Identifying Player Personality via a Serious Game

A Pilot Study Using Item Response Theory

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Abstract — Serious Games (SG) use playability to achieve specific goals in a playful way. Obtaining player's engagement is needed to enhance the expected goals with SG use. Player's profiles are directly influenced by personality constructs and affects engagement. Thus, considering player personality is important for SG design and adaptation. Personality has served as a theoretical basis for player profiles in several studies. The five personality traits model, also called Big Five Factors (BFF) model, is considered gold standard. There are no published studies presenting SG as a tool to identify personality with BFF model nor using an Item Response Theory (IRT) - based intelligence system. The aim of this work was to develop a SG to automatically identify player's personality, using an intelligence system based on IRT. The kernel of the SG intelligence system uses IRT to calculate player's latent personality trait, specifically Conscientiousness. A pilot study was conducted with a 122 subject sample of all genres. The SG was capable to assess personality and the IRT intelligence system proposed is adequate, reaching the aim of this work. However, more activities will be developed, aiming the comprehension of more personality traits. There are no approaches about the use of personality in game development process based on player's profile. This is the first step for necessary advances to SG development providing automatic identification of player's personality based on their actions.

Serious Games; Personality; Assessment; Player Profile

I. INTRODUCTION

The act of playing games is defined as a voluntary activity that seeks to absorb full attention of the player. The ludic characteristic of games allows them to provide entertainment, fun and pleasure. In addition, the challenges that constitute the activities of games allows the player to remain motivated, excited and interested in continuing to obtain this satisfaction [1].

Serious games (SG) use playability to achieve specific goals in a playful way, that is, conduct therapy, and promote learning, training or marketing [2]. Nagle, Wolf, and Riener [3] found that the predisposition to join one or other game changes individually. Thus, adherence to a game is influenced by aspects related to the audience for which it is intended, such as the player's own profile, personality and motivation. Those authors found results that support that the personality affects the taste of the individual game preferences. Similarly, Menendez, Vindel and Camacho [4] indicated that player profile can influence the type of game chosen, as well as provide information that allows the structuring of level controls, strategies, art, narrative and mechanics, as well as motivation to play, being the profile characteristic strongly related to the player's personality traits.

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Personality has served as a theoretical basis for player profiles in several studies. The five personality traits model, also called Big Five Factors (BFF) model, is considered gold standard [5]. One paper found relation between BFF and game preferences in general [6]. Another study, also based on BFF, sought to relate personality traits and motivation to online playing in order to understand different player profiles [7]. An article by Shen et al. [5] proposed an algorithm that intends to predict personality traits of users. A recent paper [8] describes the need for personality identification that considers aspects associated with games and points to gamification as a possible strategy. They present several studies considering simple text-based games wich were used as an alternative to identify personality. However, the results have not vet shown significant advances in this area and these authors present the need for more studies that consider personality identification based on games or gamification.

Furthermore, no articles were found that present the use of SG to personality identification. Previous studies that approached the relationship between BFF and SG or Games presented statistical models based on the Classical Test Theory (CTT), correlation or regression analysis [7-8]. CTT has some problems pertaining to sample dependent and test dependent. In other words, these problems must be considered when using CTT [9]. The alternative theory to CTT is Item Response Theory (IRT) that considers latent trait as a predictor of individual behaviors. The IRT uses difficulty and discrimination as parameters to calculate choice probability in items or activities. IRT is also known as latent trait theory. Latent trait is the individual subjectivity that influences behaviors. It is part of this article's aim to present IRT as a robust and appropriate intelligence system for automatic personality identification using a SG.

Given what has been presented, a guiding question arises: is it possible to use a SG to identify personality using IRT as intelligence system? The aim of this work was to develop a SG to automatically identify player personality using an intelligence system based on IRT.

The hypothesis of this work is that it is possible to identify personality through a SG using an IRT intelligence system. In order to achieve that, this paper presents the design process and a SG pilot test that has as theoretical base the latent personality trait of Conscientiousness, and uses IRT as the kernel of the intelligence model of the SG.

II. PLAYER PROFILE

Multiple factors and variables can affect player profile. These are influenced by socio-demographic

characteristics, such as age, genre, graduation, profession, but also by genetics, personality, social environment, and previous experiences that influence directly their tastes and costumes. To develop products that provide a good experience, it's necessary to completely understand their behavior, preferences, and needs of the potential user.

Personality can be defined as a grouping of psychological qualities that contribute to the construction of distinct patterns of behavior from which an individual feels, thinks and behaves [10]. It can be considered as hereditary and it's establishment occurs in childhood and continues to develop into adulthood. Except for traumatic cases, personality does not tend to change over the individual's life [11]. It is possible to understand, then, that subjects will respond to the medium in regular ways, which represent their individuality and the attributes that define their behavior.

A model that considers personality traits is the Big Five Factors (BFF). This is a model that can cover a large part of the personality construct with a smaller number of dimensions [12]. Its structure is considered as a key concept for research and guarantees a coherence and dominant structure for understanding Personality Psychology. From the personality traits individuals express their behaviors, which are responses to the environment or to a stimulus, as in SG.

The BFF is known by the acronym O-C-E-A-N that has in its meaning the factors Openness to experience, Conscientiousness, Extraversion, Agreeableness and Neuroticism. This classification was adopted in this study as presented now; in addition, it consists of a constitutive definition for each personality trait:

1) **Openness to experience**: Related to exploratory behaviors, which seek new experiences. They are creative, intelligent, curious, imaginative people, with the main relation being the openness to new experiences, disconnection of norms and conventional values and intense experiences of emotions. In addition, there is openness to new ideas, varied aesthetics and other types of intellectual experiments, being interested in experimenting with varied activities [13];

2) **Conscientiousness**: It is linked to behaviors related to organization, control and self-motivation to achieve goals. They do not procrastinate, are reliable, persistent, prolific, punctual, ambitious, scrupulous, and persevering [13];

3) **Extraversion**: High volume of interpersonal interactions. People are usually considered intense, have high levels of activity and rejoice easily. They are sociable, talkative, active, affectionate. They may also be considered self-confident, dominant, seekers of excitement, and require much stimulation [13];

4) **Agreeableness**: Linked to interpersonal relations, but with regard to the types of interactions, with a strong aspect of compassion. Individuals with a high level of this factor are generous, kind, selfless, highly empathetic and helpful people, they are peacemakers and have an optimistic look, relying heavily on others [13];

5) **Neuroticism**: This factor is linked to the chronicity of emotional adjustment and also to its instability. It is linked to psychological sufferings, individuals with low tolerance for frustration, feelings of sadness and anxiety, hostility, vulnerability and impulsivity [13].

III. MATERIAL AND METHODS

The objective of this work is to develop a SG to automatically identify personality based on the BFF model, with an intelligence system based on IRT. To achieve that, activities were designed to the BFF Conscientiousness trait. The activities were modeled considering game elements, based on the expanded Schell tetrad proposed by Machado, Costa, and Moraes [14], that suggests that mechanics, aesthetics, story, and technology are permeated by the specific content of the SG. The SG was composed by rules and challenges to achieve their purpose. The targeted public was composed by subjects with age between 20 and 40 years, with a minimum study level of elementary school.

The game intelligence was based on IRT, and considered two variables in the personality identification process for the Conscientiousness trait. The parameters to identify the trait level were previously calculated by the Birnbaum model [15-16].

This pilot SG was tested in a technology fair. That provided participation of a diverse public, compatible with the SG targeted public, with a sample of 122 subjects. The players needed to agree with the consent term, play the SG, fill in a sociodemographic and a BFF questionnaire.

IV. DESIGN PROCESS

The SG design and implementation process demand a multidisciplinary team and observe multiple requirements. The necessary basis to SG design considers specific content permeating mechanics, story, aesthetics, and technology.



Figure 1. Expanded Tetrad from Machado, Costa and Moraes [14].

For each trait, were conceived operational and constitutive definitions. The constitutive definition theoretically defines the trait concepts in all their aspects. The operational definition consists in converting the trait theoretical definition in reasonable and compatible behaviors.

To this SG pilot study, was considered specifically the Conscientiousness trait of BFF. This trait, as previously mentioned, is related to self-discipline, self-motivation, direction to challenges, and organization. The theoretical characteristics, organization, and direction to challenges, are chosen as main activities on this SG. The task was designed as an activity related to observe balls falling into a basket. These balls can be red or blue and the player is invited to indicate the color that most frequently reached the basket. After that, the game presents player performance and invites them to new options (Figure 2). In this context, were considered two main facets called Challenges Direction and Organization Sense:

- For the Challenge Direction facet, the action was to choose if they would like to "try to respond to the exact quantity" (*V1*). Regardless of any previous errors, the player was invited to try this option. When the subject presents a high level of Challenge Direction latent trait he is more likely to try this activity independently of the previous errors or activities.
- For the Organization Sense facet, the action was to choose "organize the tent" (*V2*). Regardless of any player previous error, he was also invited to try this option. When the subject has a high level of Organization Sense latent trait, he tends to keep things organized. Then the player is invited to organize the tent that had been left messy.

An example of the SG visual appearance can be seen in figure 2. The four options available can be observed on the right side: green option refers to try the exact quantity of balls (associated to variable V1), the blue option refers to organize the tent (related to variable V2), the red option refers to a new try and the rose option refers to finish the game.



Figure 2. SG scenes: the task (on left) and the options (on right).

To each choice is recorded 1 to yes, if the player chooses this action, and 0 to no, if the player does not choose this action. Also, these options are used by the intelligence system. Thus, the mechanic is based on rules system defined by activities previously defined for the BFF traits. In addition, the mechanic is influenced by the IRT intelligence system and its description is presented in the next topic.

V. INTELLIGENCE SYSTEM - IRT

The SG intelligence system was based on IRT, initially applied to skill or performance tests. Scientists point out that IRT can be described as a group of psychometric models that seek to develop and refine psychological instruments [9]. IRT refers to a set of mathematical models that correlate the test observable variables (items) and the not observable hypothetical traces, thus the interest is about the items and not on the measure sum. In this context, it can be considered that the subject choice depends on the latent trait level it possesses. For this SG, IRT allows deliberate the latent trace levels that are responsible for the players' choices and provides access to variables responsible for decision making.

The IRT owns two basic postulates: 1) the subject performance in one task is predictable considering a set of hypothetical variables, named latent traits, identified by the Greek letter theta (θ); and 2) the relationship between the task performance and the latent trait is described by a mathematical function called Item Characteristic Curve (ICC). The ICC indicates that increases in the extent between the subject latent trait level (the theta - θ) increases the subject probability to choose an option in a task. Thus, it can be understood that the θ enables the

individual's response estimation in each task, and an individual calculation is also possible [9].

The IRT postulates the existence of parameters that can be observed in the ICC. It was adopted, in this work, the Birnbaum two parameters method with a (discrimination parameter) and b (difficulty parameter) [15-16]. The logistic equation used to calculate the two parameters method probability is presented in Equation (1).

$$P_{i}(u_{is}=1|\theta) = \frac{1}{1+e^{-a_{i}(\theta-b_{i})}}$$
(1)

This equation indicates that the subject probability to respond correctly item *i* is given by the logistic function of the correct response over the hit plus the Euler number raised to the item negative discrimination multiplied by θ minus the difficulty of the item. The parameters estimation was obtained using the data vector generated by the player's choices on SG.

To estimate the ability in IRT, the θ , it is necessary to execute a series of maximum likelihood procedures. It functions with response standards, which are vectors. The maximum likelihood logarithmic equation is the Equation (2):

$$LogL(u_{is}=1|\theta) = \sum_{i=1}^{n} logP_{i}(\theta) + (1-u_{is}) logQ_{i}(\theta)$$
(2)

that points i = 1, 2, ..., n items; and u_{is} = subject response to items. However, to solve this question it is necessary to estimate the hit probability $[P_i(\theta)]$ from the two parameters model. It is also necessary to use the interaction algorithm from Newton-Raphson [9]. However, the method used for individual's θ calculation, can generate cases which θ tends to infinite (positive and negative). When such cases happen, the software enters in an infinite loop and generates overhead (excess computation time). Some solutions can be proposed and, in this study, we fixed the θ interval in ±6.

VI. RESULTS

Two SG activities were available and provided variables V1 and V2, respectively. The variables were collected in a binomial form, meaning 1 for yes and 0 for no. The parameters of difficulty (*b*) and discrimination (*a*) were calculated and displayed in Table 1.

TABLE I. DISCRIMINATION AND DIFFICULTY PARAMETERS FOR SG VARIABLES

Activity/Variable	а	b
V1	3,291	0,227
V2	0,974	-1,033

V1 presented better levels parameters, discrimination (3,291) and difficulty (0,227). *V2* presented median levels for both, discrimination (0.974) and difficulty (-1.033). Discrimination refers to capturing minimal latent trait differences between subjects. The difficulty refers to how players feel about performing or not the SG activity or, in other words, the difficulty whether or not to choose to do the activity. This data enables the execution of the model test and generates the theta levels for each response vectors, as presented in Table 2.

TABLE II. THETA FOR RESPONSE VECTORS

Responses vectors	Theta
11	6.000
0 0	-6.000
10	0.568
0.1	-0.422

We observed in Table 2 that the intelligence system pointed to the theta maximum, which was per-established as 6.000, to players who chose to do both activities. The opposite occurred with players that chose not to perform the two activities, presenting theta -6.000. For players who chose V1 but not V2, theta results in 0.568 and for those who chose V2 but not V1, theta results in -0.422. Since the V1 activity presented higher values to the discrimination and difficulty parameters, then when the player selects to perform it he would need to present a higher latent trait level, unlike players who chose not to perform V1 and perform V2, obtaining a negative theta and then a lower latent trait level. Considering these results, it is possible to affirm that we are in the correct direction using IRT to recognize the latent trait level. This shows that using two strong theories, and relating them, one to base the specific content and the other to base the intelligence system, it is possible to automatically assess personality from player's actions.

VII. FINAL CONSIDERATIONS

The Conscientiousness was the first trait chosen to test an automatic identification of personality traits through a SG using IRT intelligence. We observed that the BFF model is robust and consistent for this purpose. The results obtained indicates that it is possible to automatically know player's personality trait levels by SG. It is recommended to carry out new studies with more variables that allow for more complex SG validation, bringing contribution to the instructional design.

The importance of considering the personality profile as the basis for the player's profile is based in connections between personality and engagement, and in how the two constructs are important when talking about SG. Considering that one of the objectives of a game is that the player continues to be interested in playing and return to play, this feature has important relevance in the context of SG.

The connections brought in the present research and the importance of using theoretical bases for player profile based on personality traits, suggests the use of this theory to instructional design and automatic configuration in order to provide personalized experiences. Another suggestion would be to use this theoretical basis to perform a real-time adaptation of the activities in order to suit the application to the player, seeking to maintain their interest in continuing to play, that is, keeping them engaged or promoting their re-engagement. Thus, the personality traits identification would allow to direct the application more clearly, causing the SG to present tasks, characters and dialogues, among other possibilities, aimed at the player profile, enhancing the player's engagement.

Another technological possibility lies in the creation of integrated profiles databases, on which SG designers could consider the players' profile in the process of automatic adaptation [17].

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