Towards Incorporating Personality in Serious Games for Health

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Abstract—This work proposes the integration of personality traits from the Five-Factor Model in serious games for health and how it may offer a better rehabilitation process, since it may provide greater motivation for the patient. Firstly, we discuss the relevance of the personality traits Neuroticism, Openness to Experience, and Conscientiousness for rehabilitation processes. We continue by presenting a set of guidelines to be applied to the game design in order to adjust the rehabilitation routine to patients that have relevant values on the mentioned traits while also taking into account their past experience in the rehabilitation process. Finally, we consider a serious game for health focused on upper-limb rehabilitation and we project two scenarios on how the guidelines can be applied to the game in order to improve the rehabilitation for patients.

Index Terms—Serious Games, Upper-Limb Rehabilitation, Adaptable Gameplay, Design Guidelines, Personality

I. INTRODUCTION

Video games are part of our culture, not only for entertainment, but also to educate and train people [1]. There is already research on using video games with patients experiencing diseases or physical disabilities [2]–[4]. Naturally, the greater the motivation to participate in rehabilitation tasks, the more likely will be to have patients with an active participation [3]. Therefore, if we can provide a greater motivation, patients will play for a longer time, which leads to longer therapeutic sessions and greater functional outcomes over the course of the treatment. With this in mind, serious games for health should keep players interested in playing until their rehabilitation process is over.

Several games [5], [6], already try to adapt their gameplay to the patient in order to provide a better experience, yet there are more dimensions to be explored in a game, such as the personality of the patient [7], [8]. The Five-Factor Model (FFM) is the most widespread and generally accepted model of personality [9], [10], consisting of five traits: Neuroticism, Extraversion, Openness to Experience, Agreeableness and Conscientiousness. This model provides a nomenclature and a conceptual framework that unifies much of the research findings in the psychology of individual differences. Although there is evidence of the importance of including personality in serious games, to the best of our knowledge, there is no work focused on design guidelines for serious games for health incorporating the FFM to help patients in the rehabilitation process.

In this study, we present and discuss a concept that can be applied to game adaptation based on the patient’s personality traits of the FFM and prior experience in order to improve the rehabilitation process. In particular, we focus on Neuroticism, Openness to Experience, and Conscientiousness, as we believe that they are the most relevant traits for our concept. First, we present each of these FFM dimensions and how they are relevant in the rehabilitation process. Afterwards, we propose a strategy on how to incorporate them using two different scenarios in InMotion [11] as an example. Finally, the conclusion and the further work are discussed.

II. RELEVANCE OF PERSONALITY TRAITS FOR THE REHABILITATION PROCESS

Regarding Neuroticism, this trait distinguishes the stability of emotions and even-temperedness from negative emotionality, which can be described as feeling nervous, sad and tense [12]. It is often referred to as emotional instability, addressing the tendency to experience mood swings and negative emotions such as anxiety, worry, fear, anger, frustration, envy, jealousy, guilt, depressed mood, and loneliness [13]. Highly neurotic people are more likely to experience stress and nervousness, and are at risk for the development and onset of common mental disorders [14]. As it would be expected, higher Neuroticism is associated with greater health care use [15] and this trait showed significant influences on oral impact on daily performance among patients with mucosal diseases [16]. Moreover, those who are highly neurotic do not believe that emotions are malleable, but rather difficult to control and strong in their expressions [17]. Finally, people with lower Neuroticism tend to be calmer and more self-confident, but at the extreme they may be emotionally reserved. In particular, patients with chronic diseases who are treated by therapists who tend to be calmer, more relaxed, secure and resilient have a greater reduction in severity of complaints compared to patients treated by therapists who show less of these traits [8].

In serious game for health, if players perform under stipulated values, in addition to a high self-consciousness, they may become too self-aware of their mistakes leading them to higher states of anxiety, anger and/or depression. Therefore, people with high emotional instability may not be able to cope with failure if they do not meet the exercise requirements.
This may lead to a state of frustration and, consequently, to stop the rehabilitation process due to the large negative emotional charge. Therefore, we consider Neuroticism as an important psychological trait to consider in the adaptation of the rehabilitation process of the patient.

Openness to Experience describes the wholeness and complexity of an individual’s psychological and experiential life [12]. It measures a person’s imagination, curiosity, seeking of new experiences, and interest in culture, ideas, and aesthetics. It is related to emotional sensitivity, tolerance, and political liberalism. People high on Openness to Experience tend to have a great appreciation for art, adventure, and new or unusual ideas. They also tend to devise novel ideas, hold unconventional values, and willingly question authority [9]. It has shown to relate to aesthetic emotions as well as to greater awareness, clarity, and intensity of their own emotions at the time [18]. On the contrary, those with low Openness to Experience tend to be more conventional, less creative, and more authoritarian. They tend to avoid change for its own sake and are usually more conservative and traditional in their outlook and behavior. They also prefer familiar routines to new experiences, and generally have a narrower range of interests. Openness to Experience has been found to be a significant positive predictor of adherence ratings during rehabilitation appointments [19]. Ibrahim et al. [20] found that low Openness to Experience and high Conscientiousness seem to be key factors of chronicity in patients with low back pain. Therefore, we predict that people with low values will not only be more prone to miss appointments, but they will also be resistant to a change of their rehabilitation plan.

Finally, Conscientiousness suggests self-use of socially prescribed restraints that facilitate goal completion, following norms and rules, and prioritizing tasks [12]. It measures the preference for an organized approach to life as opposed to a spontaneous one. This dimension is considered to be the least emotionally charged, and is correlated with positive and negative emotions [17], [18]. People high on Conscientiousness are more likely to be well organized, reliable, and consistent. They plan ahead, seek achievements, and pursue long-term goals. They also live lives that are overall less emotional, more balanced, more predictable, and will encounter fewer emotionally intense situations (fewer extreme lows, as well as fewer extreme highs). Low Conscientiousness individuals are generally more easy-going, spontaneous, and creative. They tend to be more tolerant and less bound by rules and plans, which explains why they are also more likely to engage in antisocial and criminal behavior [21].

Conscientiousness was directly associated with lower systemic inflammation, which may explain the better health and the lower frequency of metabolic syndrome and cardiovascular events in such people [22]. Focusing on conscientious people, they are good at formulating long-range goals, organizing and planning routes to these goals, and working consistently to achieve them despite facing difficulties. In the health field, we can expect this type of people to generally listen to health advice, maintain a balanced diet and comply with medical treatments. In fact, low consciousness was associated with smoking habits [23] and highly conscientious individuals practice regulatory dietary restraint, preventing unfavorable food choices by reducing overeating styles [24]. With this in mind, we can expect that, while conscientious individuals will follow a therapist’s requests willingly, patients with low Conscientiousness will not have the same discipline and self-control, leading to an underwhelming rehabilitation. This leads us to address this psychological trait with special attention to people with low values, since a therapist needs to provide extra guidance to this type of patients so that they can fulfill their rehabilitation process.

III. GUIDELINES FOR PERSONALITY-BASED SERIOUS GAMES ADAPTATION

Our approach is to provide support for participants that have high Neuroticism, low Openness to Experience, and low Conscientiousness. We specifically address patients with emotional instability because they are more prone to not be able to cope with poor rehabilitation results and/or the criticism from the therapist. People with low Openness to Experience are also critical due to their resistance to change their exercise routine. Finally, low Conscientiousness can lead to a lack of self-discipline, thus patients may miss their appointments and/or not aim to perform the exercises at the expected rigor level of the therapist. The levels for these traits will be compared to the Portuguese population values [25]. Moreover, we want to include the context of the rehabilitation and prior experience of the patient in the adaptation process, so that specific actions trigger only in situations where they make sense. Therefore, we aim to increase persuasion and motivation of participants while they perform their rehabilitation routines.

Table I presents examples of rules that, depending on the personality of the patient and the actions of the patient or a trigger in-game lead to a response from the game. This approach allows us to take into account not only past experience from the participant in the rehabilitation process, but also their personality traits which serve as a strong structuring factor when the game has no information regarding the patient. With these rules in mind, we can extrapolate and elaborate how these guidelines can be applied in an existing game called InMotion [11] by covering two possible scenarios.

IV. INCORPORATING THE PERSONALITY IN-GAME

In a real case, Pinto et al. [11] are currently developing InMotion, a serious game on upper-limb rehabilitation. This type of rehabilitation focuses on the recovery and rehabilitation of the arm and hand after a neurological injury, an illness or a disease. InMotion is composed by four different mini-games: Abstract Masterpiece (throw colored balls to paint a picture on a canvas), Boat Sailing (sail on a boat to a target destination), Classic Clock (mimic a pendulum movement), and Butterflies (chase and touch butterflies with both arms). In our discussion, we will focus on two patients, the first playing Abstract Masterpiece and the second Boat Sailing (see Figure 1).
Firstly, the game needs to calibrate its variables based on the personality of the user, which can be either inserted by the therapist or by presenting to the patient a validated instrument to collect it. Thus, personality is collected before they interact with the game so that it can be adapted in the first usage. Afterwards, the patient is ready to use the game.

**Abstract Masterpiece** is focused on flexing the upper-limb to shoot successive paintballs towards an empty canvas and create an abstract painting. The metric to evaluate the movements is the amplitude of the upper-limb relative to the floor. In addition, the authors defined some limits for different difficulties, which are the minimal angles that the patient needs to reach with their upper-limb and can be used by the game to classify the patient’s performance.

Regarding **Boat Sailing**, the patient controls the movement of a rowboat using their forearm in a plane parallel to the floor. The amplitude of the forearm varies the propeller angle, which sails the boat in a different direction. The objective is to sail through several checkpoints until the patient reaches the final destination. Therefore, the metric is the number of checkpoints that the patient was able to cross in a session.

Taking into account both InMotion and strategies we defined for different personality types, we can explore different scenarios in which our guidelines are deployed within that specific serious game.

Regarding the patients for the scenarios, we define the first patient (P1) with low Neuroticism, high Openness to Experience, and low Conscientiousness. The second patient (P2) is the complement of P1, having high Neuroticism, low Openness to Experience, and high Conscientiousness. Regarding the rehabilitation plan, it is first created by the therapist and it can be changed either by the therapist or the adaptation framework within the game.

Imagine that the beginning of the routine of P1 for a certain day is composed by the *Abstract Masterpiece* mini-game. Before starting the game, it should display the rehabilitation plan and where P1 is, since P1 has a low Conscientiousness. In particular, if P1 missed a routine day, the game should specially focus on showing the progress and results of the rehabilitation so far, and encourage P1 to keep it up. Afterwards, when P1 chooses to perform the exercise, the game can ask if P1 would like to choose a specific art period to work on because of the high Openness to Experience. We can change the base game and allow the patient to choose between different art periods, such as Stone Age, Renaissance, Romanticism, Modern, or Contemporary. Then, the in-game environment can change to look like the specific period. In addition, the painting on the canvas can be gradually constructed with each paintball hit on canvas reassemble a famous painting of that art age. Focusing in particular on the problematic trait, the game should incorporate a visualization to show the patients how well they are performing. Another approach is to consider the imagination and the adventurousness these people have. The game should consider how they will be prone to try distinct upper-limb movements that are different from the correct one to achieve the result, which is a straight movement in a precise angle. If the therapist considers it has too much of negative impact on the therapy, the game should detect wrong angles and do not count them for the goals of the routine. Finally, after each routine, the serious game should again show the rehabilitation plan and reinforce to the users how their progresses are due to their effort and dedication to fulfilling that plan so far. Again, this is important given that P1 has low Conscientiousness: we need to acknowledge that their effort produces results.

In a different scenario, P2 starts their routine with a round of **Boat Sailing**. P2 has high Neuroticism, which can increase anxiety or frustration. The game has to treat the patient in an empowering and reassuring manner. Therefore, while P2 controls the direction of the rowboat, the game could give instructions or advises on where and how to turn the boat. If P2 is having a bad performance, the game should encourage P2 in a friendly way, e.g. "I know you can do it, come on!". In contrast, the game should congratulate P2 after each successful checkpoint to motivate P2, e.g. "I knew you could do it!" or "Right on! Lets get the next one!". One interesting point is on how to solve the low Openness to Experience issue that does not motivate P2 to try new types of exercises. This

<table>
<thead>
<tr>
<th>Patient Trait</th>
<th>Trigger</th>
<th>Game Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Neuroticism</td>
<td>Bad performance</td>
<td>Encourage patient in a friendly way to try again.</td>
</tr>
<tr>
<td>High Neuroticism</td>
<td>Missing a routine day</td>
<td>Explain how continuous routine is important and tell patient it will not tell the doctor.</td>
</tr>
<tr>
<td>High Neuroticism</td>
<td>Good performance</td>
<td>Congratulate the patient for their efforts.</td>
</tr>
<tr>
<td>Low Openness to Experience</td>
<td>Good performance</td>
<td>Ask if the patient would like to try another exercise.</td>
</tr>
<tr>
<td>Low Openness to Experience</td>
<td>Start of routine</td>
<td>Ask if the patient would like to change the in-game environment.</td>
</tr>
<tr>
<td>Low Openness to Experience</td>
<td>New exercise</td>
<td>Start by performing a simple tutorial introducing the basic elements.</td>
</tr>
<tr>
<td>Low Consciousness</td>
<td>Good performance</td>
<td>Project how the rehabilitation will progress if the patient keeps the performance.</td>
</tr>
<tr>
<td>Low Consciousness</td>
<td>Missing a routine day</td>
<td>Show the routine calendar and tell patient to be more regular.</td>
</tr>
<tr>
<td>Low Consciousness</td>
<td>Bad performance</td>
<td>Warn the patient that poor results will not help the process.</td>
</tr>
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</table>

![Abstract Masterpiece](image1)

![Boat Sailing](image2)

Fig. 1: Screenshots from [11].
means that the game must not push P2 to go out of the comfort zone because it will probably lead P2 to stop the routine altogether. Instead of having the game pushing for new exercises, this should be performed by the doctor, which has a higher degree of authority. Thus, the game should only increment the difficulty of the routine in a gradual way. If P2 is tired of doing the same exercises, P2 will ask for the change.

Both the scenarios are just examples of how the design guidelines could be incorporated in InMotion [11]. Moreover, the guidelines can be implemented in any serious game for health, with preference for the inclusion of an avatar to embody the therapist.

V. CONCLUSIONS

This paper presents a concept and a support model for the incorporation of the Neuroticism, Openness to Experience, and Conscientiousness personality traits from the FFM in serious games for health. We believe it may be relevant for rehabilitation processes, since it may offer a better gaming experience, and, therefore, a better rehabilitation process. If so, serious games with a personality-based adaptation can be a further step in health investigation by providing a framework that keeps patients more engaged in the recovery process.

This study has potential limitations. As we are dealing with individual differences, there may be conflicts arising from cultural bias and other personal issues. The data-gathering process should therefore be carried out appropriately to mitigate these conflicts. Moreover, personality variables are collected by filling questionnaires. As some users may not be able to physically answer these items, participants may not provide an honest answer to avoid judgment by their therapist. Future work involves creating the adaptation mechanism following our guidelines and test it with real patients. In order to verify if the adaptation has any effect on users, we will address various aspects from the interaction, such as the impact on the frequency and the consistency of the rehabilitation exercises and to the actual impact on the rehabilitation itself. More rules should also be studied, along with other personality traits and styles, e.g. Myers-Briggs Type Indicator (MBTI).

VI. ACKNOWLEDGMENTS

This work was supported by national funds through Fundação para a Ciência e a Tecnologia (FCT) with reference UID/CEC/50021/2019.

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