Entertainment Computing 13 (2016) 10–24

Contents lists available at ScienceDirect

Entertainment Computing

journal homepage: ees.elsevier.com/entcom

Towards a system of customized video game mechanics based on player personality: Relating the Big Five personality traits with difficulty adaptation in a first-person shooter game ☆

Aniket Nagle [a,*], Peter Wolf [a,1], Robert Riener [a,b,2]

[a] Department of Health Sciences and Technology, ETH Zurich, Switzerland
[b] Spinal Cord Injury Center, Balgrist University Hospital, Zurich, Switzerland

ARTICLE INFO

Article history:
Received 29 April 2015
Revised 25 September 2015
Accepted 11 January 2016
Available online 21 January 2016

Keywords:
Personality-based video game mechanics customization
Different difficulty adaptations
Enjoyment and duration of gameplay
First-person shooter

ABSTRACT

While personality is known to moderate the kind of video games people like to play, the link between personality and game mechanics has not been explored. Finding such a link can enable customizing game mechanics based on personality, potentially making games more enjoyable and suited to a wide range of players. The present work investigated the relationship between the Big Five personality traits and four different implementations of difficulty adaptation, a popular game mechanic, in a first-person shooter game. In Study 1, a linear regression model was derived to relate the five personality traits with enjoyment (ENJ) and gameplay duration (DUR) in the four difficulty adaptations. In Study 2, this regression model was used to construct a predictor that chose a difficulty adaptation which maximized ENJ and DUR based on player personality. The predictor was tested against dynamic difficulty adjustment (DDA), which matched difficulty to user performance. ENJ and DUR were significantly higher in the prediction group than the DDA group. The present work highlights the importance of difficulty adaptation as a game mechanic, and suggests that personality could also be related to other game mechanics. Accordingly, a framework for personality-based game mechanics customization is proposed to foster future research.

1. Introduction

1.1. Personality and video games

Anyone who has ever owned a piece of modern computer technology, from the large (desktop PCs) to the small (smartphones) has probably played a video game at some point or another. The term *video game* itself today can refer to casual games like Candy Crush and Angry Birds, graphically realistic, immersive behemoths like Far Cry or Call of Duty, and anything in between. Despite their all-pervasive nature, it is apparent that not everyone likes playing video games in equal measure, and that different people like different genres of games. Research in the last decade has lent a measure of empirical insights into these intuitions, and it all relates to that one exemplification of an individual: *personality*. The concept of human personality has been grappled with by scientists and philosophers alike, who have tried to objectify and deconstruct it, as a way to formalize people's likes, dislikes, and ultimately who they are as individuals. Game researchers and psychologists have not been far behind in trying to find a link between video game play and personality, since playing video games is a voluntary activity that individuals do in their free time, which says a lot about their personality.

Numerous studies have found that personality affects both the kind of games that people like to play [1–7] and their play style [8,9]. Several studies have also found that matching a video game to player personality results in a more enjoyable playing experience [10,11], and, in the case of serious games, improved performance [12]. The links between game genre preference, play style, and personality, suggest that a game can also be individualized for a player based on their personality. Such individualization has the potential to make games more enjoyable and that players want to play for a long duration. Video game designers want their games to sell well, which means making games that can be enjoyed by a wide range of audience. Over the decades, distinct game genres,

☆ This paper has been recommended for acceptance by Matthias Rauterberg.

* Corresponding author at: Sonneggstrasse 3, ML G55, 8092 Zurich, Switzerland. Tel.: +41 44 632 8738.
E-mail addresses: aniket.nagle@hest.ethz.ch (A. Nagle), peter.wolf@hest.ethz.ch (P. Wolf), robert.riener@hest.ethz.ch (R. Riener).
[1] Address: Tannenstrasse 1, TAN E6.2, 8092 Zurich, Switzerland. Tel.: +41 44 632 7109.
[2] Address: Tannenstrasse 1, TAN E4, 8092 Zurich, Switzerland. Tel.: +41 44 632 6679.

http://dx.doi.org/10.1016/j.entcom.2016.01.002
1875-9521/

such as first-person shooters, role-playing games, platformers, simulation, and racing. have emerged. However, even within one genre, there is a high variability in the enjoyment experienced by players for a particular game, just as there is variability in how much different people like games in general [13]. Game designers could thus benefit from individualizing their games so that they appeal to as wide an audience as possible without compromising on core gameplay. While commercial game designers have the resources to make large, good-looking games that they can hope to sell despite the lack of any individualization, designers in other domains, like serious games and casual games, can benefit even more from individualization to make their games more enjoyable.

Using personality preferences to individualize the game experience has been suggested before [14–16], but has not yet been empirically tested for. One of the few commercial video games known to use personality-based adaptation is *Silent Hill: Shattered Memories* [17], in which non-playing characters ask the player some questions by which the player's personality profile is created and used to adapt gameplay elements. However, being a commercial game, the exact mechanism is not known. Realizing personality-based game individualization requires looking more closely into the aspects that make video games enjoyable.

While aspects like high fidelity graphics, deep gameplay, and multiplayer features are obvious ways to get people to enjoy games, they are one of the many techniques at the game designers' disposal. Anyone who has ever played Tetris for long knows that it's not any sort of graphics, but the game mechanic of dexterously and emphatically completing one row after the other, and the fact that the pieces fall faster and faster as one progresses, that makes Tetris addictive. Such a dynamic interaction is a particular example of a *game mechanic*, loosely defined as "the various actions, behaviours and control mechanisms afforded to the player within a game context" [18]. Examples of game mechanics include difficulty adaptation, level design, avatar customization, reward systems, etc. While there is plenty of research on personality and video games in general, the relationship between game mechanics and personality is relatively underexplored. Previous studies on gamified systems have found links between personality traits and game mechanics like rewards and leaderboards [19], while others propose a matrix of game mechanics and personality traits that could be related [20]. However, results of these studies cannot be generalized to video games; moreover, they miss some important mechanics like difficulty adaptation. Other studies looked at the effect of the similarity between player personality and game character on enjoyment [21]. Besides these few examples of studies that dealt with game mechanics, most of the other previous research has tended to treat video games as black boxes. Thus, there is limited empirical evidence on what kind of difficulty adaptation would a person with a particular personality enjoy, or what kind of in-game reward would spur them on, or what complexity of level design would they prefer, and so on. Understanding this link could help making video games much more enjoyable and individualized for a particular player.

1.2. Difficulty adaptation in video games

Among the many game mechanics elements that have an impact on how much players enjoy and how long they play a game, *difficulty adaptation*, which involves dynamically changing the game difficulty based on certain criteria, has become one of the most prominent ones. In general, difficulty adaptation comes in two types:

1.2.1. Dynamic difficulty adjustment

Dynamic difficulty adjustment (DDA) is the process of modulating the systems of a game world to respond to a particular player's abilities over the course of a game session [22]. The diversity in games makes this definition necessarily a broad one, since which systems of the game to modulate and how to measure or derive a player's abilities are highly game-dependent. Generally, DDA attempts to adjust game difficulty to match player skill, so that the player is neither bored (low difficulty, high skill) or overwhelmed (high difficulty, low skill), with such balancing theorized to increase enjoyment [23]. The range of actual DDA implementations, however, is quite diverse, from the simple, such as scaling task difficulty to match derived or computed user performance [24], to the more complex, such as player models to adapt game AI [25], adjusting opponent tactics in addition to player systems [26], weighted rules to select game AI actions [27], applying and updating game strategies immediately rather than perform iterative learning [28], and procedural level generation [29]. DDA implementation by scaling task difficulty parameters has been a popular game mechanic, especially in serious games [24,30,31] and casual games [32].

The first-person player game considered in the present work (described in detail in Section 2.1.1) consisted of the player being able to do a single type of action ("shoot"), and an enemy being able to do a single type of behaviour ("attack"). Games that contain a limited number of parameters benefit from using difficulty scaling to implement DDA, whereby the parameters are compared to preset threshold values and accordingly adjusted [33], and therefore DDA was implemented as difficulty scaling. Additionally, it was reasoned that DDA implemented as simple difficulty scaling would be a fairer comparison to the difficulty curves (described next), and could also increase the genericity and applicability of the results.

1.2.2. Static difficulty curves

Another approach used by game designers is to construct a difficulty curve, which specifies how the difficulty level of a game changes as a function of either time or distance travelled in the game (according to some game-specific metric) [34,35]. It is defined by the game designer and, unlike DDA, does not depend on player performance during the game; therefore, it is termed *static*. Static difficulty curves are especially useful in situations where assessing performance, as required by DDA, is either not possible or does not accurately reflect the game designer's intention for the player. Difficulty curves come in various flavours, and have been used in various commercial video games; prominent examples are high difficulty level in the beginning which decreases over time/distance (REVERSE), linearly increasing difficulty with plateau after a point (PLATEAU), and linearly increasing difficulty interspersed with rest periods of low difficulty (REST) (Fig. 1).

Game designers usually consider two kinds of difficulty: absolute [36], or nominal difficulty [37], which is the difficulty due only to the characteristics of the game, and perceived difficulty, which depends on the skill of the player and experience with the game [36]. Adams [36] provides the following concise equation to estimate perceived difficulty:

$$\text{Perceived difficulty} = \text{absolute difficulty} - (\text{power provided} + \text{in-game experience})$$

The assumption here is that the more power (weapons, ammo, shields, etc.) a player is provided, and the more experience they have with the game, the less difficult they will perceive the challenges of the game to be. However, it must be observed that the "equation" above is merely a simplified rule-of-thumb, and that "in-game experience" might include previous experience with similar games, dexterity with controls, etc. Inclusion of these subjective factors renders determining perceived difficulty an