out, which consisted in verifying if the satisfaction result calculated by the proposed satisfaction model obeys the assumptions and premises defined in Carneiro, Marreiros, et al. (2015). To perform our simulations, we used a prototype (previously developed) that uses a negotiation architecture based on social networks (Carneiro, Martinho, Marreiros, & Novais, 2016) and implements the argumentation-based dialogue model proposed in Carneiro, Martinho, Marreiros, Jimenez, and Novais (2017). All the simulations carried out consisted of inserting a set of previously defined inputs in order to see if the obtained results varied according to what was expected.

Considering that the proposed satisfaction model includes the aspects considered in the assumptions defined in Carneiro, Marreiros, et al. (2015), the main objective was to understand if the proposed model validates the premises defined in Carneiro, Marreiros, et al. (2015). In Carneiro, Marreiros, et al. (2015) 9 premises were defined "that need to be validated by a decision satisfaction analysis model to be complete":

- P1: "When expectations are exceeded the final satisfaction will be positively affected";

- P2: “When the expectation is maximum and the result is the expected, expectations do not influence satisfaction”;
- P3: “Expectations have a greater impact on events that are considered most important”;
- P4: “When the expectations are not reached, final satisfaction will be negatively affected”;
- P5: “When there are no expectations and the final outcome is not as expected, expectations do not affect satisfaction”;
- P6: “A positive emotional cost positively affects the final satisfaction”;
- P7: “A negative emotional cost negatively affects the final satisfaction”;
- P8: “A neutral emotional cost will not affect final satisfaction”;
- P9: “The adopted strategy affects satisfaction”.

The first experiment aimed to study premises P1 and P2. To that end, 231 simulations were carried out, which consisted in varying the participant’s expectations and evaluating the preference of his preferred alternative, in order to determine if his satisfaction (calculated by the proposed model) with the decision would vary according to what was defined in P1 and P2. The participant agent has always been the same throughout all simulations and is referred to in this paper as DM_x ($Decision - Maker_x$). In order to study P1 and P2 it was also considered that the alternative selected by the group was always the preferred of DM_x, since it was only intended to study the situations in which expectations were met or exceeded. As previously stated, the expectation in relation to the “Probability of the participant’s preferred alternative to be chosen” varies in the [0; 1] range. The final satisfaction varies in the range [-1; 1] and the preferences of alternatives vary in the range of [0; 1]. Figure 5 presents the results obtained in this experiment. At the top of Figure 5 are presented the evaluations considered regarding the preferred alternative of DM_x (0; 0,1; 0,2; 0,3; 0,4; 0,5; 0,6; 0,7; 0,8; 0,9; 1,0). For each of these preferences, 21 simulations were performed, where expectations were varied (Figure 5 – x-axis) of DM_x (0,00; 0,05; 0,10; 0,15; 0,20; 0,25; 0,30; 0,35; 0,40; 0,45; 0,50; 0,55; 0,60; 0,65; 0,70; 0,75; 0,80; 0,85; 0,90; 0,95; 1,00). In Figure 5, it is presented the final satisfaction of the DM_x calculated for each scenario. As is clear for each of the 11 alternative preference evaluations, the final satisfaction is higher in scenarios where the expectation was lower. This only did not happen in two situations: when the evaluation of the alternative is maximum (1) and when the evaluation of the alternative is minimal (0). In the scenario where the evaluation is maximum, the final satisfaction never changes because it is already maximum, so expectations end up not having influence since we are dealing with a finite scale. In the scenario where the evaluation is minimal, expectations also do not influence the satisfaction since the participant does not have any type of preference for the alternative in question.

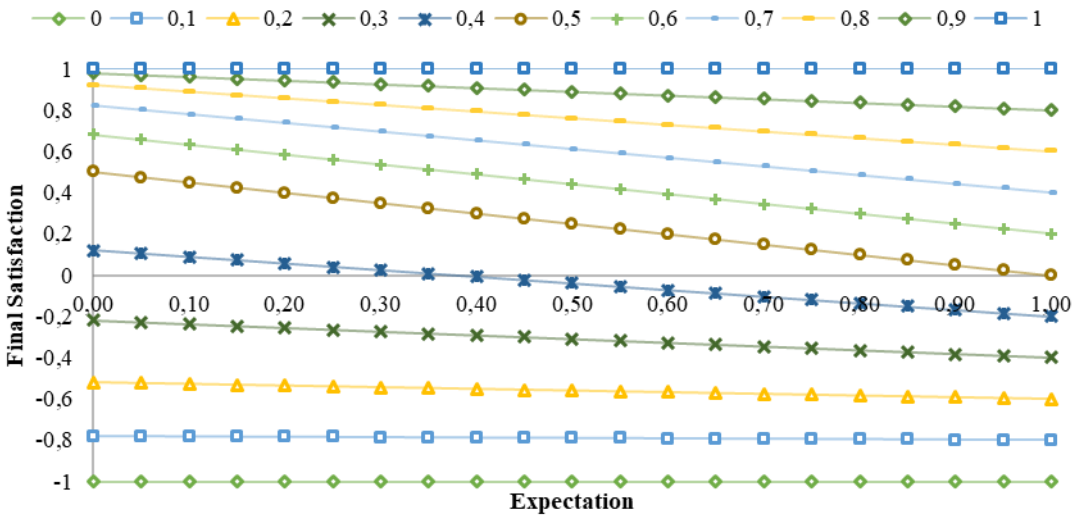


Figure 5. Expectations' positive impact on final satisfaction.

This way, we may consider that the proposed model validates P1. In relation to P2, it is also verified that the proposed model validates this premise. As can be seen in formula 4 of the proposed model, when we are faced with a scenario in which the preferred of DM_x is the one chosen by the group (and expectations can have a positive impact on the satisfaction calculation), the fact that the expectation is 1 results (according to formula 4) on an impact of 0. This means that P2 is validated because the fact that the expectation is 1 has no influence on the satisfaction calculation.

The second experiment aimed to study P3. To study P3 we used the same simulations (231) that were performed in the first experiment, but in this case the value we were interested in studying was the calculation of the impact of the expectation rather than the calculation of the final satisfaction. Figure 6 presents the results obtained in this experiment.

At the top of Figure 6 are presented the evaluations considered regarding the preferred alternative of DM_x (0; 0,1; 0,2; 0,3; 0,4; 0,5; 0,6; 0,7; 0,8; 0,9; 1,0). For each of these preferences, 21 simulations were performed, where expectations were varied (Figure 6 – x-axis) of DM_x (0,00; 0,05; 0,10; 0,15; 0,20; 0,25; 0,30; 0,35; 0,40; 0,45; 0,50; 0,55; 0,60; 0,65; 0,70; 0,75; 0,80; 0,85; 0,90; 0,95; 1,00). In Figure 6 of the y-axis, the expectation impact calculated for each scenario is presented. As is clear for each of the 11 alternative preference evaluations, the expectation impact is greatest in scenarios where the preferred alternative has a higher rating. This is true for all cases where the expectation is the same. In this way, it was possible to clearly perceive that the proposed model validates P3.

The third experiment aimed to study P4 and P5. To do this, 168 simulations were carried out, which consisted in varying the participant's expectations and evaluating the preference of his preferred alternative, in order to determine if his satisfaction (calculated by the proposed model) with the decision varied according to what was defined in P4 and P5. To study P4 and P5 it was also considered that the alternative selected by the group was never the preferred alternative of DM_x, since it was only intended to study situations in which expectations were not matched or did not affect satisfaction. To do so, it was considered that the alternative chosen by the group was evaluated by DM_x in 0.2 (making it always the comparison value/value to be compared). Figure 7 shows the results obtained in this experiment.

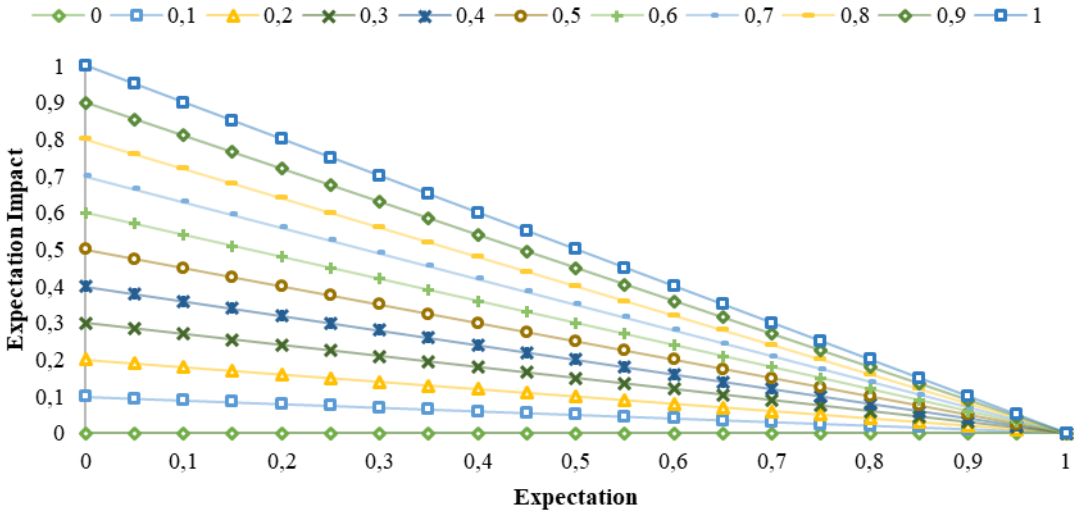


Figure 6. Expectations' impact according to the level of preference.

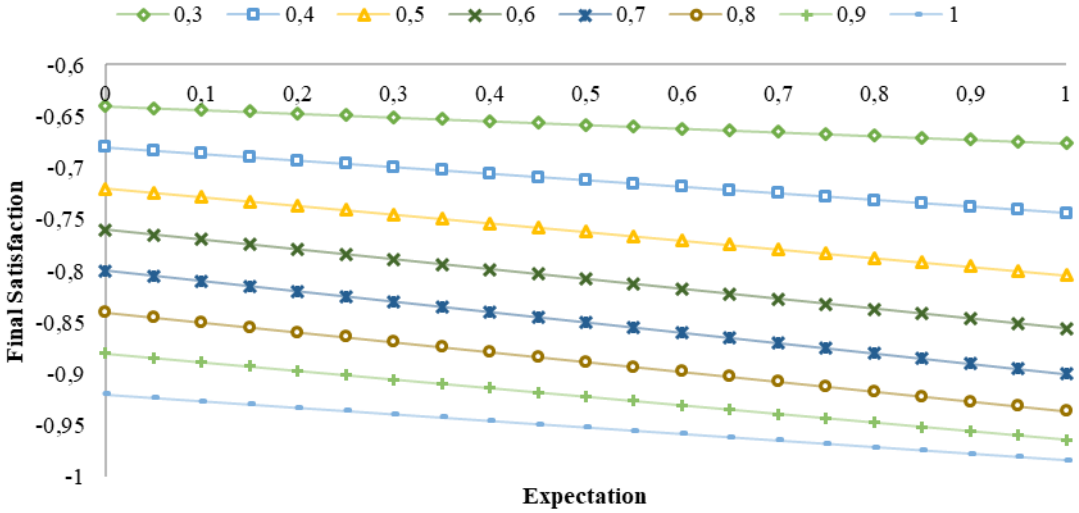


Figure 7. Expectations' negative impact on final satisfaction.

In the upper part of Figure 9 are presented the evaluations considered in regard to the preferred alternative of DM_x (0,3; 0,4; 0,5; 0,6; 0,7; 0,8; 0,9; 1,0). In this case the evaluation of the preferred alternative begins at 0,3 since it must have at least a value higher than that used to evaluate the preference of DM_x relative to the alternative chosen by the group (0,2). For each of these preferences, 21 simulations were performed, where the expectations were varied do DM_x (0,00; 0,05; 0,10; 0,15; 0,20; 0,25; 0,30; 0,35; 0,40; 0,45; 0,50; 0,55; 0,60; 0,65; 0,70; 0,75; 0,80; 0,85; 0,90; 0,95; 1,00). In Figure 7, the final satisfaction of DM_x is calculated for each scenario. As is clear for each of the 11 alternative preference evaluations, the final satisfaction is lower in scenarios where the expectation was higher. This way, we can consider that the proposed model validates P4 because it is verified that in scenarios in which the expectations are not reached the final satisfaction is negatively affected. In addition, we found that the higher the expectations, the greater the negative impact. Regarding P5, it is also verified that the proposed model validates this premise. As is shown in formula 6 of the proposed model, when we are faced with a scenario in which the preferred alternative of DM_x is not the one chosen by the group (and expectations may have a negative impact on the satisfaction calculation), the fact

that the expectation is 0, results (according to formula 6) on an impact of 0. This means that P5 is validated because the fact that the expectation is 0 has no influence on the satisfaction calculation.

In order to study P6, P7, P8 and P9, no simulations were performed because the formulation of the proposed model itself allows us to validate these premises. As we have seen in formula 18 of the model proposed in this paper, the *Cost* (emotional) is considered and has an impact on the final calculation of satisfaction. As such, in case *Cost* is positive, it will have a positive impact on the satisfaction calculation, which allows us to validate P6, in case Cost is negative it will have a negative impact on the satisfaction calculation, which allows us to validate P7. In the case of Cost being 0, either because no emotions were generated during the process, or because (incredibly) the intensity of positive emotions and the intensity of negative emotions cancel each other out, there will be no impact on the calculation of satisfaction, which allows you to validate P8.

Finally, as shown before, this model allows decision-makers to select one of several styles of behavior to be represented with. This way, decision-makers can define a strategy that best represents their intentions, which may generate different emotions and different intensities (since different events are considered). As follows, it is obvious that with different emotions and different intensities, the adopted strategy affects the satisfaction in different ways, which in turn allows us to validate P9.

5. Study 2

In this Section we intended to determine how our model would be able to predict the participants satisfaction. For this, we developed a prototype of a Web-based GDSS that allows participants to express their preferences regarding four possible alternatives. Also, they were asked to express their expectations towards having the group decide in accordance to their preferences, in various steps of the decision-making process, being allowed to (re)set their preferences between different rounds and also to (re)set the style of behavior to be represented with. In order to achieve this, first, as previously put forward in (h2) we needed to empirically validate the system's ability to accurately predict the user's satisfaction, comparing the predicted and the reported satisfaction. Besides evaluating the ability to match the participants expectations, we intended to achieve some more in-depth insight upon their own perception of satisfaction, i.e., to see if the system may go beyond their ability to do so.

5.1. Method

5.1.1. Participants

In this study participants were 43 adults, 27 men and 16 women, aged between 21 and 64 years old (*M=33,4; SD=11,47%*) most of which either had higher education degrees or were undergraduate students, whereas 9,3% didn't attend higher education. In respect to their fields of expertise, respondents were professionals from a wide variety of backgrounds, ranging from technology to social sciences. In Figure 8 we present their distribution.

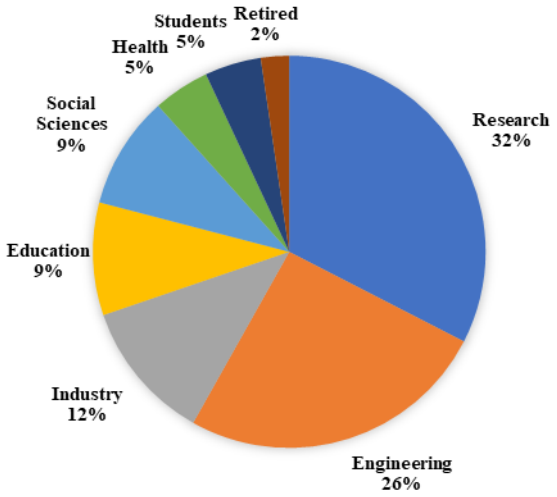


Figure 8. Distribution of participants according to area of expertise.

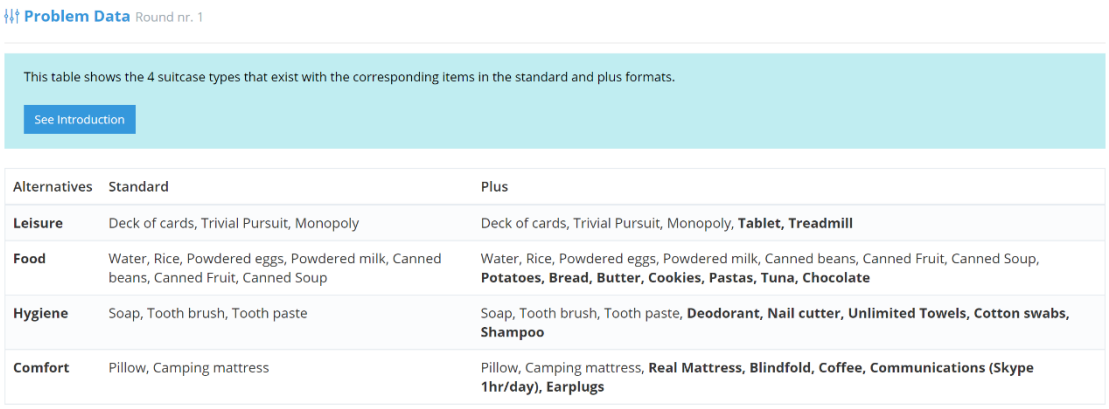
5.1.2. Procedure

In this study, (real) participants were asked to engage in a fictional scenario where they were supposed to imagine that they had been selected to take part in the preparation of a mission to Mars, and where a group decision was to be made regarding the most well-equipped type of items they were to carry with themselves, among four alternatives, each emphasizing one area of their needs: Leisure, Food, Hygiene and Comfort.

For a better understanding, actual instructions were as follows:

> *"Welcome, adventurer! Congratulations! You have been selected as one of the few that will take part in the mission to Mars scheduled for 2021.You will integrate a team of 12 passengers with whom you will have opportunity to participate in the preparation of the trip. (…) Each passenger will carry 4 suitcases and each suitcase will be of a different type (Leisure, Food, Hygiene and Comfort). Each type of suitcase exists in 2 formats: standard and plus. Passengers can only carry one of the suitcases in the plus format, which, once chosen, will be the same for everyone. It is intended that together with the remaining passengers you choose the type of upgraded suitcase to be carried as the plus version. This application allows you to express your preferences regarding each type of suitcase and to follow how the expression of preferences by the rest of the group unfolds. The decision process consists of several rounds, among which you can reset your preferences. If no consensus is reached within a maximum of 5 rounds, the suitcase with the highest number of supporters will be the selected one."*

The Figure 9, regarding our problem data, presents the items that constitute the standard and the plus version of the suitcases.



Alternatives	Standard	Plus
Leisure	Deck of cards, Trivial Pursuit, Monopoly	Deck of cards, Trivial Pursuit, Monopoly, **Tablet, Treadmill**
Food	Water, Rice, Powdered eggs, Powdered milk, Canned beans, Canned Fruit, Canned Soup	Water, Rice, Powdered eggs, Powdered milk, Canned beans, Canned Fruit, Canned Soup, **Potatoes, Bread, Butter, Cookies, Pastas, Tuna, Chocolate**
Hygiene	Soap, Tooth brush, Tooth paste	Soap, Tooth brush, Tooth paste, **Deodorant, Nail cutter, Unlimited Towels, Cotton swabs, Shampoo**
Comfort	Pillow, Camping mattress	Pillow, Camping mattress, **Real Mattress, Blindfold, Coffee, Communications (Skype 1hr/day), Earplugs**

Figure 9. Composition of the different suitcases to choose from.

They were then asked to express how they would value their preference towards each suitcase by means of a slide bar ranging from “Not Preferred at all” to “Totally Preferred”. Since the chosen template allows us to set the values with all bars being visible together, the task of valuing the alternative automatically entails the purpose of comparison. Figure 10 depicts the instructions and the slide bars to value each alternative, as they were shown to the participant.

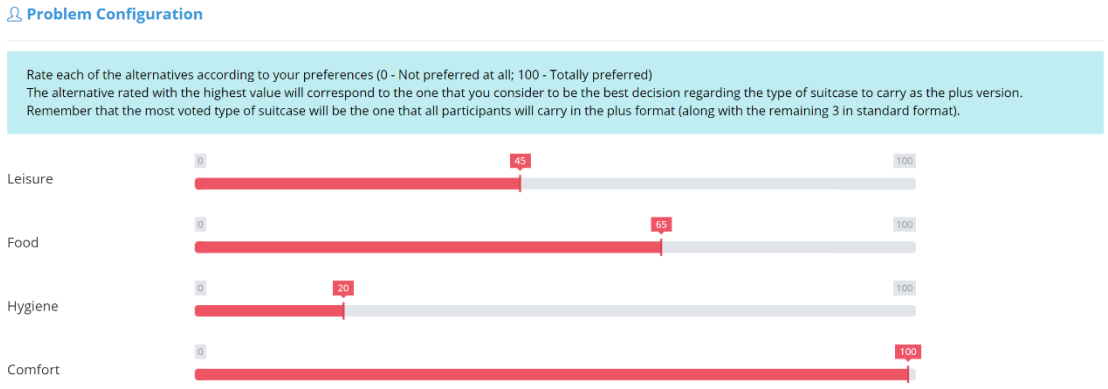


Figure 10. Slide bars used by the participant to define his/her preferences.

Additionally, participants were asked to define the style of behavior with which they would like to be represented in their simulated interaction and also to state their perceived level of expertise regarding the task in hand (Figure 11). This choice of level of expertise was introduce merely for dramatic effect and to promote a greater involvement in the task, not being subject to any computation.

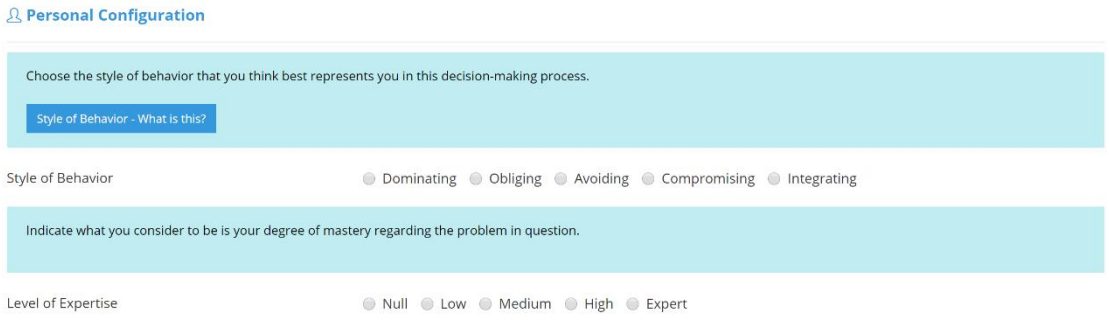


Figure 11. Configuration of the participant’s style of behavior and expertise level.

After configuring all the problem and personal settings participants proceeded to the simulated rounds and got feedback after each one regarding how many supporters each alternative was gathering at that point (Figure 12).

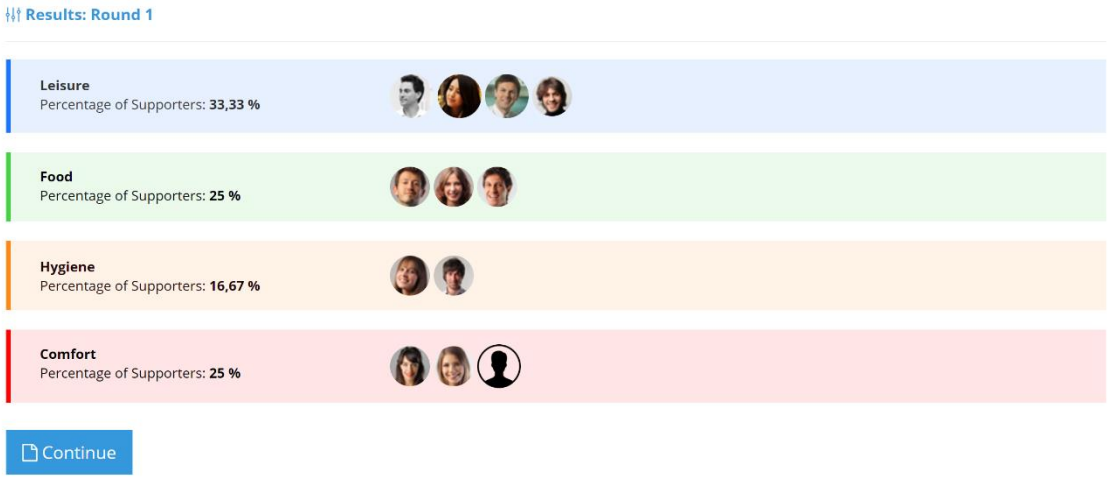


Figure 12. Presentation of supporters for each alternative.

Upon seeing this, they were asked to (re)set their expectations in light of new information and were able to redefine their preference and/or behavior style to try to facilitate the pursuit of their goal, either new or the one initially stated. In the end of the five rounds, participants were asked to express their satisfaction with the final decision by means of a slide bar ranging from "Extremely Dissatisfied" to "Extremely Satisfied" and only in a second phase (so as not to influence the evaluation of the satisfaction made by the participants) they were asked if they agreed with the satisfaction predicted by the model.

5.2. Results

To interpret the results, it was essential to include a certain amount of sensitivity in order not to compromise the scientific validity of the study. Obviously, the prime objective was to assess the ability of the model to predict decision-makers' satisfaction with the decision. However, there were a number of factors that had to be considered in such a way that the evaluation of the model's ability to predict satisfaction was properly elaborated. Since at the end of each decision process each participant was questioned whether he/she agreed with the satisfaction provided by the model, i.e., if the designation presented (Table 3) by the system corresponded to its final satisfaction, in a simplistic way this percentage of agreement could be considered as the probability of the model to correctly measure satisfaction. Out of 43 participants, 38 (88,4%) agreed with system's prediction regarding the scale before mentioned in Table 3 (not excluding any case, even if it later is possible it is to be addressed as possible error or outlier).

As mentioned earlier (Subsection 5.1), at the end of the decision process participants were asked to express their satisfaction with the final decision by means of a slide bar ranging from "Extremely Dissatisfied" to "Extremely Satisfied" and only in a second phase (so as not to influence the evaluation of the satisfaction made by the participants) they were asked if they agreed with the satisfaction predicted by the model. In Figure 13 the satisfaction of all participants is presented, with reported and predicted values. For each participant is presented the satisfaction expressed by the participant using the slibe bar (Reported Satisfaction) and the satisfaction predicted by the model (Predicted Satisfaction).

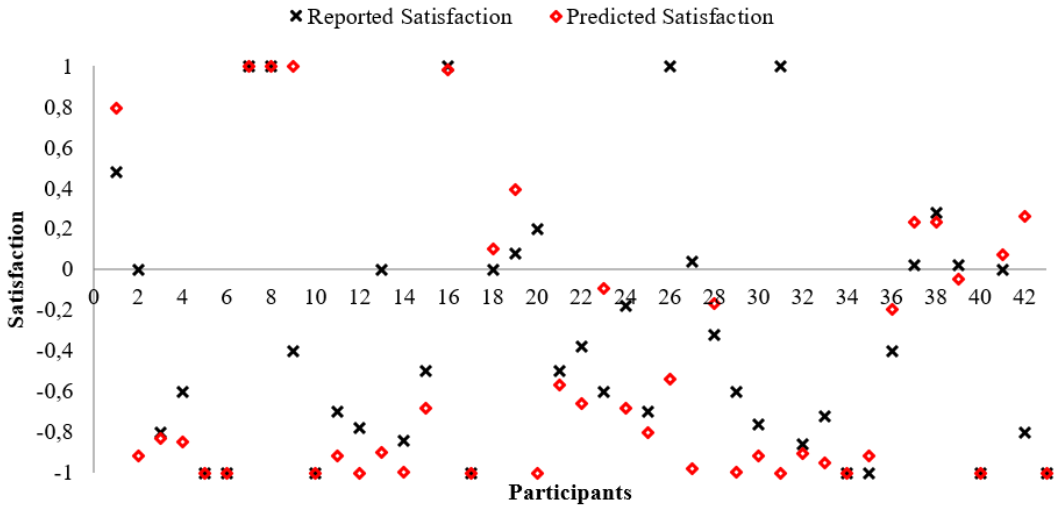


Figure 13. Participants' satisfaction – reported and predicted values.

In a first moment, we tried to understand why 5 of the 43 participants (11,6%) did not consider the prediction of satisfaction presented by the model to be correct. For this, each case was analyzed individually.

Participant 20 clearly adopted a strategic approach, artificially polarizing his/her positions (Table 4) trying "to beat the system", forcing it in the direction of his/her preferred alternative and pretending to dislike an alternative that he/she actually did like. However, when asked to evaluate his satisfaction with the final decision, he/she evaluated it as "Some Satisfaction", which clearly means that the evaluation of 0 (in the interval [0; 1]) with which he/she evaluated the alternative chosen by group clearly did not represent his/her real preference for this alternative. This is undoubtedly one of the greatest future challenges of this type of model, to be able to see if the reappraisal of a particular alternative occurs due to a real change of opinion (due to arguments that have been changed, or other factors) or if it only happens due to a decision maker's intent to manipulate the system.

Table 4. The set of participants who did not consider the satisfaction predicted by the model to be correct (11.6%).

Participant	Reported Satisfaction [-1; 1]	Predicted Satisfaction [-1; 1]	Chosen Alternative [0; 1]	Preferred Alternative [0; 1]
20	0,20	-1	0	1
26	1	-0,539	0,46	0,75
31	1	-1	0	1
40	-1	-1	0	1
42	-0,8	0.260	0,75	0,9

Participant 40 (Table 4) is clearly an example of someone who made a mistake when he/she rated the satisfaction presented by the model as incorrect. So, let's see, he/she evaluated the alternative chosen by the group as "Not Preferred at all" (numerically evaluated it as 0 in the interval [0; 1], evaluated its preferred alternative as "Totally Preferred" (numerically evaluated it as 1 in the interval [0; 1]) when asked to rate his/her satisfaction with the final decision rated his/her as "Extremely Dissatisfied" (numerically rated his/her satisfaction as -1 in the range [-1; 1]) which makes sense considering that he/she rated her preferred alternative with a "maximum preference" and evaluated the alternative chosen by the group with "a minimum preference" and finally when asked if it agreed with the "Extremely Dissatisfied" satisfaction prediction, it replied that it was not. This way, the satisfaction predicted by the model was correct.

Finally, of the 11,6% of the participants who did not agree with the evaluation predicted by the model, 3 of them (6,9% – participants 26, 31 and 42) presented a scenario that only allowed us to conclude that these fit into one of two possibilities : (1) the study was not internalized (by these participants) with a level of seriousness that would at least approximate a real scenario, which resulted in somewhat random or not very serious configurations; (2) the participants had difficulties in expressing/evaluating their own satisfaction, as we will see later on, which is also something that has happened in some participants who agreed with the prediction of satisfaction presented to them by the model.

The study of each of the 5 participants who did not agree with the satisfaction predicted by the model showed that there are situations (even if for different reasons) in which the participants are not able to correctly express their satisfaction. What on the one hand is positive in the sense that it illustrates another benefit of the model presented in this paper, on the other hand, denoted the need to analyze almost every single case of the remaining 88,4% of participants who considered that the forecast of the satisfaction presented by the model was correct. Of these 88,4%, only 45% reported a satisfaction value that was exactly in the same range (Table 3) of the satisfaction value predicted by the model, which is not worrisome (despite being a low percentage) since in this model are considered 8 intervals (designations) for the satisfaction. However, taking into account the knowledge previously extracted, we were able to analyze within 88,4% of the participants who agreed with the prediction of satisfaction presented to them, possible cases in which the participant's satisfaction evaluation was not a demonstration of their preferences and what had happened in the process. Again, cases were detected in which the satisfaction indicated by the participant was not minimally demonstrative of their true satisfaction. With the advantage that it has now been possible to determine that in these cases, the difference between the indicated satisfaction (through the slide bar) and the expected satisfaction that was consequently considered correct by the participant was not due to strategic reasons. Table 5 presents the participants who indicated values of satisfaction that did not correspond minimally to the designation of satisfaction considered correct by the participant himself.

Table 5. The set of participants who considered the satisfaction predicted by the model correct but indicated a satisfaction value that does not correspond to what was predicted.

Participant	Reported Satisfaction [-1; 1]	Predicted Satisfaction [-1; 1]	Chosen Alternative [0; 1]	Preferred Alternative [0; 1]
2	0	-0,919	0,3	0,9
9	-0,4	1	1	1
13	0	-0,898	0,4	1
27	0,04	-0,979	0,17	0,88

If, on the one hand, having questioned the participants about their agreement to the satisfaction provided by the system was one of the main indicators of the ability of the model to predict satisfaction (88,4% of agreement), on the other hand, comparing the satisfaction predicted by the model with the satisfaction reported by the decision-makers (in what are purely numerical evaluations) it was necessary to use other strategies. For this, the participants mentioned in Table 4 and Table 5 (21% of the total participants) were removed, since they have performed unconscious, illogical configurations or manipulation strategies that represent "noise" in the analysis that is intended to be done. Thus, 79% of the population (34 participants) initially surveyed is represented in Table 6 (all numerical values presented are in the range [-1; 1]).

Table 6. All participants excluding the presented in Table 4 and Table 5.

Participant	Reported Satisfaction	Outcomes	Expectations	Predicted Satisfaction
1	0,48	0,26	0,43	0,79

3	-0,8	-0,5	-0,66	-0,83
4	-0,6	-0,5	-0,7	-0,85
5	-1	-1	-1	-1
6	-1	-1	-1	-1
7	1	0,94	0,95	0,99
8	1	1	1	1
10	-1	-1	-1	-1
11	-0,7	-0,76	-0,78	-0,91
12	-0,78	-1	-1	-1
14	-0,84	-0,97	-0,99	-0,99
15	-0,5	-0,5	-0,56	-0,67
16	1	0,8	0,81	0,98
17	-1	-1	-1	-1
18	0	0,22	0,22	0,10
19	0,08	0,46	0,45	0,39
21	-0,5	-0,12	-0,47	-0,56
22	-0,38	-0,29	-0,39	-0,65
23	-0,6	0,22	0,03	-0,09
24	-0,18	-0,51	-0,62	-0,68
25	-0,7	-0,5	-0,6	-0,8
28	-0,32	-0,11	-0,14	-0,16
29	-0,6	-0,95	-0,97	-0,99
30	-0,76	-0,78	-0,81	-0,91
32	-0,86	-0,76	-0,82	-0,90
33	-0,72	-0,85	-0,89	-0,94
34	-1	-0,99	-0,99	-0,99
35	-1	-0,84	-0,88	-0,91
36	-0,4	0,22	0,07	-0,19
37	0,02	0,26	0,25	0,23
38	0,28	0,381	0,35	0,23
39	0,02	0,10	0,03	-0,04
41	0	0,37	0,25	0,07
43	-1	-1	-1	-1

The “Outcomes” column presents the expected calculated satisfaction only considering the formulation introduced in Subsection 3.1, the “Expectations” column presents the calculation of the expected satisfaction already including the formulation presented in Subsection 3.2 and finally the “Predicted Satisfaction” column includes all the proposed formulation (inclusion of the intentions of the decision maker and the emotional cost in the final calculation of the satisfaction prediction). As we can see, for several participants it was fruitful to have the variables “expectations” and “emotional changes” being computed, since only after the inclusion of these factors expected satisfaction value reached the same interval (Table 3) of the reported satisfaction. Although it may seem that “expectations”, on its own, does not take the participant to the correct value, it is the approximation which it facilitates that makes it possible for the inclusion of the “emotional changes” layer to have an effect and lead to the correct evaluation.

In order to study the difference between the satisfaction value reported by the decision-makers and the satisfaction value predicted by the proposed model, the values of the Mean Absolute Error, Normalized Mean Absolute Error and Root-Mean-Square Error were calculated. The calculated values are given in Table 7.

Table 7. Values of Mean Absolute Error, Normalized Mean Absolute Error and Root-Mean-Square Error.

Mean Absolute Error	Normalized Mean Absolute Error	Root-Mean-Square Error
0,14353	0,14211	0,20031

As shown in Table 7, the approximate value of Root-Mean-Square Error is approximately 0,20, which means that the model presented has a very good predictability. In addition, we have also been studying the results obtained regarding precision, accuracy, recall and F1 score. For this, it was necessary to make a confusion matrix. Since our satisfaction scale is presented in the interval [-1; 1] and contains 8 possible designations, each designation occupying a size of 0,25 on the scale. Therefore, we considered that the predicted satisfaction value (PS) belongs to the real value class (satisfaction value reported by the decision maker – RS) if $PS \geq RS - 0{,}25 \wedge PS \leq RS + 0{,}25$. Table 8 represents the confusion matrix including all participants (43). True Class represents the response given by the participant, i.e. if the satisfaction forecast presented to you was or was not correct and Predicted represents, as stated, whether the predicted satisfaction value falls within the range described above.

Table 8. Confusion matrix.

		True Class	
		Yes	No
Predicted	Yes	TP (28)	FP (1)
	No	FN (10)	TN (4)

Table 9 presents the accuracy, recall, accuracy and F1 Score values for the confusion matrix presented in Table 8.

Table 9. Values of Precision, Recall, Accuracy and F1 Score.

Precision	Recall	Accuracy	F1 Score
0,966	0,737	0,744	0,836

In this context the value that becomes more important to analyze is that of precision since it represents the proportion of positive predictions performed by the satisfaction model proposed here. A precision of 0,966 is an excellent value, an accuracy of approximately 75% is also a fairly good value, although it does not fully illustrate the good results obtained by the model since that in this context only the number of "True Negatives" truly represents the number of situations in which the model predicts the satisfaction incorrectly. Since there were only 4 True Negatives, it is possible to say that the probability of the proposed model to predict the decision incorrectly is 9%. Only one participant was considered as False Positive, which in turn allows to conclude that the model was able to predict the satisfaction of the participants in 91% of the situations.

6. Discussion

When using agents to represent decision-makers, studying satisfaction inherently may lead us to focus on those (users) who are the most harmed when they don't succeed. We need to take into account that there are emergent situations arising from a decision-making scenario, from which events are generated empirically. For instance, we perceive that a fear-generating event may arise in some situations when, despite having a lot of supporters behind the preferred alternative, it is not the most supported one. As we are not controlling for this, emotions that we calculate may have a greater impact than we anticipated, i.e., notwithstanding our conclusion that they indeed help approximate the model from the "true" satisfaction, the inevitable imperfection in the definition of events cause these "errors" to occur. Nevertheless, the model is capable of predicting with great accuracy.

What possible could enrich our model would be a more mixed-type scenario, where, for instance the user's favorite alternative has a lot of supporters from the start (without being the

favorite), causing hope to be experienced, but that as the process unfolds, another alternative starts gathering support, becoming better placed to win. Instead of generating hope, fear would be generated, for seeing his/her objectives as less likely to be reached. Despite ascertaining the importance of integrating emotional variables into the process – in the sense that it helps to approximate to what the participant's satisfaction actually is – we need to bear in mind that in our case we only used "concern for self" type-events, making it impossible for us to know how the model would respond to "concern for others" type-events. Would their inclusion indeed prove to be beneficial or only bring uninformative noise, ending up clouding the calculus/computation.

What we may ponder at this point is that, in principle, it would also help predicting satisfaction with a higher degree of accuracy. Besides having confirmed the premises we put forward, it was also possible to understand that the emotional cost tends to vary in accordance to how important the decision is for each decision-maker, the degree of attachment of the decision-maker with his/her preferred alternative cause the impact of the emotional cost to vary, as well as the difference in the evaluation between the alternative that is chosen by the group and the one that was his/her favorite.

We also verified that, since we work with expectations tied to a supported alternative, the evaluation may suffer a loss whenever the preferred is not the one that ends up being chosen by the group. It may even suffer a loss that sprouts from the contingent emotional cost, but may otherwise have gains on the expectation side, in case the alternative chosen by the group is the one that was the one supported by the decision-maker at that point in time. Another situation that may be worthy of note is when the systems' use is perverted. As is easily understandable, when a user that evaluates an alternative with zero ("not preferred at all") by merely strategic reasons, not feeling that complete aversion towards the alternative, is behaving in a way that is "against" the system, as if it were a game to be won. This person won't be benefiting from a system of this kind according to its initial purpose and this highlights the need for a period of training so that decision-makers can make the most of the model.

To the best of our knowledge, there still are not other approaches in literature that allow to predict a decision-maker's satisfaction in respect to the decision taken as a whole, or a part of the decision-making process is yet supported by a GDSS or other kind of collaborative system. This way, it was necessary to resort to sound knowledge coming from other areas of study. Our main concern was to formulate this model based in knowledge upon which there would be the highest possible agreement, resulting in a less ambiguous formulation. What also in a certain way necessarily resulted in the use of a less recent literature. We consider that the study of satisfaction in this context will become a relevant topic and that this work opens a line of thought for models that may be a lot more sophisticated and with higher levels of precision.

7. Conclusions and Future Work

In this article, we proposed a whole new model which allows the automatic assessment of the participants' satisfaction in a meeting supported by a Web-based Group Decision Support System. We believe that the proposed model allows the obtainment of a large amount of useful and valuable information.

Satisfaction can be used as a metric to compare different Web-based GDSS or automatic negotiation mechanisms. In addition, satisfaction can either be used as a utility function in order to maximize the decision-makers' satisfaction or can be used by agents to predict the decision-maker's satisfaction. To evaluate satisfaction, we considered the comparison and evaluation of alternatives, the expectations, emotions, mood and the process. The values obtained in the calculus of satisfaction respect the premises that were defined in a previous work. In addition,

we ran a case study with real participants that allowed to understand that the proposed model is capable of predicting the users' satisfaction with a very interesting degree of accuracy.

As future work, we intend to study the satisfaction of participants that seem to adopt strategic approaches along the process, i.e., focusing on those who, from a certain point on, evaluate the alternatives not according to what they consider to be the intrinsic value of the alternative for solving a problem/task but instead, behave so as to manipulate the decision. Here we could also see that it may also be important to identify the emergent satisfaction in dealing with the situation these previously unintended ways. Also for future reference it will be important to enrich the emotional features, as well as the events, allowing us to clarify some aspects as well as reason about the timing of decisions in the process, both in terms of duration and outlook in terms of timespan.

Acknowledgements

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References

Agor, W. H. (1986). The logic of intuition: How top executives make important decisions. *Organizational Dynamics, 14*(3), 5-18.

Alonso, S., Herrera-Viedma, E., Chiclana, F., & Herrera, F. (2010). A web based consensus support system for group decision making problems and incomplete preferences. *Information Sciences, 180*(23), 4477-4495.

Babin, B. J., & Griffin, M. (1998). The nature of satisfaction: an updated examination and analysis. *Journal of Business research, 41*(2), 127-136.

Beach, L. R. (1990). *Image theory: Decision making in personal and organizational contexts*: Wiley Chichester.

Bjørn, P., Esbensen, M., Jensen, R. E., & Matthiesen, S. (2014). Does distance still matter? Revisiting the CSCW fundamentals on distributed collaboration. *ACM Transactions on Computer-Human Interaction (TOCHI), 21*(5), 27.

Blake, R. R., & Mouton, J. S. (1964). *The new managerial grid: strategic new insights into a proven system for increasing organization productivity and individual effectiveness, plus a revealing examination of how your managerial style can affect your mental and physical health*: Gulf Pub. Co.

Briggs, R. O., de Vreede, G.-J., & Reinig, B. A. (2003). *A theory and measurement of meeting satisfaction.* Paper presented at the System Sciences, 2003. Proceedings of the 36th Annual Hawaii International Conference on.

Carneiro, J., Marreiros, G., & Novais, P. (2015). Using satisfaction analysis to predict decision quality. *International Journal of Artificial Intelligence™, 13*(1), 45-57.

Carneiro, J., Martinho, D., Marreiros, G., Jimenez, A., & Novais, P. (2017). Dynamic argumentation in UbiGDSS. *Knowledge and Information Systems*, 1-37.

Carneiro, J., Martinho, D., Marreiros, G., & Novais, P. (2015). A general template to configure multi-criteria problems in ubiquitous GDSS. *International Journal of Software Engineering and Its Applications, 9*(11), 193-206.

Carneiro, J., Martinho, D., Marreiros, G., & Novais, P. (2016). Intelligent negotiation model for ubiquitous group decision scenarios. *Frontiers of Information Technology \& Electronic Engineering, 17*(4), 296-308.

Carneiro, J., Santos, R., Marreiros, G., & Novais, P. (2017). *Evaluating the Perception of the Decision Quality in Web-Based Group Decision Support Systems: A Theory of Satisfaction.* Paper presented at the International Conference on Practical Applications of Agents and Multi-Agent Systems.

Carneiro, J., Saraiva, P., Martinho, D., Marreiros, G., & Novais, P. (2018). Representing decision-makers using styles of behavior: An approach designed for group decision support systems. *Cognitive Systems Research, 47*(Supplement C), 109-132. doi:https://doi.org/10.1016/j.cogsys.2017.09.002

Costa, P. T., & MacCrae, R. R. (1992). *Revised NEO personality inventory (NEO PI-R) and NEO five-factor inventory (NEO-FFI): Professional manual*: Psychological Assessment Resources, Incorporated.

Crawford, J. R., & Henry, J. D. (2004). The Positive and Negative Affect Schedule (PANAS): Construct validity, measurement properties and normative data in a large non-clinical sample. *British journal of clinical psychology, 43*(3), 245-265.

Damasio, A. R. (2006). *Descartes' error*: Random House.

Davidow, W. H., & Uttal, B. (1989). Service companies: focus or falter. *Harvard business review, 67*(4), 77-85.

DeSanctis, G., & Gallupe, B. (1984). Group decision support systems: a new frontier. *ACM SIGMIS Database, 16*(2), 3-10.

Desanctis, G., & Gallupe, R. B. (1987). A foundation for the study of group decision support systems. *Management science, 33*(5), 589-609.

Ekman, P. (1992). An argument for basic emotions. *Cognition \& emotion, 6*(3-4), 169-200.

Frijda, N. H. (1986). The emotions: Studies in emotion and social interaction. *Paris: Maison de Sciences de l'Homme*.

Gardner, H. (1987). The theory of multiple intelligences. *Annals of Dyslexia, 37*(1), 19-35.

Gebhard, P. (2005). *ALMA: a layered model of affect.* Paper presented at the Proceedings of the fourth international joint conference on Autonomous agents and multiagent systems.

Goleman, D. P. (1995). Emotional intelligence: Why it can matter more than IQ for character, health and lifelong achievement. In: New York: Bantam Books.

Gronroos, C. (1983). Strategic Management andMarketingintheServiceSector. *Marketing Science Institute, Cambridge, Massachusetts, Report*(83-104).

Grudin, J. (2002). Group dynamics and ubiquitous computing. *Communications of the ACM, 45*(12), 74-78.

Higgins, E. T. (2000). Making a good decision: value from fit. *American psychologist, 55*(11), 1217.

Howard, P. J., & Howard, J. M. (1995). The Big Five Quickstart: An Introduction to the Five-Factor Model of Personality for Human Resource Professionals.

Husain, A. (2012). New satisfying tool for problem solving in group decision-support system. *Applied Mathematical Sciences, 6*(109), 5403-5410.

Judge, T. A., Heller, D., & Mount, M. K. (2002). Five-factor model of personality and job satisfaction: a meta-analysis. In: American Psychological Association.

Kessler, H., Festini, A., Traue, H. C., Filipic, S., Weber, M., & Hoffmann, H. (2008). SIMPLEX—Simulation of Personal Emotion Experience. In *Affective Computing*: InTech.

Kilmann, R. H., & Thomas, K. W. (1975). Interpersonal conflict-handling behavior as reflections of Jungian personality dimensions. *Psychological reports, 37*(3), 971-980.

Klein, G. (1997). Developing expertise in decision making. *Thinking & Reasoning, 3*(4), 337-352.
Kwon, O., Yoo, K., & Suh, E. (2005). UbiDSS: a proactive intelligent decision support system as an expert system deploying ubiquitous computing technologies. *Expert systems with applications, 28*(1), 149-161.
Li, T., Qiu, Y., Yue, P., & Zhong, G. (2007). *Exploiting model of personality and emotion of learning companion agent.* Paper presented at the Computer Systems and Applications, 2007. AICCSA'07. IEEE/ACS International Conference on.
Liljander, V., & Strandvik, T. (1997). Emotions in service satisfaction. *International Journal of service industry management, 8*(2), 148-169.
Lunenburg, F. C. (2011). Decision making in organizations. *International journal of management, business, and administration, 15*(1), 1-9.
Mackinnon, A., Jorm, A. F., Christensen, H., Korten, A. E., Jacomb, P. A., & Rodgers, B. (1999). A short form of the Positive and Negative Affect Schedule: Evaluation of factorial validity and invariance across demographic variables in a community sample. *Personality and individual differences, 27*(3), 405-416.
March, J. G. (1994). *Primer on decision making: How decisions happen*: Simon and Schuster.
Marreiros, G., Santos, R., Ramos, C., & Neves, J. (2010). Context-aware emotion-based model for group decision making. *IEEE Intelligent Systems, 25*(2), 31-39.
McCrae, R. R., & John, O. P. (1992). An introduction to the five-factor model and its applications. *Journal of personality, 60*(2), 175-215.
Mehrabian, A. (1995). Framework for a comprehensive description and measurement of emotional states. *Genetic, social, and general psychology monographs*.
Mehrabian, A. (1996). Pleasure-arousal-dominance: A general framework for describing and measuring individual differences in temperament. *Current Psychology, 14*(4), 261-292.
Mehrabian, A., & O'reilly, E. (1980). Analysis of personality measures in terms of basic dimensions of temperament. *Journal of Personality and Social Psychology, 38*(3), 492.
Miller, J. A. (1977). Studying satisfaction, modifying models, eliciting expectations, posing problems, and making meaningful measurements. *Conceptualization and measurement of consumer satisfaction and dissatisfaction*, 72-91.
Nass, C., Moon, Y., Fogg, B., Reeves, B., & Dryer, D. C. (1995). Can computer personalities be human personalities? *International Journal of Human-Computer Studies, 43*(2), 223-239.
Oliver, R. L. (1985). *An Extended Perspective on Post–Purchase Phenomena: Is Satisfaction a Red Herring?* Paper presented at the Annual Conference of the Association for Consumer Research.
Oliver, R. L., Rust, R. T., & Varki, S. (1997). Customer delight: foundations, findings, and managerial insight. *Journal of retailing, 73*(3), 311-336.
Oliver, R. L., & Winer, R. S. (1987). A framework for the formation and structure of consumer expectations: Review and propositions. *Journal of economic psychology, 8*(4), 469-499.
Olson, J. C., & Dover, P. A. (1979). Disconfirmation of consumer expectations through product trial. *Journal of applied psychology, 64*(2), 179.
Ortony, A., Clore, G. L., & Collins, A. (1990). *The cognitive structure of emotions*: Cambridge university press.
Parasuraman, A., Zeithaml, V., & Berry, L. (2002). SERVQUAL: a multiple-item scale for measuring consumer perceptions of service quality. *Retailing: critical concepts, 64*(1), 140.
Paul, S., Seetharaman, P., & Ramamurthy, K. (2004). *User satisfaction with system, decision process, and outcome in GDSS based meeting: an experimental investigation.* Paper presented at the System Sciences, 2004. Proceedings of the 37th Annual Hawaii International Conference on.

Prakash, V. (1984). Validity and reliability of the confirmation of expectations paradigm as a determinant of consumer satisfaction. *Journal of the academy of Marketing Science, 12*(4), 63-76.

Rahim, M. A. (1983). A measure of styles of handling interpersonal conflict. *Academy of Management journal, 26*(2), 368-376.

Rahim, M. A., & Magner, N. R. (1995). Confirmatory factor analysis of the styles of handling interpersonal conflict: First-order factor model and its invariance across groups. *Journal of applied psychology, 80*(1), 122.

Rahwan, I., Ramchurn, S. D., Jennings, N. R., Mcburney, P., Parsons, S., & Sonenberg, L. (2003). Argumentation-based negotiation. *The Knowledge Engineering Review, 18*(4), 343-375.

Roseman, I. J., Spindel, M. S., & Jose, P. E. (1990). Appraisals of Emotion-eliciting Events. *Journal of Personality and Social Psychology, 59*(5), 899-915.

Schimmack, U., Oishi, S., Furr, R. M., & Funder, D. C. (2004). Personality and life satisfaction: A facet-level analysis. *Personality and social psychology bulletin, 30*(8), 1062-1075.

Shum, S. B., Cannavacciuolo, L., De Liddo, A., Iandoli, L., & Quinto, I. (2013). Using social network analysis to support collective decision-making process. *Engineering Effective Decision Support Technologies: New Models and Applications*, 87-103.

Staller, A., & Petta, P. (1998). Towards a tractable appraisal-based architecture for situated cognizers. *C. Numaoka, D. Canamero, \& P. Petta, Grounding emotions in adaptive systems. SAB, 98*.

Tian, X., Hou, W., & Yuan, K. (2008). *A study on the method of satisfaction measurement based on emotion space.* Paper presented at the Computer-Aided Industrial Design and Conceptual Design, 2008. CAID/CD 2008. 9th International Conference on.

Van Kleef, G. A., De Dreu, C. K., & Manstead, A. S. (2010). An interpersonal approach to emotion in social decision making: The emotions as social information model. In *Advances in experimental social psychology* (Vol. 42, pp. 45-96): Elsevier.

Walton, R. E., & McKersie, R. B. (1965). *A behavioral theory of labor negotiations: An analysis of a social interaction system*: Cornell University Press.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. *Journal of Personality and Social Psychology, 54*(6), 1063.

Wirtz, J., & Bateson, J. E. (1999). Consumer satisfaction with services: integrating the environment perspective in services marketing into the traditional disconfirmation paradigm. *Journal of Business research, 44*(1), 55-66.

Wirtz, J., Mattila, A. S., & Tan, R. L. (2000). The moderating role of target-arousal on the impact of affect on satisfaction—an examination in the context of service experiences. *Journal of retailing, 76*(3), 347-365.

Woodruff, R. B., Cadotte, E. R., & Jenkins, R. L. (1983). Modeling consumer satisfaction processes using experience-based norms. *Journal of marketing research*, 296-304.

Zeithaml, V. A., Berry, L. L., & Parasuraman, A. (1993). The nature and determinants of customer expectations of service. *Journal of the academy of Marketing Science, 21*(1), 1-12.