Modelling Core Personality Traits Behaviours in a Gamified Escape Room Environment

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Abstract: Personality Traits are one of the most important aspects of human behaviour analysis that can be widely used in a plethora of scientific fields. Nowadays, a variety of industries use self-assessment techniques to evaluate their employees or candidates to form effective teams based on the relationships between the personnel. The Big Five personality traits, also known as the OCEAN Five model, encompass an individual's behaviour on five factors: Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism. Currently, the evaluation is based on questionnaires, which are prone to subjectivity and can be biased. In this paper, we analyse the behaviours on which each trait is based, in a series of 3D Escape Rooms with the aim of collecting metrics in a number of settings/situations to effectively assess them, with the use of gamification. Each Escape Room has unique features and simulates special occasions to monitor the player's reactions as well as gameplay style to generate specific models that calculate the level of each personality trait. The final profiling, however, is based on a combination of metrics from the different rooms since the behaviours are common and overlap with each other but can be evaluated in different situations. Results validate the mathematical models of metrics for each behaviour and crystallise the nature of the situations in which these behaviours can be modelled. Therefore, through gamification, a new generic model for categorising players, based on the Ocean five personality trait model, is generated.

Keywords:
gamification, personality, behaviours, Escape Room

1.   Introduction

Personality traits assessment is deemed necessary in a wide variety of areas. Personality questionnaires have been utilised as the traditional way of carrying out personality assessment. However, given the biases and drawbacks of self-reference and self-report (McDonald, 2008), a virtual environment which directly and more objectively assesses behaviour seems the ideal way to measure one's way of interacting with their surroundings.

Gamification has been proven to be a useful practice in assessing personality and soft skills in an immersive way. It is an innovative tool that promotes behavioural changes in non-game situations by utilising targeted game design principles (Robson et al., 2015) and has been applied in areas such as education, marketing, and even team building. Some of its main characteristics include leaderboards, points, and challenges (Dicheva et al., 2015). Gamification can make the entire assessment process more appealing by motivating and challenging the players while keeping records of various game aspects, different types of statistics, and how the game progresses.

One area in which these two elements can be applied is Escape Rooms (ERs) (Pan, 2017). ERs are categorised as physical and/or online, with the former being multiplayer games and the latter mostly single player. They require the player(s) to work efficiently alone or in a team, something that companies use to their advantage for evaluating and assessing their teams and employees. As previously noted, gamification requires data collection. In a physical ER, it is almost impossible to be able to systematically collect a player's or a team's statistics. Thus, the development of virtual Escape Rooms can assist in processing and analysing the entirety of the required information.

In this paper, we present a series of five unique ERs that implement a variety of puzzles, tests, and scenarios that are based on different kinds of personality traits. The goal is to generate profile models regarding the players' personality traits depending on how they interact with and solve each room.

2. Related Work

Recent research primarily focuses on ERs and their benefits in novel educational approaches (Traldsen et al., 2020), in healthcare settings (Zhang et al., 2018), and in organisational research (Cohen et al., 2020). Personality traits have also been studied extensively primarily through the use of questionnaires for assessment (Chamorro-Premuzic et al., 2007). However, there seems to be a gap in the literature regarding personality traits and how they can be implemented in online ERs.

Regarding the former, there has been a variety of online ERs for educational purposes (Traldsen et al., 2020; Vergne et al., 2020). Most of them are quite simple, built with tools like Google Forms, alongside–Video Conference software where players must interact with each other to solve puzzles and riddles and progress to the next levels. The downsides to such ER games include a lack of statistics on how players solved the puzzles or communicated in such ER games, as well as the fact that they are usually a simulation of a game with no 3D or 2D environment to interact with. Additionally, the use of online ERs in educational contexts is primarily focused on learning process optimization. So far, little has been done to identify each student's personality traits and learning styles utilising online ERs for personalised intervention programs and new teaching techniques.

Furthermore, there has been research done about ERs and personality traits by Liapis et. al (2021). The authors presented an ER including IQ tests as riddles, alongside the typical gameplay mechanics. Moreover, Deep Reinforcement Learning agents were trained to solve the ER by finding specific buttons and solving the IQ tests. They were also emulating human behaviours through specific movement metrics. The main difference between that game and ours is that we create a series of ERs, each with its own puzzles and scenarios, presenting greater overall complexity. This allows for the examination of each trait and its behaviours more thoroughly in a customised environment.

3. Background

Personality, as a scientific term, describes a set of cognitive, emotional, motivational and behavioural characteristics one can possess. Personality traits have a long legacy as a way of conceptualising and analysing human behaviour and various theoretical contexts have been constructed to identify and organise core tendencies. There is considerable controversy about the ideal personality conceptualisation. Some of the most widespread and historically well-regarded have been Eysenck's three factor model (Eysenck, 1953) and Cattell's 16 personality factor model (Cattell, 1943). However, the one most consistently supported by empirical data is the Five-Factor Model (FFM), also known as the OCEAN Five, which stands for Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism (McCrae & Costa, 1987). Existing research supports the FFM as a comprehensive and efficient tool for the description of personality traits and their relation to other phenomena (McCrae & John, 1992). Before diving into further methodological analysis, the basic structure and traits regarding each factor are presented.

Openness to Experience is characterised by intense curiosity, imagination, appreciation of art and problem solving with divergent thinking (McCrae & Greenberg, 2014). Conscientiousness encompasses matters related to order, dutifulness, and thoroughness. Conscientious people have the tenacity to complete a task despite being bored or distracted (Goldberg, 1993), while individuals low on conscientiousness can be lax, negligent or careless (Cervone & Pervin, 2013). Extraversion is characterised by sociability, assertiveness and a proclivity for positive feelings (McCrae & Costa, 1987). Generally, extraverts tend to be more energetic and person-oriented, while introverted individuals appear more reserved and timid. Agreeableness represents a tendency towards altruism, helpfulness, and compliance (Costa et al., 1991). Individuals with high agreeableness in games reveal higher levels of cooperation (Volk et al., 2011). In contrast, less agreeable individuals are more antagonistic and cynical. Neuroticism encapsulates traits such as anxiety, panic, and impulsiveness. Individuals high on neuroticism struggle to handle stress and they may get easily frustrated or irritated at others (Costa & McCrae, 1992).

Importantly, data converge to the conclusion that humans perceive virtual environments analogously to real-life environments. More specifically, they seem to retain a sense of and assumptions about personal space, invasion of which can lead to sequelae of emotional responses like distress, panic, or awkwardness. To avoid experiencing such feelings, they try to keep their distance from other avatars and avoid persistent staring, the same way they would in a real-life scenario (Wilcox et al., 2006). This very fact can point to the possibility of using virtual spaces in the study of socio-emotional responses, and in the orchestration of interventions.

4.   Methodology

Our goal is to develop and configure five rooms for assessing all five personality factors – Openness, Conscientiousness, Extroversion, Agreeableness and Neuroticism – and resulting behaviours. Even though each room assesses behaviours related to each factor, some are common between traits. Thus, the player ought to play all five rooms for complete profile feedback. Preliminary designs were drawn on paper and final decisions about each room's characteristics were made. Each place has three or four rooms and is defined by its own events (different situations taking place in that scene) and puzzles to be resolved for the player to succeed.

For the implementation, we use the Unity Game Engine (Unity Technologies, 2015), a cross-platform integrated development environment, used for developing 2D/3D games. 3D implementation was chosen in order to maximise the game's realism and player immersion. Respectively, visual and audio effects are applied.

There is also a sixth place that serves as the main menu of the game and as a tutorial. The gameplay is based on a third-person character with actions like walking, running, jumping, and picking up and collecting items. These items can be helpful or misleading in solving the riddles. The player can use the drag and drop method to move some of the objects in the scene, and click on kitchen appliances, drawers and doors to open or close them. Another feature of the game is the zoom function in specific areas, as an added tool at the player's disposal to be used when needed. All these abilities and functions make it easier to observe one's interaction with the environment and obtain behavioural measurements.

On the screen, there is a user interface (UI) displayed, consisting of the inventory, a 20-minute timer, and two icons: task list and map. Additionally, messages appear during the gameplay to inform the player about their progress or even about an occurring event. Through the code scripts, we obtain the measurements by counting mouse clicks, time to solve the room, walking speed, etc. We also contemplate the strategy followed by the players to solve the puzzles, by examining specific conditions.

4.1   Escape Room Game

For each Escape Room, there is a story describing the tasks one must accomplish to win. The puzzles are related to these tasks and are designed to collect gameplay metrics for each OCEAN Five personality trait. The players have 20 minutes at their disposal to complete their to-do list and eventually "escape". In the following sections, we analyse the gameplay and the riddles of each room.

However, the ER game, including the five rooms, it is not yet available for the players' access and assessment as a demo. The puzzle ideas, and the observed behaviours, were based on how the OCEAN Five personality traits' behaviours are bibliographically analysed. The game keeps track of the players' actions and gameplay style (e.g. movements). All these observations will be summed up and the personality traits will be examined, based on the HidAC OCEAN Five behaviour simulation (Durupinar, 2011).

4.1.1 Room 1: Openness

The first ER was created to assess creativity, curiosity, and imagination; in other words, Openness. The most representative riddle developed to gauge one's creativity is the "playing the piano" task. We created this task because creativity is tightly tied with music (Webster, 2016). The story behind this riddle is the participation of the player in a piano competition. More specifically, the player wants to rehearse one more time at home before departing for the contest, but one of his music sheets is missing. The player has to find the PIN to unlock the main door and finally leave.

Specifically, the first challenge is finding the music sheet. It shows four alphanumeric characters generated randomly each time one enters the scene. Alphanumeric characters were chosen over notes so that the rationale underlying his action to pick it up (since its use is not obvious) could be examined. If he first gets to the piano and later to the music sheet, then he is able to associate that these alphanumeric characters coincide with these on piano keys. After picking the music sheet up, it is time to play the listed piano keys.

Figure 1: In-game screenshot of the music sheet placed on the piano and the room.

If we examine the example displayed in Figure 1, then E6, E3, G-4, and C3 piano keys must be pressed in that exact order so as to be considered correct. Contrariwise, the player needs to play the piano again from the start. In Table 1 we can observe the most important measurements taken, as well as the outcome behaviours in this ER.

Table 1: Measuring openness trait

Riddle	Metrics	Observed behaviour
Finding the music sheet and playing the piano	We check if the player wants to play the piano without knowing the musical composition they must perform or not (Webster, 2016)	Whether or not they enjoy playing any melody on that instrument, which counts as positive/negative to their creativity and imagination
	The time it takes to rehearse the composition or by counting clicks made during their trial	Indications about the player's openness to trying new things
Find PIN code and insert it on keypad	Efficiency and time spent to spot the clues on the pots	Rates high at curiosity and exploring the environment

4.1.2 Room 2: Conscientiousness

In the Conscientiousness room, the aim is to measure the player's organisation level and whether he follows the game's flow. As highly conscientious people tend to be more disciplined and goal-oriented, they are expected to persist and work hard towards solving the puzzles in time.

With this rationale, we created a story with two riddles. The first one is a 2D jigsaw puzzle that pictures an animated character, which gives a clue that the missing ingredient is the carrots. The second is collecting ingredients according to the recipe located in a kitchen cabinet. The story of this specific ER is to manage to cook a recipe within the time boundary, because the player needs to go to an appointment. The problem is that water was spilled on the recipe and an ingredient is not clearly visible. There are two options to deal with it: guess the ingredient by collecting random food supplies and putting them in the pan, where the rest of the ingredients are put to cook, or solve a jigsaw puzzle revealing the missing ingredient.
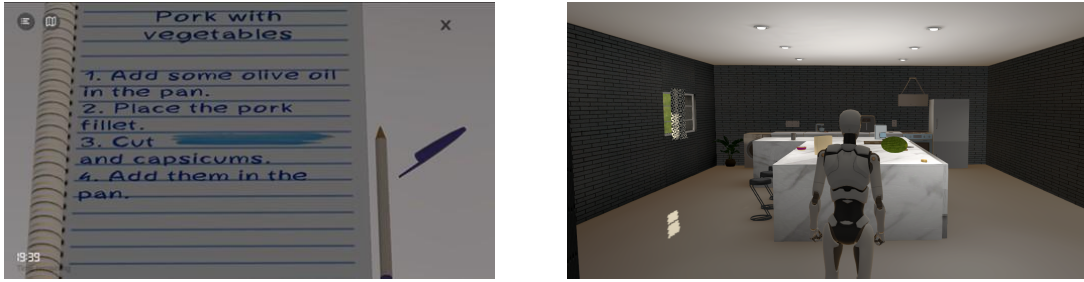
Figure 2: In-game screenshot of the recipe that must be made, written in a notebook and the kitchen.

As we can see in Figure 2, the recipe states that olive oil, pork fillet, and capsicums are needed. However, there is a hidden ingredient (carrots) in the recipe that the player needs to find and add. For the ingredients to be found, some of the kitchen's drawers and the fridge must be opened. Metrics to be calculated and observed behaviour are summarised in Table 2.

Table 2: Measuring conscientiousness trait

Riddle	Metrics	Observed behaviour
Search for ingredients reported on recipe and place them in the pan	The order in which the player picks up the ingredients and the order in which they place them in the pan (Haizel et al., 2021)	Organised and disciplined or not
2D Jigsaw puzzle	How the player places the pieces in the frame, i.e. start from the edges or randomly, as it is strategically easier	Whether the pieces/or the frame are ordered and well-organised or disordered and messy
	Time spent to associate the animated character to the carrots	Being distracted by the character or focused on the riddle's resolving

4.1.3 Room 3: Extraversion

For the Extraversion Escape Room, the aim is to gather metrics regarding the player's sociability and assertiveness. So, we implemented non-player characters (NPC) to fulfill the roles of party guests, since at this point of the story a big party to which the player has been invited is happening, as we can see in Figure 3. In this scenario, the player wishes to have another drink before leaving the party which is thought to be available at the bar. However, there is a queue in front of him. One can choose to overpass the people waiting and get to the bar without caring about appearing rude, as seen in Figure 3. The second option is to stay behind the others and patiently wait until those who precede finish. Aside from the drinks found at the bar, there is a locked drawer in the office with a bottle inside that can be accessed only by interacting with the host, who is an NPC, and asking for the key.

Figure 3: In-game screenshot of the Extraversion Room.

The player is informed that the key is somewhere in the living room and he must search to find it. In order to proceed with that, the pillows on the sofa must be moved. At this point, he may throw them on the floor or simply move them around a little. His choice reflects the player's public persona.

In the scenario where the player chooses to wait at the bar rather than talking to the host, he gets informed that the drink of his preference lacks. However, he is able to fill his glass with ice so that he does not have to come back and wait again. Respectively, by proceeding with obtaining the bottle from the locked drawer, he notices, through a displayed message, that he must go to the bar either way to add some ice. In both cases, the player must wait at the bar and also talk to the host. As examined in Table 3, there are ways to estimate the level of one's extroversion.

Table 3: Measuring extraversion trait

Riddle	Metrics	Observed behaviour
Reach kitchen for a drink	Distance kept from the rest of people waiting by measuring the waiting radius and patience which the player indicates (Liu et al., 2019)	Patience and kindness or impatience and rudeness towards others
Talk to the host and search the key to unlock the drawer	Chooses to speak to the host instead of waiting	Confidence to speak to a person the player is not so familiar with
	Makes the place untidy by throwing the pillows or keeps it clean	Whether respect to the other guests is shown, whether the person cares to keep their public Figure safe

4.1.4 Room 4: Agreeableness

Agreeableness is a personality trait associated with prosocial behaviour, like helping others and prioritising their needs. Therefore, in this ER, the player's behaviour is examined through his reactions during a friend's gathering. NPCs are introduced as our player's friends. One of them asks the player to play a specific game, but the player prefers a different one. Nonetheless, due to the way this ER is implemented, it is required to play both games suggested.
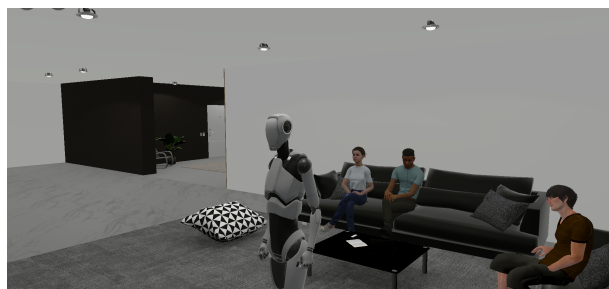

Figure 4: In-game screenshot of the Agreeableness room.

Once they have both decided, they begin to play the chosen game. The games are "find the difference between two pictures" and "break the bricks". The gameplay of his friend is programmed, whilst the player's gameplay is monitored and assessed as it is reported on Table 4, where all the metrics are given. The player is able to watch his friend's progress while both playing.

Table 4: Measuring agreeableness trait

Riddle	Metrics	Observed behaviour

Making a decision about what game to play	Observing if the player retreats and plays what their friend wants or persists on playing the game of his own preference (Volk et al., 2011)	Agreeable, friendly and compromising person, otherwise unwilling and strict
		Giving priority to others' desire or his own
Playing both games	Gameplay, i.e., examining the time the player spends, clicks per second and compare it with opponent's gameplay	Being competitive by playing very aggressively - noting large percentage of clicks per second or being apathetic by letting his friend win

4.1.5 Room 5: Neuroticism

The Escape Room measuring Neuroticism is implemented in a way to elicit panic, with the scope of collecting data regarding the player's attitude in stressful situations. Neuroticism is manifested through one's emotional stability and calmness. For that reason, the story for this ER is an ongoing storm loud enough to frighten the player. A thunder strikes the oven igniting a fire, while the storm causes a power cut and turns the lights off. To simulate a storm, effects including loud rain sounds and intense light changes are utilised.

Figure 4: In-game screenshot of the Neuroticism room.

For the fire event, the player has the opportunity to use the fire extinguisher hanging on the wall inside a glass box. However, he first needs to break the glass, which can only be done by using a hammer. As we aim to detect the player's patience during this weather occurrence, we intend to arouse distress by forcing him to find and unite the two pieces of the hammer, instead of it being given intact. To solve the second riddle, which is related to the electric power that went out, the player, who has been using a flashlight since the start of the level, must fix the electric fuse box to restore the power. To fix it, some cables must be connected based on their colour. Table 5 contains the metrics and the observations made.

Table 5: Measuring neuroticism trait

Riddle	Metrics	Observed behaviour
Gathering and connecting pieces of the hammer to use the fire extinguisher	Walking speed and unnecessary actions taken while collecting and connecting the pieces (Sarwar & Jaffry, 2017; Stephan et al., 2017)	Acts calmly and stabling or rushes to accomplish this task, i.e., explore the level of neuroticism
Resolving the fuse box problem by connecting same-coloured cables	Attempts to connect the cables (counting the clicks, correct - false connections, and time needed)	Checking whether he can stay collected enough to act effectively and figure out he must connect the pieces

To summarise, this ER game comprises five rooms, each designed to generate metrics for each of the OCEAN five personality traits, based on the behaviours it maps on. This can be a useful gamifilied tool and a basis for creating a new assessment way that analyses a player's behaviour and generates a profile based on it. This will

ameliorate the assessment process, as it tackles limitations of self-reporting questionnaires, such as response and self-reference bias. By creating a gamified tool, there will be a more immersive and interactive way of assessing personality, as well as opportunities for analysing occurring behaviours. Promising potential in the field of assessment is offered, but further exploration in terms of reliability and validity is needed.

5.   Conclusion and Future work

In this paper, we presented a series of ER games including specific types of puzzles, riddles, and events to pinpoint and assess the OCEAN five personality traits. First, we analyse the behavioural portrayal of each trait. Then, we create riddles and puzzles that generate metrics by associating each behaviour to a personality trait. Finally, we build a game in such a way that allows us to generate overall gameplay metrics for measuring each player's gaming style across a wide range of play styles. Specifically, the story behind each room and some events occurring during the game generate statistics on how a player moves and interacts with the environment. For example, during a kitchen fire-related event, such as the one developed for the neuroticism ER, individuals displaying high levels of neuroticism are more likely to struggle and get frustrated. In any case, their reactions will provide us with information regarding their emotional stability. Moreover, the employment of NPCs in other contexts is a vital technique to assess personality traits, such as extraversion and agreeableness, as they allow for the observation of social interactions.

Our first goal to explore the player's personality traits depending on how they interact with and solve each room is theoretically achieved. It must be noted that the lack of a ground truth regarding the metrics, and the behaviours to be examined in a room, is considered a limitation of our current work. However, this was our first attempt to gain a better understanding of individuals' personality traits and how they would affect different play styles and vice versa. This study provides a foundation for future personality research.

Future expansions of our game will feature a multiplayer version, in environments with additional puzzles and numerous events that occur in different times and places. This will ensure that the metrics and the profiling will be based on real-time interaction and communication with other players. Additionally, communication templates can be created and provided to the players for a more customised game experience. Finally, the participants are encouraged to complete a reliable and valid personality questionnaire in a supervised psychological assessment context, which will serve as the basis for the game's results.

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