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Modeling Preferences through Personality and Satisfaction to Guide the Decision Making of a Virtual Agent

Jorge Castro-Rivera [1], María Lucila Morales-Rodríguez [1], Nelson Rangel-Valdez [2,*], Claudia Gómez-Santillán [1] and Luciano Aguilera-Vázquez [1]

1 División de Estudios de Posgrado e Investigación, Tecnológico Nacional de México, Instituto Tecnológico de Ciudad Madero, Los Mangos 89440, Mexico; D10070283@cdmadero.tecnm.mx (J.C.-R.); lucila.mr@cdmadero.tecnm.mx (M.L.M.-R.); claudia.gs@cdmadero.tecnm.mx (C.G.-S.); luciano.av@cdmadero.tecnm.mx (L.A.-V.)

2 División de Estudios de Posgrado e Investigación, CONACyT—Tecnológico Nacional de Mexico, Instituto Tecnológico de Ciudad Madero, Los Mangos 89440, Mexico

* Correspondence: nelson.rv@cdmadero.tecnm.mx

Abstract: Satisfaction is relevant for decision makers (DM, Decision Makers). Satisfaction is the feeling produced in individuals by executing actions to satisfy their needs, for example, the payment of debts, jobs, or academic achievements, and the acquisition of goods or services. In the satisfaction literature, some theories model the satisfaction of individuals from job and customer approaches. However, considering personality elements to influence satisfaction and define preferences in strategies that optimize decision making provides the unique characteristics of a DM. These characteristics favor the scope of solutions closer to the satisfaction expectation. Satisfaction theories do not include specific elements of personality and preferences, so integrating these elements will offer more efficient decisions in computable models. In this work, a model of satisfaction with personality characteristics that influence the preferences of a DM is proposed. The proposed model is integrated into a preference-based optimizer that improves the decision-making process of a Virtual Decision Maker (VDM) in an optimization context. The optimization context addressed in this work is the product selection process within a food product shopping problem. An experimental design is proposed that compares two configurations that represent the cognitive part of an agent's decision process to validate the operation of the proposed model in the context of optimization: (1) satisfaction, personality, and preferences, and (2) personality and preferences. The results show that considering satisfaction and personality in combination with preferences provides solutions closer to the interests of an individual, reflecting a more realistic behavior. Furthermore, this work demonstrates that it is possible to create a configurable model that allows adapting to different aptitudes and reflecting them in a computable model.

Keywords: Decision Maker; satisfaction; personality; preferences; Virtual Decision Maker

MSC: 93A30; 68T05

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1. Introduction

Satisfaction is a factor that represents the perception of individuals about the final result of a decision process, where elements such as cognitive effort and level of satisfaction intervene. Currently, organizations and institutions resort to strategies aimed at recognizing the expectation of satisfaction that meets the needs of decision makers (DM, Decision Maker). In this way, it is possible to offer goods and services closer to what the individual expects to obtain beyond their preferences.

For example, the preference for dark clothing does not imply that any dark garment meets the individual's expectations. Said garment may cover all the preferred search criteria (price, fabric quality, size, among others). However, it may be that the garment is not to the individual's liking when trying it on. The above is related to causes associated with the individual's personality, which reflect traits that help define their level of satisfaction. Knowing this type of characteristics related to satisfaction (personality and preferences) guarantees suggestions of goods and services with a high expectation of satisfaction.

According to the previous idea, if organizations or institutions adopt this type of optimization mechanism, the existing link with their established market could be strengthened by offering their goods or services personalized. They are even making it possible to venture into a new potential market due to the new and efficient attention, which can be interpreted as profits. These gains are the result of addressing the perception of the preferences of each individual, in particular, considerably reducing results perceived as unfavorable by the individual.

For example, the authors Cruz-Reyes et al. [1] provide a study focused on the integration of the perception of individuals through their preferences to optimize decision processes, reflecting in some way their satisfaction. Another study that can be highlighted is that of the authors Castro-Rivera et al. [2], where they were not limited to integrating only the preferences of the individual but also their personality to give a better approximation to what satisfies them according to a decision context.

In general, profits play an essential role in different works that provide studies in favor of integrating the perception of individuals through their preferences. Such a link between profits, perception, and preferences is built to gain an advantage in computable optimization processes so that better solutions can be achieved [1,2]. Hence, the profits can be seen as a means of characterizing the impact of a particular individual's perception over distinct alternatives, which can vary. For example, from the perspective of some individuals, it may be healthy to consume coffee with a lot of sugar, but for others, it is a precursor to disease. The example above is a clear manifestation of preferences and the influence of satisfaction on them.

Satisfaction modeling is related to decision making, representing DM satisfaction through conceptual models. These models seek to provide various components that visualize the decisions of individuals and their agreement on the results. These components have been grouped into satisfaction models under the job and customer approaches. Both approaches share a relationship between their main components to represent the satisfaction of individuals. For example, they share emotional factors, motivation, commitment, equity factors, and strengthening the quality of goods and services. In addition, these models can model satisfaction from questionnaires provided by the DM, generating representative values of their satisfaction expectations.

The job and customer satisfaction approaches aim to reflect the satisfaction of the DM by providing the degree of satisfaction concerning a decisional context [3,4]. However, representing the satisfaction of the DM is a problem that requires involving more characteristics, such as preferences and personality.

The reason for considering personality as a characteristic to achieve the satisfaction of the DM is that preferences are particularities derived from personality; that is, personality influences preferences. Additionally, personality distinguishes the DM's behavior relative to others in the decision-making process. For example, when buying products, an individual with a relaxed personality tends to see product attributes with similar relevance, regardless of whether the quality is lower than the price. On the other hand, an authoritarian personality emphasizes a preference for one of the product's attributes over another. To emulate this type of behavior in decision making, indirect strategies are applied [1,5], and optimizers are based on preferences and influences of personality [2].

Personality influences not only the DM's preferences but also their satisfaction. The satisfaction characteristic allows one to observe the influence of personality through satisfaction, showing that each individual expresses what uniquely satisfies them. The DM's level or degree of satisfaction indicates if the expectation of satisfaction concerning the results from a decision-making process has been achieved. Results can be obtained through a strategy based on preferences, such as HHGA-SPP (Hyper-Heuristic Genetic Algorithm for Social Portfolio Problem) [6], RPM (Robust Portfolio Modeling) [7], or NOSGA-II (Non-Outranking Sorting Genetic Algorithm) [8].

Integrating characteristics such as personality and satisfaction in an optimization strategy based on preferences from the literature could offer more representative solutions for the interest of the DM. These alternatives are evaluated to see if they meet the DM's expectations or degree of satisfaction. This type of satisfaction indicator, together with the influence of personality on preferences, is an innovative feature of the proposed satisfaction model. Furthermore, the integration of satisfaction in metaheuristic algorithms has not been applied previously.

In this work, a satisfaction model with personality characteristics is proposed to influence the preferences of the DM seeking to improve the decision-making process of a VDM under an optimization context. Optimization context addresses the product selection process within a food product shopping problem. This context will serve to evaluate the functioning of the proposed satisfaction model. In this case study, the intelligent agent is virtual and takes on the role of a sales assistant who offers the user food product suggestions according to interests through an optimization strategy based on preferences.

The configuration of the suggestions was classified according to the elements with which they were generated. This classification consists of two elements: (1) suggestions generated with satisfaction, personality, and preferences, and (2) suggestions generated with personality and preferences. These suggestions will be compared with each other and evaluated with user satisfaction. It is expected that the suggestions of group 1 meet the satisfaction expectation of the individual concerning the suggestions of the other group.

The main contributions of this work revolve around a satisfaction model and an architecture of intelligent agents to facilitate an interaction mechanism with the user. The proposed satisfaction model uses personality properties to influence an individual's preferences through preference-based solution strategies. Influencing an individual's preferences through these characteristics is the most remarkable contribution of this work. The developed architecture of intelligent agents integrates into its cognitive process the assisted satisfaction model with personality attributes and a strategy based on preferences in its deliberative process. Both the personality attributes and the preference-based optimization strategy come from the literature. The optimization strategy within the deliberative process is influenced by the features provided by the satisfaction model. This architecture is the means to represent the cognitive part of the decision process of an intelligent agent with the role of a VDM.

This research's main objective is to model a DM's preferences influenced by personality characteristics and satisfaction level to improve the decision-making processes of a virtual agent in an optimization context. Furthermore, this objective intends to demonstrate that the integration of a satisfaction model that reflects the degree of satisfaction of an individual in optimization problems that consider the characteristics of their personality and preferences will provide better solutions than processes that do not integrate a model of satisfaction. This hypothesis is discussed extensively in Section 5.6.

The following describes how the sections of this document are organized. Section 2 presents the theoretical foundation that supports the realization of this work. Section 3 shows the general architecture of the VDM project. Section 4 presents the satisfaction model proposed in this work and the description of its components. Section 5 presents the formulas involved in the satisfaction model and the evaluation of the model's performance through a case study, as well as the experimental design. Section 6 corresponds to the discussion about the results achieved in the experimentation. Finally, Section 7 corresponds to the conclusions of this work.

2. Background

2.1. Approaches to Satisfaction in the Literature

The main concepts for developing theories and models of satisfaction are addressed in the literature from two approaches: the job and customer approach. In most jobs, job satisfaction is the most recurrent concerning the satisfaction of individuals. Job satisfaction is made up of emotional and cognitive processes, and through these, the individual evaluates their experience at work [9,10]. Cognitive job satisfaction arises from evaluating job characteristics more consciously and comparing them with a cognitive standard [10,11]. On the other hand, affective or emotional job satisfaction represents a positive emotional response from the employee towards work as a whole [10,12].

In addition to job satisfaction, another recurring concept in the literature is the concept of customer satisfaction. The wealth of companies comes mainly from having their customers satisfied. According to the above, it is necessary to have robust processes and qualified personnel who provide the consumer's service or product quality. Measuring customer satisfaction allows one to know if the conditions in which said processes and personnel are carried out are adequate and, in this way, to predict the consumption of sales. Therefore, it is relevant to know the opinion of consumers about the service provided [13]. The concepts of customer satisfaction are illustrated through customer satisfaction models, which are based on market research and are classified as macro- and micro-models [4].

Some of the most recurrent theories or models under the approach to job satisfaction are: the theory of affect [14], the theory of the two factors, the model of expectations of Porter and Lawler [15], Fit-Job theory [16], among others. On the other hand, customer satisfaction models are divided into macro-models and micro-models. Macro-models highlight consumer satisfaction by comparing performance standards of services or products. Some of these macro-models are the traditional model, the models based on the value chain, and the perceived quality of the service. On the other hand, micro-models look more directly at customer satisfaction. The micro-models are listed in seven types [4,17], such as the model of disconfirmation of expectations, model of perceived performance, model of norms, model of multiple processes, models of attribution, affective models, and models of equity.

The job and customer satisfaction theories can be associated with personality theories and agent architectures to develop support models in decision making that make satisfaction explicit through traits, types, emotions, cognitive elements, and real-world symbology. According to the above, the models of job satisfaction that, at first glance, show more similarities at the conceptual level with the theories of personality and the architectures of agents are the Theory of Labor Adjustment or Fit-Job (it belongs to the emotional approaches) and Comparison Theory (belongs to a Motivational approach). In the case of customer models, the Traditional Model has more similarities with personality theories and agent architectures, followed by the Value Chain Model.

The Fit-Job satisfaction models, Comparison Theory, Traditional Model, and the Value Chain Model are functional for developing a decision-making model in an intelligent virtual agent that integrates the satisfaction and personality of the individuals in various decision contexts.

2.2. *Personality*

Personality is commonly seen as the set of behaviors that make up a person's individuality and is regularly used to describe and classify a person's behavior. The personality includes the external behavior of the person (gestures, behaviors, and observable events) and the internal experience of the person (desires, thoughts, feelings, and beliefs), which will produce observable events in the environment [18].

Studies on personality are supported by Personality Theories based on psychology, which explain the behavior of humans through two study approaches personality traits and types [19]. Both approaches seek to describe the personality of individuals through their strengths, weaknesses, preferences to act, and emotional states.

2.2.1. Personality Traits

In the development of systems that interact with people (simulators of human behavior), personality traits cannot be ignored due to their influence. They constitute a decisive part of human reasoning and behavior, mainly if one agent's emotional state can influence the decisions. Furthermore, some personality traits can influence the definition of emotions and their intensity, as is the case with neuroticism, which reflects the mood of the person [20].

In contemporary psychology, a personality model seeks to describe the characteristics of human behavior that constitute its individuality. In general, some of the most spread trait-based personality models are: big three [21,22], the big five [23,24], and the Five-Factor Model (FFM) (also known as OCEAN (Openness, Conscientiousness, Extraversion, Agreeableness, Neuroticism) [25]. According to McCrae and John [25] and Penn-State [26], six facets are derived from each of the five dimensions or factors of the OCEAN model, which are: (1) Extraversion: friendliness, gregariousness, assertiveness, activity level, excitement-seeking, and cheerfulness. (2) Agreeableness: trust, morality, altruism, cooperation, modesty, and sympathy. (3) Conscientiousness: self-efficacy, orderliness, dutifulness, achievement-striving, self-discipline, and cautiousness. (4) Neuroticism: anxiety, anger, depression, self-consciousness, immoderation, and vulnerability. (5) Openness: imagination, artistic interests, emotionality, adventurousness, intellect, and liberalism.

2.2.2. Personality Types

Personality types represent another of the approaches that conceptualize personality. In this approach, each of the humans presents a different vision of the world, making it clear that each individual is unique and independent in their behavior [27].

There are models of personality that employ Jung's theory. This theory consists of three dichotomies that explain how humans differ in the way they perceive their environment, interact with others, and how they make their decisions based on these personality types [27]. Some of these models are MBTI (Myers-Briggs Type Indicator) [28], and the Keirsey Temperament Sorted (KTS) model of temperaments [29], which is based on MBTI. Of these two grand theories of personality on human behavior, the FFM and MBTI models stand out as the most recurrent in the scientific literature. These types of models are commonly used to model socio-emotional agents. In addition, they could influence decision making through metaheuristics, mainly those that take into account other behavioral factors, such as preferences.

2.3. Solution Strategy That Integrates the Preferences of a DM, NOSGA-II

Most current multi-objective evolutionary optimization literature approaches focus on adopting an evolutionary algorithm to generate an approximation of the Pareto Frontier. For example, the NOSGA-II (Non-Outranking Sorting Genetic Algorithm) algorithm [8] characterizes the best compromise solution of a multi-objective optimization problem by increasing the selective pressure toward the most satisfactory solutions. In this way, it integrates the preferences of a DM established a priori in a genetic algorithm [8,30].

In this work, NOSGA-II is used to integrate the preferences of a DM and generate alternatives influenced by a personality profile and satisfaction factors to further facilitate decision making. The configuration applied in this work for the operation of NOSGA-II is described in the work of the authors Fernández et al. [8].

In Section 2.4, it is possible to find some works related to strategies that integrate the preferences of a DM, as well as research that offers a proposal to influence personality factors in this type of metaheuristics.

2.4. State the Art Analysis

Various investigations reveal the importance of personality and preferences on human behavior in different situations, particularly decision making. They hypothetically visualize that these characteristics allow them to reach the expectations of satisfaction of the individuals through the results of the application of their methodologies. However, the satisfaction of individuals is an issue whose characteristics must be considered in decision-making processes.

The absence of some of the distinctive factors of human behavior mentioned above is usually observed in the literature. For example, the work of Delgado-Hernández et al. [31] characterizes a dialogue with personality elements and selects the sentences of the conversation with a preference-based optimizer. However, it does not consider characteristics of satisfaction.

On the other hand, in the work of Seltzer et al. [32], the characteristics of satisfaction are considered. They relate personality, life, and job satisfaction to highlight the influence of personality on satisfaction. However, they do not consider the DM's preferences and are relevant to satisfaction. For example, a person whose job is not to their liking is more likely to harm their satisfaction than someone who performs a job to their liking.

Bradea et al. [33] propose a management tool for the selection of assets that provide optimal returns in the market. They use the preferences of the DM through an optimizer for decision making. In this work, characteristics of satisfaction and personality are not considered, so the results could improve in its experimental simulation when considering these factors.

According to the reviewed literature, no proposals were found that consider the three topics of human behavior (personality, preferences, and satisfaction) interacting in a computable model. For this reason, the proposal of a satisfaction model influenced by a personality that helps model the preferences of a DM is one of the novel characteristics of this research work.

3. General Architecture of VDM

This section deals with a proposed architecture of a virtual agent with human-like behavioral traits [34] through satisfaction, personality, and preference models. This architecture represents a VDM with the role of a decision maker.

The architecture of this work has a degree of topological and mathematical abstraction [35]. The VDM and the flow of its components are modeled through a diagram. The data flow between its components comes from applying models that resort to mathematical formulations, as is the case of the proposed satisfaction model in this work.

In addition, the proposed architecture is based on the structure of a utility-based agent [36] and on the fundamentals of a BDI (Beliefs, Desires, and Intentions) architecture [37,38]. This work aims to provide a framework [39,40] that facilitates the development of various decision contexts in which the VDM and a real DM can interact.

Figure 1 shows the general scheme of the VDM, whose structure has been developed to work in any case study. The operation of the architecture consists of selecting from the knowledge base the contextual elements, information on personality (through the MBTI [28] and IPIP-NEO [26] questionnaires), the Corpus Processed representative of the preferences (with the questionnaire proposed by Castro et al. [2]), and the DM satisfaction profile. With this information, it will be possible to obtain preferential parameters influenced by the VDM's personality and approximate the degree of personal satisfaction.

In this project, the PMUDC-I model (Personality Model Under a Decision Context I) [2] is responsible for generating personality parameters, as well as preferential parameters. Therefore, the PMUDC-I is the basis for concluding with the development of the PMUDC-II model. However, this investigation will not address its calculation procedure until future investigations.

Satisfaction-based personality traits (detailed in Section 5) are generated by the PMUDC-II model. Therefore, the satisfaction metric to evaluate the results of the deliberative process conformed by NOSGA-II comes from the satisfaction model.

In general terms, the VDM architecture aims to emulate a DM's characteristics through a decision context. For example, the emulation of the skills of a laboratory technician, developing experimentation in a virtual laboratory as if they were the DM. This document focuses on the blocks within the dotted area of the agent architecture (Figure 1). Section 4 presents the characteristics of the satisfaction model proposed in this work.

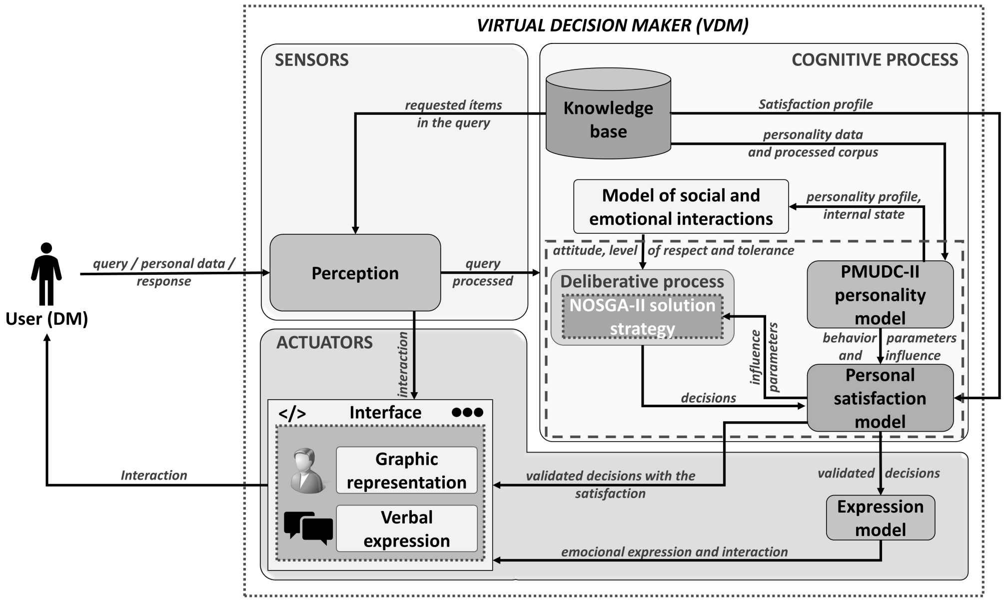

Figure 1. VDM architecture is composed of the satisfaction model, NOSGA-II, and PMUDC-II.

4. Personal Satisfaction Model

The module of the personal satisfaction model is part of the cognitive process of the agent or VDM. This model provides the parameters that reveal the satisfaction of the DM. This model comprises the customer satisfaction models, which are the Traditional Model and the Theory of Value, as well as the theories of job satisfaction, which are the Comparison Theory and the Fit-Job Theory.

The personal satisfaction model has three process blocks: definition of satisfaction parameters, parameter update, and satisfaction level validation module. Figure 2 shows the personal satisfaction model with its process blocks. The interaction with the PMUDC-II model, the knowledge base, and the agent's deliberative process (NOSGA-II) is mainly observed. Sections 4.1–4.3 describe the three process blocks of the personal satisfaction model proposed in this work.

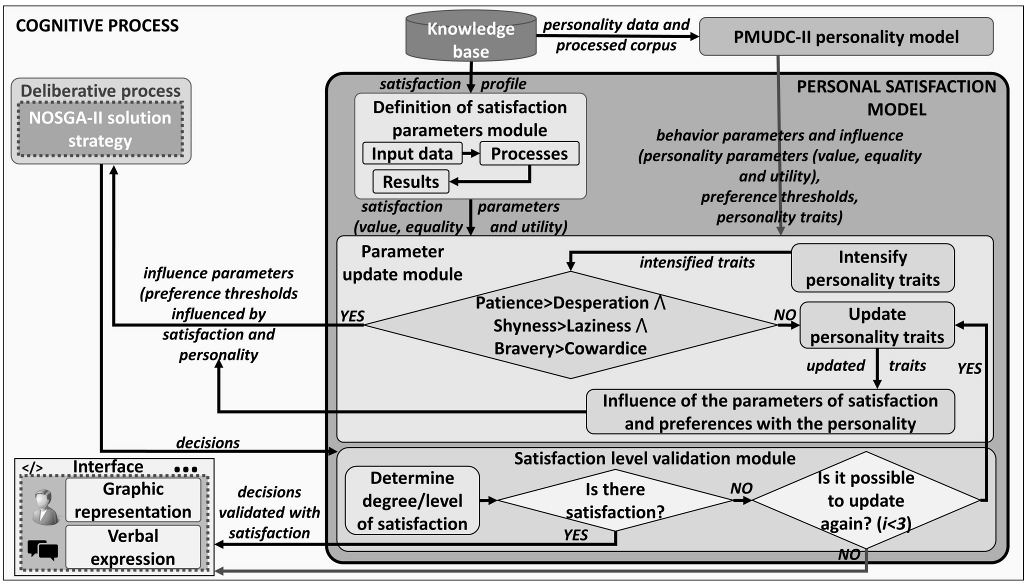

Figure 2. Proposed satisfaction model and the interaction of its process modules.

4.1. Definition of Satisfaction Parameters Module

The definition of satisfaction parameters module consists of three internal blocks, which are: input data, processes, and results, which are composed of a combination of the approaches of job satisfaction and customer satisfaction for their relationship in similar processes.

In short, the block input data is responsible for retrieving the information from the satisfaction profile, which contains the attributes of the service-product (s-p). These attributes are: expected performance, quality, quality-performance standards, emotional value, RIASEC test [41], and the ideal-real expectations of the s-p. The block process compares quality and performance with quality standards to interpret satisfaction, comparing ideal and actual expectations, reporting whether or not there is satisfaction with the s-p. Finally, it retrieves the RIASEC test score. The block process defines satisfaction parameters named value, equality, and utility.

Specifically, the parameter value is made up of information on the perceived performance of the p-s, combining characteristics of the Traditional Model and the Theory of Value. Furthermore, the parameter equality compares the ideal-real expectations based on the Comparison Theory. Finally, the utility parameter obtains the evaluation provided by the RIASEC test, which comes from the Fit-Job theory.

Once the satisfaction parameters are generated, they are sent to the block parameter update module.

4.2. Parameter Update Module

The block parameter update module is made up of the following blocks: intensify personality traits, update personality traits, and influence parameters of satisfaction and preferences with personality. In general terms, the parameter update module readjusts the parameters of satisfaction, personality traits, and preferences to reflect the DV's behavior in more satisfying and personality-influenced decision making.

Personality traits are given by the PMUDC-II model and are based on satisfaction attributes. These traits come from a set of personality parameters called value, equality, and utility and are intended to characterize satisfaction attributes, which are supported by satisfaction models in the literature [3,4].

By way of clarification, from the perspective of satisfaction, the parameter value is developed from the traditional models, and value theory [4] and represents the sentimental value of the goods or services that produce well-being. On the other hand, from the perspective of personality, the parameter value comes from the facets of the OCEAN dimension agreeableness and represents the moral values of the individual, which can produce satisfaction and well-being by correctly orienting their actions towards society.

In the case of the satisfaction parameter equality, it is based on the comparison theory [3,42], and represents the satisfaction or dissatisfaction in the expectation of a service or product. The personality parameter equality is based on the OCEAN facets of the factor neuroticism and represents dissatisfaction if conditions of equality with others do not exist.

Finally, the satisfaction parameter utility is based on the Job Fit theory [16] and aims to highlight the skills of the person in the work areas where they perform best and feel satisfied. The personality parameter utility is based on the facets of the extraversion, conscientiousness, neuroticism, and openness factors, reflecting aspects that intervene in decision making, favoring or limiting the results. For example, a shy person may lose opportunities in their environment due to self-consciousness; on the contrary, a naive person could make unreasonable decisions.

Through the personality parameters (value, equality, and utility), a set of personality traits associated with satisfaction are derived. These traits are quantified through the intensifies personality traits block described below.

The block intensify personality traits assigns the value of the OCEAN facets (discussed in Section 5.3) to the set of personality traits proposed in this work (discussed in

Table 1). This assignment of values gives intensity to personality traits, thus influencing the representative parameters of satisfaction and preferences.

Table 1. Classification of personality traits.

Updating Cycle	Influence of Parameters		
Utility	**Value**	**Equality**	**Utility**
Patience Desperation Shyness Laziness Bravery Cowardice	Ethic Humility	Cruelty Generosity	Conceit Egoism Naivety

The intensity of personality traits determines how much influence they can provide on the parameters mentioned above. Intensity is obtained through the IPIP-NEO (International Personality Item Pool-Neuroticism, Extraversion, and Openness) [26] questionnaire.

The relationship between the OCEAN facets and personality traits is possible through the similarities in its description's attributes. In the case of facets, their descriptions have been taken from the OCEAN model [25,26]. The descriptions or definitions of the personality traits proposed in this work have been taken from the RAE [43].

For example, according to OCEAN, the gregariousness facet of the extraversion dimension mentions that gregarious people find the company of others rewarding and enjoy the excitement of crowds. However, people with low scores tend to feel overwhelmed by large crowds. This description has similarities to the shyness trait, so the gregariousness facet score can be assigned to the shyness trait. This assignment of values can be consulted in Section 5.3, where the assignment of the values obtained from each facet to the personality traits through the IPIP-NEO questionnaire is observed.

Yet another example of similarity in their descriptions is the facet activity level and the trait laziness. The facet activity level refers to participation in multiple activities. Low scores on this facet indicate a very relaxed pace. The personality trait laziness describes a person as being too lax in carrying out their tasks. The relationship of the rest of the facets with the personality traits can be consulted in [44].

The block update personality traits receives the intensified personality traits to update other personality traits, according to the classification presented in Table 1. Personality traits are classified in two ways: traits that control the update cycle of parameters and traits that influence preferences, satisfaction, and even other elements of personality. The traits belonging to the utility parameter, such as patience, desperation, laziness, timidity, bravery, and cowardice, control the update cycle of the parameters. Other personality traits that also belong to the utility parameter, as well as to the value and equality parameters, influence the elements of satisfaction, preferences, and personality.

Once the personality traits are updated, they will be sent to the influence parameters of satisfaction and preferences with a personality block to influence the satisfaction parameters (value, equality, and utility) and in the preference thresholds given by PMUDC-I. After the previous process, the influenced parameters will be sent to the deliberative process (to NOSGA-II) to integrate the preference thresholds. Solutions given by NOSGA-II will be evaluated by the Satisfaction level validation module.

4.3. Satisfaction Level Validation Module

The satisfaction level validation module receives the solution alternatives from the deliberative process and validates them through the satisfaction characteristics, which make up the DM degree of satisfaction, in addition to the query or request formulated from the beginning by the DM.

The solution alternatives of the deliberative process and the DM request are composed of criteria or attributes. Depending on the context, these criteria may be colors, sizes, and costs, which may be about selling or offering services. The criteria DM's request consists of a value, which must be accumulated to be compared with the accumulated total of the solution alternatives obtained together with the representative tolerance of the DM. For example, if a request is made under an element selection context, whose criteria or attributes are its color and size, assuming that each attribute has a weight, the procedure to perform to obtain the accumulated total is to add the weights of each criterion. Afterward, the accumulated total is evaluated with the tolerance, representing the deviation or distance between the expectation (request) and the reality (alternatives).

If the accumulated value of an alternative received criterion does not exceed the tolerated percentage, it will be counted as a hit. The more hits an alternative has, the more satisfaction it will reflect. For example, a received or suggested alternative or list containing three items governed by two criteria would generate a maximum of six hits and a minimum of zero. Satisfaction is subjective, so an alternative with three correct answers out of six may be considered satisfactory if the individual's tolerance allows it. On the contrary, an alternative with five correct answers out of six may not be acceptable. The above depends a lot on the personality profile of the individual.

If the solution alternatives are close to those expected by the DM, they are sent to the graphical interface. Otherwise, the parameters will be updated again to reach a level of satisfaction more appropriate for the DM, as the update cycle allows (e.g., $iteration < 3$). The iteration limit avoids spending too much time searching for an improvement that may no longer exist because it has already been achieved. The equations and the procedure explained above can be consulted in the topic Section 5.7.

Section 5 presents how satisfaction is modeled through the characteristics of four individuals under a case study. In addition, the experimental design and the analysis of the results are described.

5. Analysis and Results

This section shows how the satisfaction model works using a food purchase case study. The calculation of parameters and values of each of the modules or process blocks presented in Section 4, corresponding to the personal satisfaction model, will be shown.

In Section 5.7, the case study will be addressed through two analysis cases. The first case analyzes an individual's satisfaction with a collaborative personality profile. The second case analyzes the satisfaction of an individual corresponding to the rest of the personality profiles (optimistic, inquirer, and strict). The food products consider the price and content criteria in both analysis cases.

The representation of the shopping list is based on the Project Portfolio (PP) problem [45]. The personality profiles, the preferential parameters, and the tolerance parameter are based on the work of Castro-Rivera et al. [2].

Table 2 shows the input data for the first case of analysis, belonging to a DM with a collaborative profile. These data are preference thresholds representative of the food product shopping context, the tolerance parameter, and the personality parameters from the perspective of satisfaction (Table 1). In the second case of analysis, the input data will be detailed in Section 5.7.

Table 2. Collaborative profile individual and its parameters.

Parmeter | Threshold	Price	Contents	Value	Personality Parameters
Indifference (q)	23.78	185.37	—	Value = 0.4
Preveto (u)	31.81	271.58	—	Equality = 0.37
Veto (v)	39.85	357.79	—	Utility = 0.65
Credibility (λ)	—	—	0.71	
Asymmetry (β)	—	—	0.08	
Symmetry (ϵ)	—	—	0.04	
Tolerance (φ)	—	—	0.58125	

The satisfaction parameters, developed from the information provided from the satisfaction profile, have been used in the experiments of the four individuals under analysis. The above is to observe the positive impact of the influence of satisfaction on the decision making regardless of the personality/decision profile of the DM. On the other hand, observe the contrast of the analysis of the results when there is no influence of satisfaction in decision making.

The process blocks of the satisfaction model are described through Sections 5.1–5.5. In Sections 5.1 and 5.2, the modeled satisfaction parameters are described. Sections 5.3 and 5.4 show how personality traits influence satisfaction characteristics. Finally, Section 5.5 presents the influence of satisfaction parameters and personality traits on preference modeling.

5.1. Interpretation of the Satisfaction Profile

The personal satisfaction model requires a series of input parameters for its operation, including the satisfaction profile. This profile is obtained from a questionnaire with five questions structured according to the Linkert scale (Appendix E). Each question represents the concepts of satisfaction models from the literature.

The description of each question and the satisfaction model supporting it are as follows: Question 1. The expected performance of the s-p is based on the Traditional Model and Theory of Value; Question 2. Quality is expected to perceive and is built from the Theory of Value; Question 3. Emotional value for the s-p is based on the Theory of Value; Question 4. Finally, the ideal expectation of s-p takes its elements from the Comparison Theory; Question 5. The fulfillment of realistic expectations of the s-p is based on the Comparison Theory.

In addition, the satisfaction profile provides quality standards, which are elements required by the Traditional Model to compare the quality and performance of the s-p. These standards represent elements of the context previously-stored and evaluated according to different opinions collected from users. This profile also provides the result of the RIASEC test (based on Fit-Job Theory) [16] to take into account the capabilities of the individual in the areas that satisfy him at work.

Through the satisfaction profile, you can obtain a minimum of 1 and a maximum of 5 points. The result of the satisfaction profile is shown in Table 3 as an example, together with the literals that identify each concept.

Table 3. A hypothetical score of the satisfaction profile questionnaire.

Satisfaction Profile Concept	Points
Performance (D)	5
Quality (C)	5
Value (V)	5
Ideal expectation (A)	5
Real expectation (B)	4
RIASEC test (R)	7
RIASEC test (I)	4
RIASEC test (A)	5

Table 4 aims to illustrate the quality and performance standards according to the decision context or case study (purchase of products). However, the values corresponding to performance Y and quality Z in the calculations have been proposed and not taken from a collection of authentic standards. From these data, the perceived disagreement (d) can be calculated, which is a concept of the traditional model that measures the negative-positive impact of s-p.

Once the satisfaction profile data is known, it is possible to define the satisfaction parameters, named as value, equality, and utility.

Table 4. A hypothetical example of the context element standards.

Item	Type	Color	Contents	Availability	...	Performance (Y)	Quality (Z)
1	Product	Coffee	3 pieces	—	...	3	5
2	Service	—	—	—	...	—	—
4	Product	...	...	...	...	3	4
3	Product	...	...	...	...	...	...

5.2. Procedure for Defining Satisfaction Parameters

After obtaining the input data of the satisfaction profile, inside block processes define the parameter value the performance (Y) and the quality (Z) of the standards for obtain the perceived disconfirmation (d). This calculation consists of taking only those values closest to the quality (C) and performance (D) given in the satisfaction profile. The selected Y and Z values will be averaged. The Equation (1) shows the sum of the average between Y and Z, as well as the sum between C and D, resulting in d.

$$d = (\overline{Y} + \overline{Z}) + (D + C) \tag{1}$$

Within the block processes, D, C, V, and d are used to interpret the DM's satisfaction (s) with the s-p through Equation (2).

$$s = \frac{D \times C \times V}{d} \tag{2}$$

To calculate the equality parameter, the ideal expectation must be compared with the real expectation of the s-p, according to the Theory of Comparison. The Equation (3) shows the comparison procedure between A and B.

$$\begin{aligned} A = B &\rightarrow satisfaction \\ A > B &\rightarrow dissatisfaction \\ A < B &\rightarrow guilty, \quad inequity, \quad discomfort \end{aligned} \tag{3}$$

Within the results block, the level of dissatisfaction or guilt obtained by the Equation (3) is defined using the absolute difference (k) between the ideal expected A and the real expectation B of the s-p. Equation (4) shows this operation. The value resulting from applying Equation (4) is the result of calculating the parameter equality.

$$k = |A - B| \tag{4}$$

Finally, within the block results, the utility parameter is defined, taking the values of the RIASEC test. According to what is specified in the RIASEC test, the highest score that can be obtained with the three literals (M) is 21; that is, 7 points for each literal. In Equation (5), a conversion of the total score to a scale of 10 is performed for easier handling, where it is assumed that each literal has a maximum score of 7. The definition of the parameter utility can be seen in Equation (6), where the value of L in each literal corresponds to that of the answered RIASEC test.

$$m = \frac{M_1 + M_2 + M_3}{10} \tag{5}$$

$$u = \frac{L_1 + L_2 + L_3}{m} \tag{6}$$

Table 5 shows, in a summarized way, the calculation of the satisfaction parameters using the equations and tables previously exposed. The data substituted in each equation (EQ) correspond to those obtained by the satisfaction profile.

Table 5. Definition of satisfaction parameters named as value, equality, and utility.

Parameter	EQ Used	Substitution of Values in EQ	Result
Value	(2)	$s = (5 \times 5 \times 5) \div 17$	7.36
Equality	(4)	$k = \|5 - 4\|$	1
Utility	(6)	$u = (7 + 4 + 5) \div 2.1$	7.62

5.3. Procedure for the Intensification or Quantification of Personality Traits

Personality traits are quantified in the intensify personality traits block. This process is possible through the facets of the OCEAN model and the scores provided by the IPIP-NEO questionnaire (addressed in Section 4.2). Table 6 shows the quantification of personality traits through the most similar facet. For example, the values shown in this table represent an individual with a collaborative decision profile. The value assigned to each trait will be the representative intensity, how shy, ethical, or desperate the person is, and influence the parameters in general. There are similarities of a personality trait with more than one facet in some cases, so it must be averaged to obtain its intensity value.

Table 6. Intensification of personality traits through the OCEAN facets [25] and IPIP-NEO questionnaire [26].

OCEAN Factors	Facets	Value with IPIP-NEO	Personality Trait	Value with Facet	Personality Parameter
Extraversion	Activity Level	0.80	Laziness	0.80	Utility
	Gregariousness	0.55	Shyness		
	Excitement-Seeking	0.17	Bravery	0.17	
Agreeableness	Morality	0.89	Ethic	0.89	Value
	Modesty	0.65	Humility	0.65	
	Altruism	0.95	Generosity	0.95	
Conscient.	Self-Efficacy	0.80	Patience	0.80	
	Cautiousness	0.72	Shyness	Average: 0.63	Utility
			Cowardice	0.72	
Neuroticism	Anxiety	0.64	Desperation	0.64	Utility
	Angry	0.27	Egoism	0.27	Utility
			Cruelty		Equality
	Immoderation	0.48	Conceit	0.48	Utility
			Cruelty	Average: 0.37	Equality
Openness	Imagination	0.50	Naivety	0.50	Utility

5.4. Personality Traits Update Procedure

The module personality traits update procedure is responsible for updating the personality traits displayed in the Table 1. Updating is possible through the association of the description between the characteristics of these features (according to [44]). In this case, the related traits are ethics with patience, which have peaceful and correct behavior in common; humility and shyness, which recognize their ability; conceit and bravery, which both emit arrogance. Table 7 shows the value of the intensity of said traits, according to the quantification presented in Table 6. This intensity value will be used to calculate the update of the decision and influence characteristics.

Table 7. The intensity of personality traits is classified as decisive.

i	Influence Traits (n_i)	Intensity (n_i)	Decision Traits (w_i)	Intensity (w_i)
1	Ethic	0.89	Patience	0.80
2	Humility	0.65	Shyness	0.63
3	Conceit	0.48	Bravery	0.17

Equation (7) shows the rules that must be followed to apply influence to decision traits; that is, if the intensity of the traits desperation, laziness, and cowardice does not exceed the intensity of the traits patience, shyness, and bravery, the latter will not be influenced, keeping their value, otherwise they will be influenced by applying Equation (8). This last equation increases a small percentage, representing the influence trait update over the decision trait. For example, the trait of patience increases due to the feedback it has with the ethics part, so that it can overcome desperation.

$$w_i^* = \begin{cases} w_i & \text{if} \quad \begin{array}{l} patience > desperation \quad \wedge \\ shyness > laziness \quad \wedge \\ bravery > cowardice \end{array} \\ (n_i \times w_i) + w_i & \text{if} \quad \begin{array}{l} patience < desperation \quad \wedge \\ shyness < laziness \quad \wedge \\ bravery < cowardice \end{array} \end{cases} \tag{7}$$

$$w_2^* = (n_2 \times w_2) + w_2 = 1.03 \rightarrow shyness^* \tag{8}$$

Updating the egoism, generosity, cruelty, and naivete traits is conducted in a similar way as explained for the previous traits. The common characteristics of these traits are intended to update the preference thresholds given by the PMUDC-I model. The relationship between the characteristics of both approaches (decision and influence) is observed as follows: egoism and laziness, both are interested only in themselves; generosity and cowardice, both have neither humor nor courage to do harm; cruelty and desperation, present a state of mind altered by anger; naivety and patience handle simplicity without alterations.

Table 8 shows the intensity corresponding to each trait based on Table 6. The influence traits are updated by applying Equation (9), except for the trait humility, which is calculated using the Equation (10). The relationship between the traits egoism, generosity, cruelty, and naivety and preference thresholds will be discussed in the topic Section 5.5.

$$n_1^* = (n_1 \times w_1) + n_1 = 0.48 \rightarrow Egoism^* \tag{9}$$

$$Humility = \frac{(Egoism^* + Generosity^*)}{2} = 1.05 \tag{10}$$

Table 8. The intensity of personality traits is classified as influential.

i	Influence Traits (n_i)	Intensity (n_i)	Decision Traits (w_i)	Intensity (w_i)
1	Egoism	0.27	Laziness	0.80
2	Generosity	0.95	Cowardice	0.72
3	Cruelty	0.37	Desperation	0.64
2	Naivety	0.50	Patience	0.80

In Table 9, the decision traits will be used to control a cycle that will determine if the influence traits should be updated or not. In addition, influence traits will serve to update preference thresholds and satisfaction parameters. Table 9 is a summary of the results of the influence on each of the personality traits. This influence is the result of applying Equations (7)–(10). Finally, it only remains to send them to the following process to influence the satisfaction and preference parameters (thresholds).

Table 9. Results of the influence calculation of the decision and influence traits.

Influenced Decision Traits	Intensity	Influenced Traits of Influence	Intensity
Patience	1.512	Egoism	0.48
Shyness	1.03	Generosity	1.63
Bravery	0.25	Humility	1.05
—	—	Cruelty	0.60
—	—	Naivety	0.90

5.5. Procedure of Influence of the Parameters of Satisfaction and Preferences with the Personality

Within the procedure Procedure of influence of the parameters of satisfaction and preferences with the personality the following elements are required: personality traits (Table 9), satisfaction parameters (Table 5), personality parameters, and preference thresholds (Table 2).

Equation (11) shows the process of influencing the satisfaction parameters with the personality parameters (relationship addressed in Section 4.2), where the parameters belonging to the same group will perform the influence or update.

Equation (12) shows as an example the calculation of the influence of the satisfaction parameter value (V_iS_j) by substituting the values from Table 10 in Equation (11) according to their corresponding group. The satisfaction parameters were taken from Table 5 and the personality parameters are found in Table 2.

$$\begin{aligned} V_iS_j^* &= (V_iS_j \times V_iP_j) + V_iS_j \\ E_iS_j^* &= (E_iS_j \times E_iP_j) + E_iS_j \\ U_iS_j^* &= (U_iS_j \times U_iP_j) + U_iS_j \end{aligned} \tag{11}$$

$$\begin{aligned} &V_iS_j^* = (V_iS_j \times V_iP_j) + V_iS_j \\ &\text{Parameter Value}^* = (7.36 \times 0.4) + 7.36 = 10.304 \end{aligned} \tag{12}$$

Table 10. Influence of personality on satisfaction through the parameters value, equality, and utility.

Params. (i)	Satisf. Params. (S_j)	Pers. Params. (P_j)	Influence of Pers. on Satisf.
Value (V_i)	7.36	0.4	10.304
Equality (E_i)	1	0.37	1.37
Utility (U_i)	7.62	0.65	12.573

The influence traits presented in Table 9 influence the preference thresholds. The preference thresholds indicate the differences between comparisons of alternatives through a strategy that integrates preferences of a DM, such as NOSGA-II [8]. The preference thresholds will be provided by the PMUDC-I model preferential impact model [2].

In general terms, the description of the threshold q indicates the minor differences between one alternative and another to consider them negligible. On the other hand, the description of the threshold v points out the significant differences between alternatives, considering one of them preferred over the other. Finally, the description of the threshold u shows the magnitude of the differences between alternatives when the veto conditions begin to be observed. These descriptions have been taken from Rivera-Zárate's work [46]

The description of the trait generosity indicates sensitivity and compassion for the misfortunes of others. The egoism trait describes excessive attention to oneself without caring about others. In the case of the humility trait, it indicates the virtue of recognizing one's limitations and weaknesses. These definitions or descriptions have been taken from RAE [43]

Through the provided descriptions of the preference thresholds and the traits generosity, egoism, and humility, it is possible to visualize a relationship in common and, in this way, influence thresholds of preference with the personality traits mentioned above. In the case of the threshold q and the trait generosity, they have in common that they are indifferent to minimal situations. The threshold v and the trait egoism reflect a restrictive character. Finally, the threshold u and the trait humility share that they both recognize their limitations, but it does not represent any problem.

Table 11 shows the satisfaction parameters and the result of the influence of personality traits. The threshold-related trait q (generosity) represents the least stringent trait; therefore, the satisfaction parameter with the least weight will be influenced by generosity, and the strictest trait egoism, will influence the parameter with the highest weight.

In Table 11, the satisfaction parameters have been ordered in ascending order and placed with the corresponding personality trait, influencing said parameter through its intensity, generating a small percentage of equivalent increases of the trait over the parameter. Through Equation (13), it is possible to influence the satisfaction parameters with personality traits to affect the DM preference thresholds later. The Table 11 shows the result of applying Equation (13).

$$\begin{aligned}
&Equality^* = (Equality \times \text{Generosity Intensity}) + Equality \\
&Value^* = (Value \times \text{Humility Intensity}) + Value \\
&Utility^* = (Utility \times \text{Egoism Intensity}) + Utility \\
&\text{Parameter } Equality^* = (1.37 \times 1.63) + 1.37 = 3.60
\end{aligned} \tag{13}$$

Table 11. Results of the influence of the satisfaction parameters with personality traits.

Parameter	Parameter Value	Influence Traits	Intensity	Result of Influence
Equality	1.37	Generosity	1.63	3.60
Value	10.304	Humility	1.05	21.12
Utility	12.573	Egoism	0.48	18.60

After influencing the parameters of satisfaction with personality, they are converted to a percentage to affect the preference thresholds consistently and moderately, increasing the equivalent percentage of each parameter over each of the thresholds. Table 12 shows the conversion of each parameter to a percentage. Equation (14) shows how the calculation of the influence of the preference parameters is carried out with the satisfaction parameters influenced by personality, and Table 13 shows the results of the influence of each threshold.

$$\begin{aligned}
&q^* = (q \times Equality) + q \\
&u^* = (u \times Value) + u \\
&v^* = (v \times Utility) + v \\
&\text{Parameter } q^* = (23.78 \times 0.036) + 23.78 = 24.63
\end{aligned} \tag{14}$$

Table 12. Conversion of the satisfaction parameters to a percentage fraction.

Parameter	Influenced Parameter Value	Conversion to %	%
Equality	3.60	$3.60 \div 100$	0.036
Value	21.12	$21.12 \div 100$	0.2112
Utility	18.60	$18.60 \div 100$	0.186

Table 13. Preference thresholds influenced by satisfaction parameters from Table 12.

Threshold	Threshold Value	Satisf. Param.	Param. Value	Result of Influence
q	23.78	Equality	0.036	24.63
u	31.81	Value	0.2112	38.52
v	39.85	Utility	0.186	47.26

The influence of the preference thresholds λ (credibility), β (asymmetry), and ε (symmetry) is completed in the same way as with the thresholds q, u, and v. In this case, the traits used to influence are cruelty, naivety, and humility.

According to the description of the threshold λ, it is associated with credibility. The more value you have, the more credibile and strict the character. The threshold β indicates a preferential distinction between comparisons of alternatives. Finally, the threshold ε establishes indifference in comparing alternatives. These descriptions or definitions were interpreted from the work of Fernández et al. [47].

In the case of personality traits, the trait description or definition of cruelty reflects a fierce or impious state of mind. The trait naivety indicates sincerity, straightforwardness, and lack of malice. The humility trait mentions recognizing limitations and weaknesses. These definitions or descriptions are based on RAE [43].

Through the provided descriptions of the thresholds λ, β, and ε, and of the traits cruelty, naivety, and humility, it is possible to visualize a common relationship and influence the aforementioned thresholds with personality traits. The common description between the threshold λ and the trait cruelty is that they both share a strong and strict character. The relationship between the threshold β and the trait humility is that they recognize their limitations. Finally, the threshold ε and the trait naivety share an opening character.

Equation (15) shows how to calculate the influence of the parameters of satisfaction with personality traits. Finally, Table 14 shows the result of calculating the influence of personality on satisfaction parameters. According to their standard description, the parameters have been ordered in descending order and with the corresponding personality trait.

$$\begin{array}{l} Utility^* = (Utility \times \text{Cruelty Intensity}) + Utility \\ Value^* = (Value \times \text{Humility Intensity}) + Value \\ Equality^* = (Equality \times \text{Naivety Intensity}) + Equality \\ \text{Parameter utility}^* = (12.573 \times 0.60) + 12.573 = 20.11 \end{array} \quad (15)$$

Table 14. Calculation of the influence of the parameters of satisfaction with the traits in order with the thresholds λ, β, and ε.

Parameter	Parameter Value	Influence Traits	Intensity	Result of Influence
Utility	12.573	Cruelty	0.60	20.11
Value	10.304	Humility	1.05	21.12
Equality	1.37	Naivety	0.90	2.60

Table 15 shows the conversion of the satisfaction parameters to generate a moderate increase in the influence of personality and satisfaction on the thresholds λ, β, and ε.

Table 15. Conversion of satisfaction parameters.

Parameter	Influenced Parameter Value	Conversion to %	%
Utility	20.11	$20.11 \div 100$	0.2011
Value	21.12	$21.12 \div 100$	0.2112
Equality	2.60	$2.60 \div 100$	0.026

Equation (16) shows how to calculate the influence of the thresholds λ, β, and ε with the satisfaction parameters. Finally, Table 16 shows the thresholds influenced by the satisfaction parameters ordered from strictest to most relaxed (in the same way as in Table 14).

$$\begin{array}{l} \lambda^* = (\lambda \times Utility) + \lambda \\ \beta^* = (\beta \times Value) + \beta \\ \varepsilon^* = (\varepsilon \times Equality) + \varepsilon \\ \text{Parameter } \lambda^* = (0.71 \times 0.2011) + 0.71 = 0.85 \end{array} \quad (16)$$

Table 16. Result of preference thresholds influenced by satisfaction.

Threshold	Threshold Value	Satisf. Param.	Param. Value	Result of Influence
λ	0.71	Utility	0.2011	0.85
β	0.08	Value	0.2112	0.096
ε	0.04	Equality	0.026	0.041

Table 17 shows the preference thresholds finally calculated and ready to be sent to the deliberative process. The increase in each parameter can be seen with the naked eye, where said increase represents the influence of satisfaction and personality on preferences during the decision-making process.

Table 17. Summary of preference thresholds influenced by satisfaction and personality.

Threshold	Threshold Value
Indifference (q)	24.63
Preveto (u)	38.52
Veto (v)	47.26
Credibility (λ)	0.85
Asymmetry (β)	0.096
Symmetry (ε)	0.041

5.6. Experimental Design

The experimental design validates the functioning of the proposed satisfaction model integrated into the cognitive process of an intelligent agent. Furthermore, the hypothesis to be validated shows that integrating the degree of satisfaction of an individual in optimization problems that take into account personality and preferences generates better solutions than process solutions that do not incorporate satisfaction. The validation is carried out through a case study that addresses the purchase of food products.

The solutions that integrate characteristics of satisfaction, personality, and preferences of the DM, come from the process of applying the satisfaction model proposed in this work, the NOSGA-II metaheuristic based on preferences [8], and a personality model (PMUDC -II). On the other hand, the solutions that only integrate personality characteristics and DM preferences come from the application of the PMUDC-I [2] personality model and the NOSGA-II strategy. These solutions represent a set of shopping lists with the products desired by the DM, which the VDM suggests. Both sets of shopping lists (generated with/without satisfaction characteristics) will be compared to validate the proposed hypothesis.

The hypothesis validation experiment will be applied to four individuals that reflect different characteristics to contrast the solutions generated. These individuals will be identified under the optimistic, collaborative, inquirer, and strict personality profiles. A parameter will indicate their tolerance for solutions differently from their decision, and a set of parameters will quantify their satisfaction from a personality perspective. To collect information on the personality of individuals, the questionnaire based on personality types of the MBTI model is used [28] and the IPIP-NEO [26] questionnaire will be applied, which is based on personality traits from the FFM-OCEAN model [25]. The personality profiles and the tolerance parameter will be taken from the PMUDC-I model [2]. The personality parameters that characterize satisfaction will be taken from the PMUDC-II model, which uses the PMUDC-I model for its development. The PMUDC-II model will be addressed in future research. The result of applying the personality questionnaire can be seen in Appendices B and C.

Information on the preferences of the individuals under experimentation will be collected through a questionnaire based on a specific decision context. In this case, the context is the purchase of food products. In this way, it will be possible to generate representative parameters of the preferences of a DM, which are: indifference, preveto, veto, credibility, asymmetry, and symmetry. The questionnaire and the preference parameters will be provided through the preferential impact model of the PMUDC-I model [2]. The result of applying the preferences questionnaire can be seen in Appendix D, and the product database can be found in Appendix A.

The information on the satisfaction profile will be obtained through a questionnaire proposed in this work, whose structure is presented in Section 5.1. The information from the satisfaction profile (results of the satisfaction questionnaire and the RIASEC test [16,41]) will be used in the experimentation with the four study subjects to influence the cognitive and deliberative process. The reason for experimenting with the same set in the decision process of the four individuals is to observe the positive impact of satisfaction on preferences regardless of the personality characteristics of the DM. The result of applying the satisfaction questionnaire can be seen in Appendix E. The result of applying the RIASEC test can be seen in Appendix F.

Using the information of the individuals mentioned above, the VDM will provide a set of instances generated with the influence of the satisfaction model and without the intervention of said influence. Each instance will be evaluated using the degree of satisfaction metric proposed in this work to determine if it meets its expectations. These instances are composed of a series of food products requested by the individual. In this set, it is simulated that the four study subjects want or request to acquire the same type of products (for example, water, milk, and bread).

The results obtained from evaluating the set of instances of the individuals' understudy will be compared through the Wilcoxon non-parametric statistical test. This statistical test will indicate whether or not there are significant differences between the solutions or instances generated with the satisfaction model and without the said model. This statistical test will reinforce the hypothesis that guides this research work.

5.7. The Evaluation Process of the Degree or Level of Satisfaction (Satisfaction Metric)

The satisfaction metric is responsible for evaluating the solution alternatives provided by the deliberative process. These solutions come from the NOSGA-II solution strategy, which integrates the preference thresholds influenced by satisfaction and personality. Therefore, the alternative solutions (decisions) provided by NOSGA-II somehow reflect the DM's satisfaction, preferences, and personality. In addition, the satisfaction metric ensures that the solutions are closest to the DM's satisfaction expectations imposed, that is, to their initial request, which, according to the case study of product shopping, is a shopping list with certain products selected by the user (DM).

The evaluation consists of taking the DM's initial request or product list as a reference and comparing it with the solution alternatives given by the NOSGA-II strategy, preventing them from exceeding the tolerance ($\varphi*$) allowed for deviation from their ideal satisfaction.

In the work of Castro-Rivera et al. [2], a method to calculate tolerance (φ) allowed for distance concerning alternative solutions other than your preference has been proposed. However, this tolerance (φ) does not reflect the DM's satisfaction. Equation (17) shows how to integrate satisfaction into tolerance ($\varphi*$), where μ represents the union of the set of satisfaction parameters and φ represents the tolerance of the DM without reflecting satisfaction.

The calculation of μ is proposed through the union of the satisfaction parameters calculated in Table 12, whose result is 0.4332. The reason for using the satisfaction parameters to influence q, u, and v, is because these preference parameters represent a less strict character with respect to the thresholds (λ, β, and ϵ), according to the description provided in Section 5.5. The above reason make them more suitable for calculating $\varphi*$ since tolerance indicates relaxation and not restriction. After calculating $\varphi*$, it is necessary to know the accumulated value of each criterion, both the DM's request and the solution alternatives given by the deliberative process (NOSGA-II), to compare them with $varfi*$.

$$\varphi* = (\varphi \times \mu) + \varphi \tag{17}$$

Table 18 shows the structure of both the query or list of products requested, as well as the alternative solutions, where R represents the set of suggested alternatives/lists/shopping baskets, be it the request or the alternatives delivered by the deliberative processes (NOSGA-II strategy). This set goes from R_1 to R_m and is made up of n elements or products x characterized by benefits, criteria, or attributes b that go from b_1 to b_p. Table 18 also shows the total sum of each of the criteria ($S_{b_{R_{mp}}}$), which is formally expressed in Equation (18). The total sum of each criterion, determined by $S_{b_{R_{mp}}}$, will be compared with $\varphi*$ using Equation (19) as the first measure of evaluation of the satisfaction.

$$S_{b_{R_{k|k \in \{1,2,\ldots,m\}}} j | j \in \{1,2,\ldots,p\}} = \sum_{i=1}^{n} b_{R_k j x_{R_k} i} \tag{18}$$

Table 18. Structure of the requested shopping list and solution alternatives/suggested shopping lists.

Lists	Products	Criteria			
	$x_{R_{11}}, x_{R_{12}}, \ldots, x_{R_{1n}}$	$b_{R_{11}}$	$b_{R_{12}}$	$\cdots$	$b_{R_{1p}}$
	$x_{R_1 1}$	$b_{R_1 1 x_{R_1} 1}$	$b_{R_1 2 x_{R_1} 1}$	$\cdots$	$b_{R_{1p} x R_1 1}$
R_1	$x_{R_1 2}$	$b_{R_1 1 x_{R_1} 2}$	$b_{R_1 2 x_{R_1} 2}$	$\cdots$	$b_{R_1 p x_{R_1} 2}$
	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	$x_{R_1} n$	$b_{R_1 1 x_{R_1} n}$	$b_{R_1 2 x_{R_1} n}$	$\cdots$	$b_{R_1 p x_{R_1} n}$
		$S_{b_{R_1} 1}$	$S_{b_{R_1} 2}$	$\cdots$	$S_{b_{R_1} p}$
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	$x_{R_{m1}}, x_{R_{m2}}, \ldots, x_{R_{mn}}$	$b_{R_{m1}}$	$b_{R_{m2}}$	$\cdots$	$b_{R_{mp}}$
	$x_{R_{m1}}$	$b_{R_m 1 x_{R_m} 1}$	$b_{R_m 2 x_{R_m} 1}$	$\cdots$	$b_{R_m p x_{R_m} 1}$
R_m	$x_{R_{m2}}$	$b_{R_m 1 x_{R_m} 2}$	$b_{R_m 2 x_{R_m} 2}$	$\cdots$	$b_{R_m p x_{R_m} 2}$
	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	$x_{R_{mn}}$	$b_{R_m 1 x_{R_m} n}$	$b_{R_m 2 x_{R_m} n}$	$\cdots$	$b_{R_m p x_{R_m} n}$
		$S_{b_{R_{m1}}}$	$S_{b_{R_{m2}}}$	$\cdots$	$S_{b_{R_{mp}}}$

Table 19 shows the structure of a list/request/alternative solution (Table 18) with the accumulated total of each of its criteria (Equation (18)). In this case, said list represents the query or shopping list of food products requested by the DM. This shopping list comprises three products and two criteria, the price and the content.

Table 19. DM's initial shopping list for the VDM.

Product	Price	Contents
Natural water	5.80	600
Soluble coffee	38	180
Sweetbread	9.90	62
—	$S_{b_{R_{01}}}$: 53.70	$S_{b_{R_{02}}}$: 842

In Table 20, there are alternative solutions or shopping lists suggested by the VDM, generated with the NOSGA-II strategy. These lists are based on the shopping list requested by the DM. Suggested lists by VDM try to cover the objectives from the list requested by DM, improving either in some criterion or in both (price or content). In addition, the suggested lists reflect the preferences, personality, and satisfaction of the DM due to the preference thresholds (Table 17) that were provided to NOSGA-II.

Table 20. Solution alternatives generated with NOSGA-II based on the list in Table 19.

List	Product	Price	Contents
List 1	Natural water Soluble coffee Sweetbread	8.50 41 14	600 180 200
		$S_{b_{R_{11}}}$: 63.50	$S_{b_{R_{12}}}$: 980
List 2	Natural water Soluble coffee Sweetbread	8.50 41 9.90	600 180 62
		$S_{b_{R_{21}}}$: 59.40	$S_{b_{R_{22}}}$: 842
List 3	Natural water Natural water Soluble coffee Sweetbread	8.50 12.60 38 14	600 1500 180 200
		$S_{b_{R_{21}}}$: 73.10	$S_{b_{R_{22}}}$: 2480

The first strategy is to evaluate what was obtained against what was expected. That is to say, the requested list with the lists suggested by the VDM. Then, it is necessary to calculate the proportion that exceeds each criterion of the suggested lists to the criteria of the requested list. In this work, it is proposed to compare the proportion of differences between criteria with the tolerance ($\varphi*$), ensuring that the total sum of each criterion ($S_{b_{R_{mp}}}$) of the suggested lists does not exceed what is allowed by $\varphi*$. It will be counted as a hit (A_b). The higher the number of hits the set of suggested lists has ($R = \{1, 2, \ldots, m\}$), the closer the DM's satisfaction will be. In Equation (19), the procedure described above is presented.

$$\begin{array}{lll} A_b = A_b + 1 & \text{si} & \varphi* \geq \frac{|S_{b_{R_{01}}} - S_{b_{R_{11}}}|}{S_{b_{R_{01}}}}, \frac{|S_{b_{R_{02}}} - S_{b_{R_{12}}}|}{S_{b_{R_{02}}}}, \ldots, \frac{|S_{b_{R_{0p}}} - S_{b_{R_{1p}}}|}{S_{b_{R_{0p}}}} \\ A_b = A_{b+1} & \text{si} & \varphi* \geq \frac{|S_{b_{R_{01}}} - S_{b_{R_{21}}}|}{S_{b_{R_{01}}}}, \frac{|S_{b_{R_{02}}} - S_{b_{R_{22}}}|}{S_{b_{R_{02}}}}, \ldots, \frac{|S_{b_{R_{0p}}} - S_{b_{R_{2p}}}|}{S_{b_{R_{0p}}}} \\ \vdots & \vdots & \vdots \\ A_b = A_b + 1 & \text{si} & \varphi* \geq \frac{|S_{b_{R_{01}}} - S_{b_{R_{m1}}}|}{S_{b_{R_{01}}}}, \frac{|S_{b_{R_{02}}} - S_{b_{R_{m2}}}|}{S_{b_{R_{02}}}}, \ldots, \frac{|S_{b_{R_{0p}}} - S_{b_{R_{mp}}}|}{S_{b_{R_{0p}}}} \end{array} \tag{19}$$

In Table 21, Equation (19) is replaced with the values of the suggested shopping lists (Table 20) and the list requested by the DM (Table 19). In this evaluation, the total hits of the set of suggested lists have been five hits out of six. Each list can obtain two maximum hits due to its two criteria and a minimum of zero hits.

Table 21. Substitution of values in Equation (19).

List	Criteria	Operation	Comparison with $\varphi*$	Hit (A_b)
List 1	Price Contents	$\lvert 53.70 - 63.50\rvert \div 53.70 = 0.182$ $\lvert 842 - 980\rvert \div 842 = 0.163$	$0.8330475 \geq 0.182$ $0.8330475 \geq 0.163$	$A_b = 1$ $A_b = 2$
List 2	Price Contents	$\lvert 53.70 - 59.40\rvert \div 53.70 = 0.106$ $\lvert 842 - 842\rvert \div 842 = 0$	$0.8330475 \geq 0.106$ $0.8330475 \geq 0$	$A_b = 3$ $A_b = 4$
List 3	Price Contents	$\lvert 53.70 - 73.10\rvert \div 53.70 = 0.361$ $\lvert 842 - 2480\rvert \div 842 = 1.945$	$0.8330475 \geq 0.361$ $0.8330475 \geq 1.945$	$A_b = 5$ $A_b = 5$

After counting the total hits of the solution alternatives (set R), verifying if the said number of hits comes close to the DM's ideal satisfaction expectation is necessary. For evaluation satisfaction of the lists suggested by the VDM, the proportion represented by the hits in the m lists of the set R must first be obtained. Then, with this proportion, it will be possible to know the percentage of satisfaction that the correct answers cover in the p criteria. Finally, this percentage should be compared to the satisfaction expectation of the DM.

If the percentage of correct answers exceeds or equals the satisfaction expectation, then the set R is accepted; otherwise, it will be necessary to readjust the satisfaction, preferences, and personality parameters. Equation (20) shows the procedure described above, in addition to the substitution of the values presented above, where $A_b = 5$, $m = 3$, $p = 2$ and $\varphi* = 0.8330475$. The result indicates that the set of lists R reaches the satisfaction expectation so that the solution alternatives are satisfactory and efficient for the interests of the DM.

$$\begin{aligned}
&\text{There is satisfaction if}\ldots && \tfrac{A_b}{m\times p} \geq |1-\varphi*| \\
&\text{Substituting}\ldots && \tfrac{5}{(3\times 2)} = 0.84 \\
& && |1-0.8330475| = 0.1669525 \\
&\text{Yes, there is satisfaction} && 0.84 \geq 0.1669525
\end{aligned} \tag{20}$$

Tables 22 and 23 show the data used in each individual to generate the lists and the evaluation of the results. In Table 23, personality parameters corresponding to each decision profile are used to influence satisfaction and preferences. The same satisfaction parameters (Table 10) were applied in the experiments of the three individuals with different profiles. The above is the purpose of observing the impact of the personality on the results, despite having the same satisfaction or expectation, and observing how it complements the satisfaction, producing highly satisfactory results when both factors are present.

In Table 24, the previous experiment has been replicated, only that this time three different personality-decision profiles are involved than that of the previously analyzed individual (cooperative decision profile). In this experiment, the results of six lists with/without satisfaction for each decision profile (strict, optimistic, and inquirer) have been evaluated. That is, solutions generated with the presence of satisfaction and without its presence are evaluated. These lists also consider only two criteria.

Table 22. Information from three individuals under studies with different decision profiles.

Profile	**Status**	**Criteria**	**Thresholds**						**Tol.**
		b	**q**	**u**	**v**	$\boldsymbol{\lambda}$	$\boldsymbol{\beta}$	$\boldsymbol{\epsilon}$	$\boldsymbol{\varphi*}$
Strict	WS	Price Contents	15.23 150.72	18.85 223.56	22.14 298.05	1.07	0.20	0.08	0.23
	WoS	Price Contents	14.88 147.27	16.49 195.53	18.11 243.8	0.92	0.17	0.08	0.166
Optimistic	WS	Price Contents	36.71 800.54	47.20 1039.43	56.28 1248.25	0.63	0.02	0.01	1.23
	WoS	Price Contents	35.93 783.41	41.63 916.62	47.33 1049.83	0.54	0.02	0.01	0.91
Inquirer	WS	Price Contents	35.01 179.95	44.38 343.55	49.28 483.67	0.93	0.13	0.06	0.39
	WoS	Price Contents	34.39 176.76	38.8 300.4	43.21 424.05	0.8	0.12	0.06	0.30

Table 23. Personality parameters corresponding to each decision profile.

Factor	Profile	Parameters		
Personality	—	**Value**	**Equality**	**Utility**
	Strict	0.253846154	0.26	0.353846154
	Optimistic	0.053076923	0.175384615	0.247692308
	Inquirer	0.27	0.2715385	0.4715385
Satisfaction	—	7.34	1	7.62

Table 24. Experimentation of the impact of satisfaction in three individuals with different decision profiles.

Profile	Status	Lists			Hits (A_b)	Satisf. (Equation (20))
			Prices	**Contents**		
Strict	With satisfaction	List 1	57.8	980	5 de 6	YES
		List 2	65.70	2342		
		List 3	53.69	842		
	Without satisfaction	List 1	69.90	1942	0 de 6	NO
		List 2	70.70	1042		
		List 3	72.00	2342		
			Price	**Contents**		
Optimistic	With satisfaction	List 1	60.00	1880	4 de 6	YES
		List 2	65.80	2480		
		List 3	75.69	1110		
	Without satisfaction	List 1	62.69	2342	3 de 6	YES
		List 2	67.70	2842		
		List 3	67	2380		
			Price	**Contents**		
Inquirer	With satisfaction	List 1	70.40	1042	5 de 6	YES
		List 2	70.90	2442		
		List 3	60.50	980		
	Without satisfaction	List 1	56.40	842	3 de 6	NO
		List 2	67.00	2880		
		List 3	75.50	3480		

The resulting shopping lists are shown in Table 24; each decision profile presents three lists for each strategy (with/without satisfaction) with the accumulated values of the price and content criteria. The lists of each strategy have been selected from the deliberative process (NOSGA-II) and represent the most optimal set of solutions suggested by the VDM concerning the satisfaction, preferences, and personality of a DM.

The results of the experiment with three individuals with different profiles in Table 24 indicate that the optimistic profile has a similar performance in both cases (with/without satisfaction). The above is due to its high tolerance since optimistic or relaxed individuals are very open to decisions other than their preferred ones. Hence, their satisfaction is high, possibly in most decision contexts, so lists with the influence of satisfaction meet the expectations of the optimistic DM. In contrast, in the case of the inquirer and strict profile, the satisfaction-influenced lists have a more substantial advantage in meeting the satisfaction expectation.

In Table 25, the same instances of the experiment above (Table 24) have been used, but evaluating each of the three decision profiles (with/without satisfaction) has. In the said table, similar behavior is observed concerning the results of Table 24, where an optimistic individual in both cases (with/without satisfaction) shows a very high tolerance. In the case of the individual with the strict profile, only the instance I1 was accepted as satisfactory, and the difference in results can be seen when satisfaction is present and when it is not present. In the inquirer profile, instances I2 and I5 show that the presence of satisfaction represents a difference concerning its absence. In Table 25, the terminology used is as follows: H (Hits), WS (With satisfaction), WoS (Without satisfaction), S (Satisfaction), Y (Yes), N (No), and I (Instance).

Table 25. Experimentation with three decision profiles using six data instances.

			Profile											
Instance	**Values**		**Strict**				**Optimistic**				**Inquirer**			
	Price	**Content**	**WS**		**WoS**		**WS**		**WoS**		**WS**		**WoS**	
			H	**S**	**H**	**S**	**H**	**S**	**H**	**S**	**H**	**S**	**H**	**S**
I1	57.8 65.7 53.69	980 2342 842	5	Y	4	N	5	Y	5	Y	5	Y	5	Y
I2	69.9 70.70 72.00	1942 1042 2342	0	N	0	N	4	Y	4	Y	4	Y	1	N
I3	60.00 65.80 75.69	1880 2480 1110	2	N	1	N	4	Y	4	Y	3	N	3	N
I4	62.69 67.70 67.00	2342 2842 2380	1	N	0	N	3	Y	3	Y	3	N	3	N
I5	70.40 70.9 60.50	1042 2442 980	2	N	2	N	5	Y	5	Y	5	Y	3	N
I6	56.40 67.00 75.50	842 2880 3480	2	N	2	N	4	Y	4	Y	3	N	3	N

The results of Table 25 were subjected to a statistical analysis taking the Hits (H) column of the WS and WoS groups of the six instances evaluated with the three profiles of the DMs'. The statistical test applied was Wilcoxon to compare both groups and determine significant differences between them. The significance level used for the test was 0.05, obtaining a p-value of 0.0393, which means that the difference in means of both groups is the same, so the null hypothesis is rejected. The preceding affirms a significant difference when a satisfaction model is integrated into an optimization problem than when its integration is not considered.

6. Discussion of Results

In this research work, the satisfaction model proposed was subjected to experimentation, validating whether the definition of the satisfaction parameters of this model generates a significant and positive influence on the preferences of a DM, improving the deliberative process of a virtual agent.

Four types of individuals were required in food product shopping to test the satisfaction model. The strategy applied to ensure that these individuals provided distinctive characteristics to the experimentation was through the PMUDC-I model [2]. PMUDC-I provides a way to identify individuals through personality and decision profiling. These profiles are optimistic, collaborative, inquirer, and strict. In addition, NOSGA-II [8] was used like an optimization strategy that acts as the deliberative process of the VDM, producing the shopping lists requested by individuals according to their preferences, satisfaction, and personality.

In the results of the experimentation shown in Table 21, carried out with the collaborative profile DM, the comparison between the criteria of the products expected by the DM and the lists suggested by the VDM could be observed. In said comparison, the level of correct answers was very significant, achieving a total of five correct answers out of six.

The more correct answers, the greater the possibility of covering the satisfaction expectation of the DM. The above could be corroborated by applying Equation (20), showing that the DM with collaborative characteristics is 84% satisfied with the suggestions given by the VDM.

The data provided in Tables 22 and 23 were used to replicate the previous experiment, generating instances or shopping lists suggested by the VDM for three different individuals. These individuals are identified under the strict, optimistic/relaxed, and inquirer profiles. The total number of instances generated was six, of which two of them were generated through the corresponding data of each individual, integrating and restricting the influence of the satisfaction model.

Table 24 shows the results of the experimentation with the six instances generated with the three individuals. These results clearly show that integrating a satisfaction model to influence an agent's deliberation positively impacts the scope of the satisfaction expectation concerning when it is not integrated. It is worth mentioning that the optimistic DM was the only one that managed to reach the satisfaction expectation in both cases due to their flexible characteristics being satisfied more easily and thus, reflected in a high tolerance. The correct answers more clearly describe the scope of the satisfaction expectation according to the profile of each DM. For example, in the case of the strict DM, the hits highlight that integrating a satisfaction model improves the scope of the satisfaction expectation. When integrating the characteristics of satisfaction, five out of six correct answers were obtained. On the contrary, zero of six correct answers were obtained by not integrating satisfaction.

In the experiment presented in Table 25, the six instances of the experiment in Table 24 were used. In this new experiment, the six instances with the three individuals (strict, optimistic, and inquirer) were evaluated using the satisfaction metric proposed in Equation (20). From this new experimental case, we observed that the optimistic DM reached their satisfaction expectation regardless of whether or not there was any influence on satisfaction. In the strict DM, it can be seen that only one instance (I1) covers the level of satisfaction required by said individual, showing five of six correct answers when satisfaction was integrated compared to four of six correct answers when satisfaction does not influence. In the rest of the instances of the strict profile, the number of correct answers did not exceed two. In the case of the inquirer DM, it was possible to meet the expectation of satisfaction in three instances, of which instance I2 stands out, due to it showing a clear significant difference when integrating satisfaction with four of six correct answers concerning one of six correct answers when satisfaction is not integrated.

To strengthen the results obtained from the experiment presented in Table 25, they were subjected to the Wilcoxon statistical test. The results reveal the feasibility of considering the characteristics of satisfaction in a computable model to improve the cognitive process of a virtual agent.

The experimentation presented in this work confirms that the proposed satisfaction model is a novel contribution to behavioral simulation. However, despite the results and the consistent behavior of each individual, it is necessary to strengthen these advantages. The above could be through the integration of personality traits more representative of satisfaction or other elements that assist in modeling the satisfaction of individuals more precisely. The preceding could give rise to future research that generates more significant advantages in the experimentation results than that reported in this work.

7. Conclusions

In this document, a satisfaction model capable of influencing and improving the decision-making process of a virtual agent in an optimization context was developed. The above was possible by integrating models from the literature aimed at assisting in the simulation of behaviors, such as the NOSGA-II preference-based strategy, the PMUDC-I model, and its predecessor in the development phase PMUDC-II, as well as models of satisfaction with work and customer, approaches.

According to the above, the main objective of this research was achieved by using the attributes provided by the PMUDC-I, PMUDC-II models, and the satisfaction model to assist in modeling and influencing the preferences of a DM, managing to improve the cognitive process of a virtual agent, as observed in the experimentation carried out in this work.

The integration of parameters and attributes of personality and satisfaction generate an impact on preferences confirming the hypothesis that arises from the main objective of this work, demonstrating that better solutions are provided by integrating a satisfaction model compared to processes that do not consider integrating it.

In addition to contributing to developing a satisfaction model, an intelligent agent architecture was also developed to facilitate an interaction mechanism with the DM. The satisfaction model was integrated with the personality model and the NOSGA-II metaheuristic in the deliberative process.

However, despite contributing to a satisfaction model that provides excellent scope for improving optimization process solutions focused on behavior simulation, there are still certain unknowns that limit the efficiency of the results in some way. These deficiencies or unknowns could be resolved by modeling other significant impacts, such as those addressed. Nevertheless, the above is a reason to continue research and analyze the emulation of human behavior through computable models that provide credibility in the development of virtual entities.

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Abbreviations

The following abbreviations are used in this manuscript:

NOSGA-II	Non-Outranking Sorting Genetic Algorithm
DM	Decision-Maker
VDM	Virtual Decision-Maker
IVA	Intelligent Virtual Agent
PMUDC	Personality Model Under Decision Context
FFM-OCEAN	Five-Factor Model-Openness, Conscientiousness, Extraversion, Agreeableness, Neuroticism
MBTI	Myers-Brigg Type Indicator
KTS	Keirsey Temperament Sorted

Appendix A. Case of the Study Details

The Table A1 present the products used in the food shopping case study, which consists of 55 product variants.

Table A1. Table of products used in the experimentation with the case study of foods products.

No.	Product	Price	Content	No.	Product	Price	Content
1	Water	5.8	600	29	Milk	21	1000
2	Water	6	1000	30	Milk	28.3	1500
3	Water	8	1500	31	Milkshake	7.2	250
4	Water	12	2000	32	Milkshake	8.5	200
5	Water	8.5	600	33	Milkshake	7.2	250
6	Water	12.6	1500	34	Milkshake	21.5	1000
7	Water	6	500	35	Wholemeal bread	29.5	480
8	Water	9	1500	36	Wholemeal bread	34.5	680
9	Water	9	2000	37	Wholemeal bread	30.7	567
10	Instant coffee	38	180	38	Wholemeal bread	82	540
11	Instant coffee	41	180	39	Wholemeal bread	64	450
12	Instant coffee	63	205	40	Sweetbread	32	240
13	Instant coffee	90	225	41	Sweetbread	9.9	62
14	Instant coffee	155.5	350	42	Sweetbread	32.9	240
15	Instant coffee	399	1200	43	Sweetbread	31.9	330
16	Instant coffee	62	120	44	Sweetbread	14	200
17	Soda	13.1	600	45	Dessert	115	700
18	Soda	12	355	46	Dessert	11	114
19	Soda	29	2000	47	Dessert	24.5	324
20	Soda	30.6	2500	48	Dessert	15.4	14
21	Soda	34.5	3000	49	Instant coffee	47.5	180
22	Soda	10	600	50	Milk	50	1000
23	Soda	8	355	51	Milkshake	50	1000
24	Soda	21.9	2000	52	Instant coffee	41.9	250
25	Soda	24	2500	53	Sweetbread	13.9	125
26	Soda	25	3000	54	Milkshake	8.5	200
27	Milk	19.9	1000	55	Sweetbread	6	100
28	Milk	18.9	1000				

Appendix B. Results from the Types-Based Personality Questionnaire

This section presents the results of the MBTI personality model questionnaire based on personality types [28]. This questionnaire consists of 4 questions that try to recognize the preference of individuals to act in their environment. These characteristics are represented by a label consisting of 4 dichotomies or letters that form the individual's personality profile. These dichotomies come from a set of 8 letters with which a total of 16 personality profiles can be formed. The results of the application of this questionnaire are presented in Table A2, where the MBTI profile of the four individuals or DM with whom the experimentation was carried out in this work and their decision profile is given by the PMUDC-I model [2] to identify the DM in decision-making more accurately.

Table A2. According to [2,28], the MBTI questionnaire results were applied to four DM.

No. of DM	MBTI Profile	PMUDC-I Profile
1	ESFP	Optimistic
2	ISFJ	Collaborative
3	INTP	Inquirer
4	ISTJ	Strict

Appendix C. Results from Traits-Based Personality Questionnaire

This section presents the results of the IPIP-NEO questionnaire [26] based on personality traits from the FFM-OCEAN model [25]. The questionnaire consists of 120 questions (reduced version) that aim to collect information about the strengths and weaknesses of an individual. Table A3 presents the results of the questionnaire applied to the four individuals mentioned in Table A2, where the values of the facets of interest in this work are observed according to each DM. In general, this table shows the dimensions or factors of OCEAN, the value of the dimension (factor value), the facets of each dimension, and the DM identified through the profile provided by PMUDC-I [2].

Table A3. Results of the IPIP-NEO questionnaire [26] belonging to the four DM under study.

		PMUDC-I Profile			
OCEAN Factors	**OCEAN Facets**	**Optimistic (DM 1)**	**Collaborative (DM 2)**	**Inquirer (DM 3)**	**Strict (DM 4)**
Extraversion	Activity Level	0.3	0.80	0.27	0.78
	Gregariousness	0.75	0.55	0.08	0.17
	Excitement-Seeking	0.41	0.17	0.04	0.38
	Factor value	0.60	0.70	0.21	0.38
Agreeableness	Morality	0.83	0.89	0.61	0.17
	Modesty	0.69	0.65	0.89	0.35
	Altruism	0.38	0.95	0.33	0.34
	Factor value	0.18	0.88	0.60	0.05
Conscientiousness	Self-Efficacy	0.34	0.8	0.01	0.58
	Cautiousness	0.93	0.72	0.64	0.64
	Factor value	0.17	0.65	0.18	0.59
Neuroticism	Anxiety	0.3	0.64	0.55	0.3
	Anger	0.27	0.27	0.2	0.65
	Immoderation	0.42	0.48	0.38	0.31
	Factor value	0.30	0.43	0.52	0.42
Openness	Imagination	0.74	0.5	0.19	0.17
	Factor value	0.34	0.59	0.51	0.20

Appendix D. Results form Preferences Questionnaire

This section presents the questionnaire proposed by Castro et al. [2], necessary to generate representative parameters of the preferences of a DM through the PMUDC-I model. The questionnaire aims to collect information on the preferences of the DM according to a decision context, which in this work was applied under a context of shopping of food products. The way in which this shopping context is expressed is through presenting the DM with a set of food products from which he must select the ones of his preference, as well as forming shopping lists with said products, according to what is requested. in the questionnaire. In this way, it is possible to collect the DM's preferences in this shopping environment and form parameters representative of the DM's preferences. The food products presented in Table A1 are the ones that the questionnaire uses to acquire the preferential information of the DM. Table A4 shows the results of the questionnaire applied to the four DM mentioned in Table A2, where the parameters or preference thresholds given by the PMUDC-I model are presented with the influence of satisfaction (WS) and without the influence of satisfaction (WoS). The values presented were rounded to two figures after the point.

Table A4. Preference thresholds resulting from the application of the preference questionnaire in the four DM under study

Profile	**Status**	**Thresholds**						
		Criteria	q	u	v	λ	β	ϵ
Optimistic (DM 1)	WS	Price Contents	36.71 800.54	47.20 1039.43	56.28 1248.25	0.63	0.02	0.01
	WoS	Price Contents	35.93 783.41	41.63 916.62	47.33 1049.83	0.54	0.02	0.01
Collaborative (DM 2)	WS	Price Contents	24.63 192.04	38.52 328.93	47.26 424.33	0.85	0.096	0.041
	WoS	Price Contents	23.78 185.37	31.81 271.58	39.85 357.79	0.71	0.08	0.04
Inquirer (DM 3)	WS	Price Contents	35.01 179.95	44.38 343.55	49.28 483.67	0.93	0.13	0.06
	WoS	Price Contents	34.39 176.76	38.8 300.4	43.21 424.05	0.8	0.12	0.06
Strict (DM 4)	WS	Price Contents	15.23 150.72	18.85 223.56	22.14 298.05	1.07	0.20	0.08
	WoS	Price Contents	14.88 147.27	16.49 195.53	18.11 243.8	0.92	0.17	0.08

Appendix E. Satisfaction Questionnaire (Satisfaction Profile of the DM) and Results

This section presents the questionnaire proposed in this work, which collects information on the satisfaction of the DM. This questionnaire consists of five questions that meet the satisfaction expectation of the DM according to a service or product. Table A5 shows the satisfaction questionnaire, which gathers the satisfaction characteristics of the DM to form a satisfaction profile.

Table A5. Satisfaction questionnaire (satisfaction profile of the DM).

No.	**Question**
1	What is the expected performance of your product? __Very low __low __Medium __Good __Very good
2	What is the quality you expect to perceive from your product? __Very low __low __Medium __Good __Very good
3	Does the product represent any emotional value to you? __Very little __Little __Regular __A lot of __Too much
4	In general terms, what is the expectation you expect from the product? __Very little __Little __Regular __A lot of __Too much
5	Do you think the product will meet your expectations? __Very little __Little __Regular __A lot of __Too much

Derived from the results of the proposed satisfaction questionnaire, representative parameters of DM satisfaction are generated. These parameters are calculated using the strategies shown in Sections 5.1 and 5.2. The values of these parameters are representative for the four DM under study. The parameters and their values are as follows: value -7.34; equality -1; and utility -7.62.

Appendix F. Results from RIASEC Test

This Section presents the result of the application of the RIASEC [16,41] test. This questionnaire consists of 6 dimensions and 42 questions that collect information on the work areas you perform best. The six dimensions comprise the RIASEC literals, where each literal comprises seven questions. The result is a label formed by the three literals with the highest score.

As in the previous Appendix E, the RIASEC result was used for the four studied individuals. The RIASEC result and its values are as follows: R (REALISTIC) −7; I (INVESTIGATIVE) −5 and A (ARTISTIC) −5.

This questionnaire is related to job satisfaction because it exposes the areas where the individual has a better performance and, therefore, greater satisfaction.

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