Hyper-Casual Endless Game Based Dynamic Difficulty Adjustment System For Players Replay Ability

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***Abstract*—This work aims to extend the life of hypercasual endless smartphone games, which is one of the most significant problems facing hypercasual games. Almost half of apps available from app stores are mobile games and most are hypercasual games. Among hypercasual games, the most popular types are endless games, which have unique characteristics, including very short play sessions and minimalistic design. However, due to the short play sessions involved, most players stop playing endless games once their skills have reached a certain level or when they cannot improve their skills enough to reach the required goal. Most endless games do not have difficulty levels that can be manipulated by players, and their short play sessions only make this problem worse. This thesis discusses the game patterns of hypercasual endless smartphone games and shows ways to control their difficulty level to allow different players to find their personalized levels of difficulty to challenge them and encourage replay**

Keywords—endless game, mobile game, hypercasual game, dynamic difficulty adjustment system, level of difficulty

I. INTRODUCTION

Over the past ten years, mobile phones have become some of the most important products in people's lives. Benefitting from this, mobile phones have also become major game platforms and markets in the world. Since the App Store was released in 2008, over 950,000 mobile games have been published on this platform [1], making games the most popular type of app (Table 1).

TABLE I. NUMBER OF ACTIVE APPLICATIONS BY MONTH

Month	Number of Active Applications by Month		
	# Apps	*# Games*	*# Total*
2020-09	3,425,669	958,540	4, 384,209
2020-08	3,424,494	958,297	4,382,791
2020-07	3,420,161	957,390	4,377,551

Over time, three kinds of mobile game types have been established: casual games, mid-core games and hardcore games, demonstrating players' interests. However, since 2017, a new game type called the hypercasual game has emerged, and it has quickly become the most popular type of game. Most smartphone players spend only 30 mins playing mobile games a day, and most of the time, 30 mins is too little time for them to finish one game [2] (Fig 1). However, the player does not need to worry about time spent playing hypercasual games due to their short player sessions, which is a unique characteristic of hypercasual games. As a result, hypercasual games are easy to learn and play, easy to become addicted to due to their short play sessions of approximately 3 to 5 mins, and easy to stop playing with low frustration value. This is especially true for endless hypercasual games, as a player cannot win them.

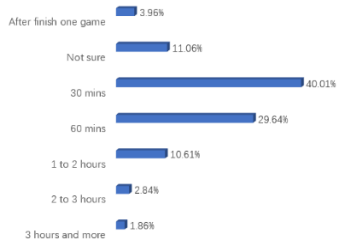

Fig. 1. Mobile Game Play Times, CNNIC, 2013.

Normally, when a game includes some mechanics that are too complicated, the player will experience problems or stop playing. As they are "easy to learn", players do not need to spend a long time learning how to play hypercasual games, and their simple and easy game mechanics allow players to have a similar experience each time, which will cause them to grow bored quickly due to the absence of new mechanics or challenges. These reasons are why most of hypercasual games have a low 7-day retention ratio date feedback value [3] (Fig 2).

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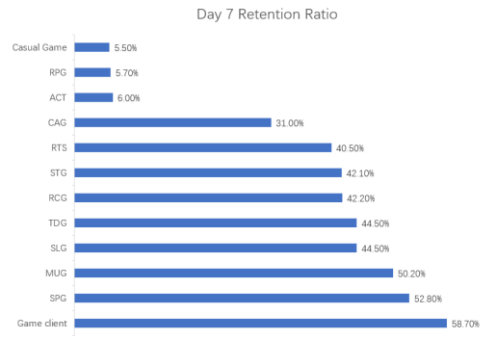

Fig. 2. 7-Day 7 Retention Ratios for Mobile Games, Jiguang, 2018.

It is not easy to find a previous research on the genre of hypercasual games, most of them are more focus on how to make more money by advertising. Hence a scientific and detailed approach is very useful and valuable for game developers. David Cao's thesis, Game design patterns in endless mobile minigames [4], and the Progression in endless games [5], which wrote by Marcelo Raimbault discussed the essential elements in endless games design patterns and the progression create unique guidelines for hypercasual games development. Benefit by them, this research aims to discuss how to extend the player interest in and, ultimately, the life of a hypercasual endless game on the mobile market.

II. Research Focus

The hypercasual game is not a new type of game (Fig 2). In its strictest sense, the hypercasual game can be described as a "renaissance" of arcade games [6], such as Break Out [7], Pac-man [8] and Tetris [9]. Hypercasual games have grown popular through the smartphone platform, and they fit the smartphone framework perfectly. The most popular hypercasual game is an endless runner game called Flappy Bird [10] published in 2014.

Fig. 3. Flappy Bird, Dong Nguyen, GEARS Studios, smartphone game, 2013.

Due to the success of the Flappy Bird, hundreds of companies have tried to copy its model, but most have failed, resulting in what was called "The Sword in the Stone Effect" by game designer Jesse Schell. "Everybody wants to be able to pull it out. Nobody can, but they try anyway", he says. "That notoriety goes a long way [11]."

Voodoo is one of the few game design companies that has developed rules for how to produce successful hypercasual games and is leading the market. Most hypercasual games have simple and easy game mechanics, requiring players to spend little time learning, and the challenges presented are easy to overcome as a matter of course. When this is the case, the player will easily become bored after a short period. Thus, Voodoo applies successful game mechanics that have been proven to work in the market and produces different versions with only a few changes until players enjoy their games, similar to how players played Flappy Bird and similar games after a few years of game development. As a result, Voodoo started leading the market very quickly and made considerable revenues over two years until 2019.

In 2019, the hypercasual game market became saturated. As shown in Figure 4, the download growth rate for hypercasual games has slowed since 2018 [12]. This is mostly the case because while an increasing number of games are being released, the number of players is still the same, so game designers must increasingly focus on how to make their games better rather than releasing more games. As Raquel Korman said, "With so many hypercasual titles popping up every week, developers may have to begin implementing deeper features in order to stand out from their competition [13]".

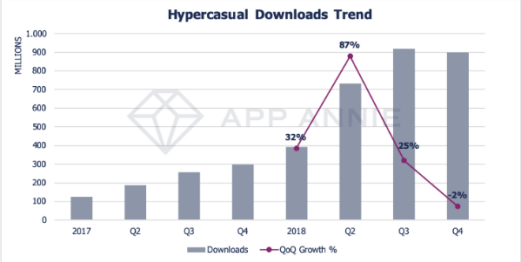

Fig. 4. Hypercasual Game Download Trends, Raquel Korman, 2019.

In conclusion, players are not loyal to one hypercasual game, and it is very easy for them to find a similar hypercasual game on the game market. Game designers must increasingly focus on how to extend the life of a game rather than release more similar game versions.

III. Analysis Patterns of Hypercasual Endless Games

As a special type of hypercasual game, hypercasual endless games are here used as a sample to discuss methods to extend the life of hypercasual games.

A. *The definition of the Hyper-Casual Endless Game*

Most hypercasual endless games on the market are action games such as *Temple Run* [14] (Fig 5) and *Flappy Bird*.

Fig. 5. Temple Run, Imangi Studios, smartphone game, 2011.

Hypercasual endless games are unique in that they cannot be won. In Temple Run, the player taps on the screen to help the character avoid obstacles. The player can obtain points

every time he or she successfully avoids an obstacle and obtains coins as a result. The player only needs to survive as long as possible until reaching a fail condition even though such games are called "endless games". Most of time, the player can only continue 3 to 5 minutes through one game, and the experience of each game is similar. Due to this stable and similar game experience, hypercasual endless games are perfectly suited to this thesis as a test sample, and data from the present test will be very useful in determining ways to extend the life of a hypercasual game and especially those of hypercasual endless games.

B. *Shortcomings of Hypercasual Endless Games*

Although many popular and successful hypercasual endless games are available app stores, their shortcomings are also numerous.

Simple game play. Most endless games only have one game mode with very simple game mechanics; therefore, players become easily bored and move on to other games. Similar to Flappy Bird, such games simply involve tapping on a screen until the game ends, and only one type of challenge is provided.

Too difficult or easy. Flappy Bird is popular due to its difficulty level, and the popular game titled Super Meat Bot adopts a similar approach. "It's hard. It's fun. It's Logo", computer scientist Seymour Papert said about his students' experience with learning the game [15]. This sense of "hard fun" represents the Super Meat Boy player's experience. Writer John Pavlus called this "intrinsic motivation — the urge to make progress toward a goal without the promise of an externalized reward" [16], providing a very good experience for design game challenges. The hard challenge mechanic design is one of the most important mechanics of popular Masocore game Dark Soul [17]. Dark Soul also includes a strong background story and other effective mechanics that support its main mechanics, which hypercasual games do not have, resulting in unfavorable positive and negative loops. In addition, no one wants to player a game which only need to press a button once to complete the game (Fig 6). As Jesper Juul said, "we expect resistance and the possibility of failure" [18].

Fig. 6. One-Button Game, Jesper Juul, The Art of Failure: An Essay on The Pain of Playing Video Games, 2013, 12.

Everyone has different skill levels; some players might think that a game is too difficult, while others might think that it is too easy, so it is difficult for a game designer to find the best solution for everyone.

The quick progressive difficulty system helps solve this problem, but it always causes a player fail at the same level, and the player must always start the game from the beginning to try the same level again; sometimes, this requires considerable time and causes some players to become bored.

C. *The Progression of Hypercasual Endless Game*

Marcelo Raimbault discusses the progression for hypercasual endless games as follows [19] (Fig 7).

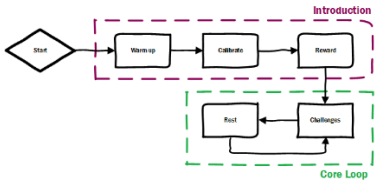

Fig. 7. The Progression of Endless Games, Marcelo Raimbault, 2016.

- Warm up. This provides the player a safe space to adapt to the movement speed and game design and acts as a tutorial for beginners.
- Calibrate. After the "warm up", the player enters a more difficult level and thus must adapt to a new speed and prepare for increasingly difficult levels (e.g., speed) due to the progressive difficulty function.
- Reward. Once the player fails, he or she is given rewards to encourage him or her to try again. This usually decreases the level of frustration experienced and enhances replay ability.
- Challenges. After the "warm up" and "practice" phases, the player begins to seek challenges through the game, and progressive difficulty levels will challenge him or her.
- Rest. After challenges are overcome, the game should give the player enough time to rest and rethink his or her strategy and reflect on mistakes made in the last game.

The "warm up", "calibrate" and "reward" steps can be called introductory parts while the main components of endless games are the "challenge" and "rest" periods. The game designer should reduce time spent on the introductory parts after the player has learned how to play the game, as the "core loop" is most central to the player having a positive game experience.

Obviously, the best way to improve the player's experience and deepen gameplay is to reinforce the "core loop". In addition, after the player knows how to play the game, it is very important to encourage him to enter the "core loop".

IV. Dynamic Difficulty Adjustment Systems in Games

Staffan Bjork discusses the "right level of difficulty" in his 2014 book titled *The Patterns in Game Design*; he believes that the "right level of difficulty" is not too easy or too difficult for players. Bjork states, "For the challenges in a game to be interesting to a player, they need to have the right level of difficulty. If the challenges are too easy, players may be bored, while if they are too difficult, players may give up playing the game" [20].

In hypercasual endless games, when the player can reach the "right level of the difficulty" in the "introductory" part of the game, this will encourage him to continue to play the game, which will lead him to enter the "core loop".

"It's the kind of thing we get from drugs, from meditation, from spiritual rituals", Frank Lantz, director of New York University's Game Center says. He continues, "I found it recently in playing Flappy Bird. For me, one of things that makes it interesting is that it is an extreme example of this experience "[21].

The enjoyable experience Lantz describes comes from Flappy Bird's "core loop". Hungarian psychologist Mihaly Csikszentmihalyi refers to this concept as "Flow (Fig 8)". "Flow" occurs everywhere, and it affects everyone's careers, including those of artists, poker professionals and video game players. In 1996, Csikszentmihalyi said, "The ego falls away. Time flies. Every action, movement, and thought follows inevitably from the previous one, like playing jazz. Your whole being is involved, and you're using your skills to the utmost" [22].

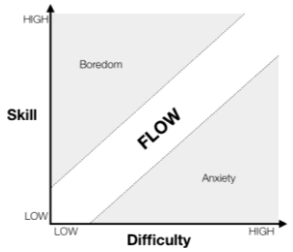

Fig. 8. Flow, boredom, and anxiety as they relate to task difficulty and user skill level, from Csikszentmihalyi, 1990.

Based on this theory, if the level of game play is too easy for the player, he or she will become bored; if the level is too difficult for the player, he or she will feel anxiety. Jenova Chen describes flow in game design as follows (Fig 9) "human beings have tolerance, there is a fuzzy safe zone where the activity is not too challenging or too boring, and psychic entropies such as anxiety and boredom would not occur" [23].

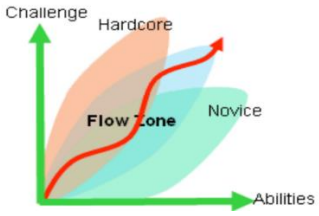

Fig. 9. Different Players and Flow Zones

In hypercasual endless games, when the player is experiencing the "core loop" and keeps restarting the game, he or she is at the "right level of difficulty" and continues seeking the "flow" experience. If he or she gets bored, this might occur because the level of difficulty no longer matches his or her skill level. In theory, dynamic difficulty adjustment systems have the potential to match the game level to the player's skill level in the "introduction" and "core loop" steps by modifying game patterns.

V. Hypothesis and Prototype

A. *Hypothesis*

Using Unity 3D, information is gathered in this chapter to explore the dynamic difficulty adjustment system. There are three hypotheses that this prototype tries to prove:

- A dynamic difficulty adjustment system allows the player to continue to play longer.
- A dynamic difficulty adjustment system lessens the player's experience with frustration after failing.
- A dynamic difficulty adjustment system ultimately extends the life of a game.

B. *Prototype Summary*

For the test, the prototype includes two versions. One test version uses the dynamic difficulty adjustment system while the other does not. The player is asked to play both versions and to complete a survey after completing games.

After analyzing players' feedback, Chapters 4 and 5 examine whether the dynamic difficulty adjustment system can prove the three hypotheses. In this game (Fig 10), the player will have five lives, and the game will end when the player loses all of his or her lives.

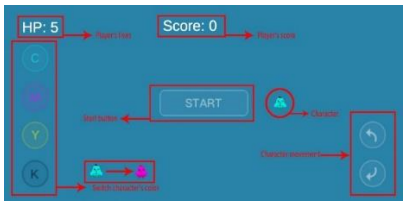

Fig. 10. Elements of The Game Patterns

In the game, the player will control a character moving passed obstacles such as circles (Fig 11). The obstacles will form from the center and continue to expand until they move beyond the extent of the screen. For the obstacles, one part is shown in one of the CMYK colors, which are Cyan, Magenta, Yellow and Black. The player must change the color of the character by tapping a button matching the obstacle's color and thus gain points.

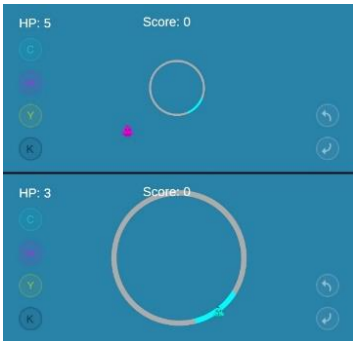

Fig. 11. Moving and Changing the Character

C. *Quick Progressive Difficulty System (QPD)*

For the quick progressive difficulty level design, the game uses the traditional method, such as those used in Temple Run,

Subway Surfers, and other similar endless games, by continuing to increase the value of elements until the maximum value is reached.

In the game, the difficulty level for each element is controlled by the player's score. If the player scores 5 points without losing health in that time, then the player will move to the next level (Fig 12).

For each adjustable element, there are five different levels of difficulty (Fig 12). If the player moves to the next level, then the obstacle's colourful section will grow smaller and the obstacle will move and form faster. The level of difficulty can only increase; there is no way to return to an easier level until the player loses all health.

```
ScoreValue+=1;
run+=1;
hpRun += 1;
if (run>=5)
{
    Spawn.difficulty += 1;
    if (Spawn.difficulty>=5)
    {
        Spawn.difficulty = 5;
    }
    run = 0;
}
```

Fig. 12. Level up Mechanics

The following game elements can be changed (Fig 13):

- Character speed;
- Character size;
- Obstacle movement speed;
- Obstacle formation speed;
- The proportion of the colourful part of the obstacle;
- The formation angle of the colourful part of the obstacle;
- The number of different colours.

To generate stable test results, the quick progressive difficulty elements of the game only include the obstacle movement speed, the obstacle formation speed, the proportion of the colourful part of the obstacle and the formation angle of the colourful part of the obstacle.

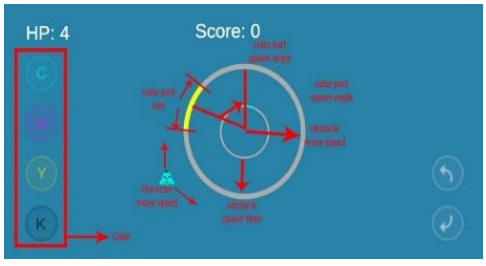

Fig. 13. The Elements Can be Changed in the Game

This version does not apply dynamic difficulty adjustment and will be developed as a traditional endless game to compare to the version of the game with dynamic difficulty adjustment.

D. Dynamic Difficulty Adjustment System (DDA)

As stated above, in endless mobile games, the quick progressive difficulty system can only increase the level of difficulty; the player cannot return to an easier level. This makes it very difficult for the player to find the right difficulty level, interrupting the "flow" experience, especially for beginners.

The progressive difficulty system only has one function, which is to increase the difficulty level. Dynamic difficulty has two functions, i.e., increasing and decreasing the difficulty level. If the player has trouble with a given level, then the difficulty level can be reduced (Fig 14).

```
public void AddScore()
{
    ScoreValue+=1;
    run+=1;
    hpRun += 1;
    if (run>=5)
    {
        Spawn.difficulty += 1;
        if (Spawn.difficulty>=5)
        {
            Spawn.difficulty = 5;
        }
        run = 0;
    }
```

```
public void EntRun()
{

    if (isLower)
    {
        run = 0;
        Spawn.difficulty--;
        if (Spawn.difficulty <= 0)
        {
            Spawn.difficulty = 1;
        }
    }
```

Fig. 14. Increasing and Reducing the Level of Difficulty

For example, if a player obtains 5 points without losing health (Fig 15), he or she will move to a more difficult level and must calibrate his or her reaction time. If the player loses health at this new level, then he or she is not ready for this level and will return to the previous level, causing the system to recount another 5 points until the player can level up again.

In the version of the game with the dynamic difficulty adjustment system, the colourful part of the obstacle can be adjusted to limit the angle of the formation area (Fig 15). For example, if the colourful part of the obstacle is at angle A, the second obstacle's colourful part can only form from angle B to C (Fig 16). This constitutes the most important and efficient part of the dynamic difficulty adjustment system of the game, providing the player enough reaction time early on to allow him or her to learn how to play.

```
private void SpawntheVault ()
{
    GameObject clone;
    if (difficulty == 1)
    {
        clone = Instantiate(Vault[Random.Range(0, 4)]);
        clone.transform.SetParent(transform);
        clone.transform.Rotate(0, 0, bird.transform.eulerAngles.z);
    }
    else if (difficulty == 2)
    {
        clone = Instantiate(Medium[Random.Range(0, 4)]);
        clone.transform.SetParent(transform);
        clone.transform.Rotate(0, 0, bird.transform.eulerAngles.z+30);
    }
    else
    {
        clone = Instantiate(Small[Random.Range(0, 4)]);
        clone.transform.SetParent(transform);
        clone.transform.Rotate(0, 0, bird.transform.eulerAngles.z + 90);
    }
```

Fig. 15. Limited Formation Angle for the Obstacle's Colourful Part

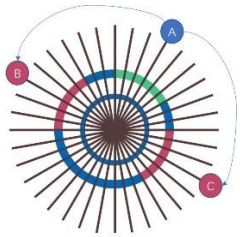

Fig. 16. Limited Formation Angle for the Obstacle's Colourful Part

VI. Hypothesis and Prototype

A. Method

Fig. 17. The progression of the test

To prove the three hypotheses presented in Section 5.1, seven players participated in the test. The game testers were separated into two groups (Fig 17) and played two different versions of the game, i.e., the version with the dynamic difficulty adjustment system (DDA) and that with the quick progressive difficulty system (QPD). During the test, none of the participants knew that they were playing two different games.

B. Data Analysis

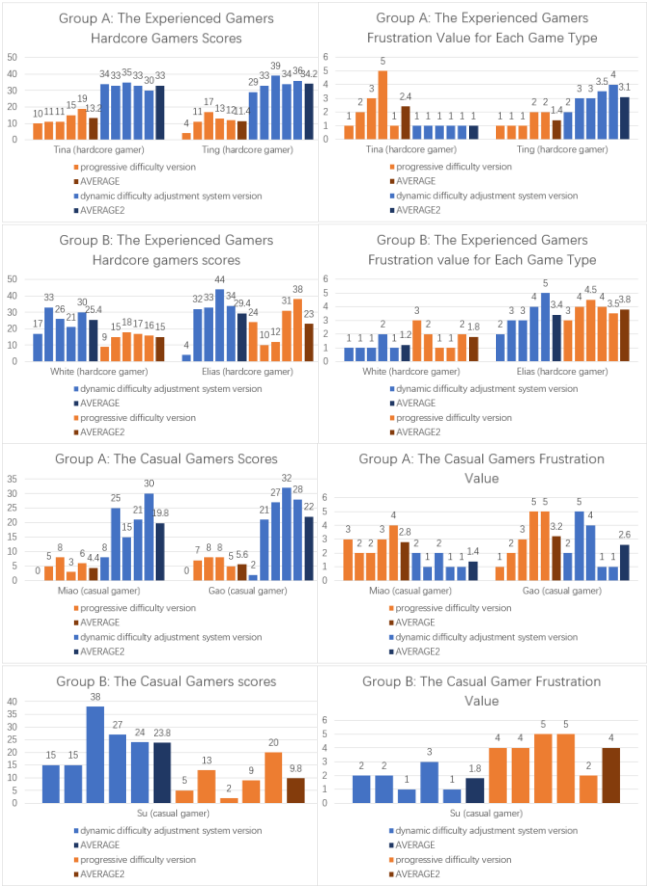

Fig. 18. Test results

According to the test results shown in Figure 18, for the first five game play sessions, experienced gamers who played the DDA version always scored more points than experienced gamers who started with the QPD version. The former participants learned faster and identified strategies earlier.

For experienced gamers, regardless of which version they started with, their frustration and enjoyment evaluation values increased at a stable rate. However, when experienced gamers who started with the QPD version moved to the DDA version, even though their scores were better, some lowered their evaluation values due to both frustration and enjoyment even though they did not know that they had played two different versions. Players who started with the DDA version were not affected; after they moved to the QPD version, their evaluations were still increasing. After being told that there were two versions, most said that they preferred the QPD version because they believed it to include more challenges and to be more interesting than the DDA version.

The casual gamers' frustration evaluation values were sensitive. Casual gamers who started with the QPD version always made positive evaluations until they moved to the DDA version, which they enjoyed much less; however, after they moved to the DDA version, their values increased. However, for casual gamers who started with the DDA version, their enjoyment was not reduced after they moved to the QPD version, but their frustration levels were higher than those for the DDA version. As they believed that they had played only one version, they thought that their scores had decreased due to their abilities. After being told that there were two versions, most reported preferring the DDA version because they could obtain more points. They felt that the ability to obtain points made the DDA version more fun than the QPD version.

One participant named Tina is a unique case. Tina considers herself a casual gamer and spends no more than seven hours playing games a week. She started with the QPD version and did very poorly; therefore, her frustration value was very high, and her enjoyment value was low. She almost gave up during her fourth game play session. However, once she started to play the DDA version, her frustration value reduced to 1, the lowest value recorded, but her enjoyment value did not increase even though she was gaining more than three times more points than she received in the QPD version. After she finished the test, she was told that there were two versions. She reported preferring the QPD version, which almost caused her to stop the test. She asked to play the QPD version again and improved her score. She then believed that she had become an experienced gamer and wanted to seek further challenges even though she typically only plays games for fun.

C. Conclusion

Whether for casual or experienced gamers, compared to the QPD system, the DDA system is a more effective system for gamers as a tutorial mode because it allows the player to learn faster. For experienced gamers, after a tutorial, they prefer to face challenges directly, and they do not want to warm up, as this is considered a waste of time. This finding seems to prove Jesse Schlle's view: "We're finding that in virtual reality, people don't like that slow ramp of tutorial-like challenges to build competence . . . They seem to much prefer a very difficult 'cliff'

that they have to confront and address. They love that it's so hard. And I have to say, right now I don't understand why that is [24]". From this perspective, the QPD system might be better than the DDA system, but it can still be improved. Casual gamers need more time than experienced gamers to learn and practice, and they play games to experience a challenge but also want to have fun by achieving good scores. The DDA system helps them do this, as it encourages them to continue to play, ultimately extending game life.

In sum, the dynamic difficulty adjustment system can allow a player to "survive" more times in an endless game and can reduce frustration after a player fails. The dynamic difficulty adjustment system can also increase replay ability and ultimately extend the life of a game. While the system is not perfect, it can improve endless games and is very helpful for beginners. To improve this system, more adjustment methods can be included, and both casual and experienced gamers can be individually served.

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