Control Player Tension with DDA Encounter Design: Post-Mortem

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Abstract

The Game Industry commonly implements DDA (Dynamic Difficulty Adjustment) to automatically modify the game features, behaviors, and scenarios depending on players' performance to keep them in the flow[1][2]. This thesis concentrates on utilizing a DDA system in "The Divinity: Original Sin 2" [3] to demonstrate the best practice of designing a DDA system to provide a similar feel of Tension for players with different skill levels.

Keywords

DDA, Tension, Dynamic Difficulty Adjustment

1 INTRODUCTION

This thesis introduces a DDA system heavily inspired by "Hamlet" [4] (A DDA system developed by Valve and used in the Half-Life series) into The Divinity: Original Sin 2.

The DDA system expects to provide a similar feeling of Tension for players with different skill levels. This thesis also demonstrates the best practices to design encounters with the DDA approach in a turn-based singleplayer game.

2 DEFINITION

According to "Toward a general psychological model of Tension and suspense" (L, Moritz, K, Stefan, 2015)[5] They define Tension and suspense as affective states that :

- Are associated with conflict, dissonance, instability, or Uncertainty
- Create a yearning for resolution
- Concern events of potential emotional significance, and
- Build on future-directed processes of expectation, anticipation, and prediction

And the key components of Tension and Suspense are:

- CONFLICT, DISSONANCE, AND INSTABILITY
  - Tension and suspense usually originated from conflict events
  - Creates a yarning of more stable, consonant stages
- UNCERTAINTY
  - Future events with Uncertainty but potentially highly significant outcomes can create strong tension experiences
- EXPECTATION, PREDICTION, ANTICIPATION
  - The emotional significance of anticipated events generated Tension or suspense
  - The degree of Tension appears to be directly related to the range of anticipated events and their emotional valence
- THE PARADOX OF SUSPENSE
  - Constant stimulation of Tension reduces Tension
- EMOTIONAL SIGNIFICANCE OF ANTICIPATED EVENTS
  - Emotional significance is how relevant the anticipated event is to the concerns of the individual
  - The amount of Tension experienced appears to depend directly on the significance or desirability of anticipated events
- LACK OF CONTROL
  - An inability to influence the course of events, often contributes to experiences of Tension
- TEMPORAL ASPECTS
  - Tension experiences can be observed at different temporal levels.
  - A complete plot of a novel
  - A single sentence

2.1 Tension for Players with Different Skill Levels

Players who have different skill levels tend to have different feelings towards the same encounters according to flow theory (fixed challenge versus different skill level)[6].

For multiplayer games like WoW or Final Fantasy XIV Online, which are difficult and unfair to modify encounters for different players, a dungeon would often have a minimum level or gear requirement to filter out those who are not qualified for the challenge. Another solution is to modify players' stats to the same equivalent standard, like the open-world quests in Guild Wars 2.

For singleplayer games, however, since we can modify the combat, the implementation of a DDA system can help to control the Tension for players with different skill levels.

3 DDA

DDA (Dynamic Difficulty Adjustment) is a method to change the game features, behaviors and scenarios automatically depends on player's performance, so that when the game is easy, they don't feel bored or frustrated, when the game is difficult[6].

There are approximately 7 DDA approaches developed in the past decades[FIGURE 1]. This thesis is mainly concentrating on researching the Hamlet system developed by Valve and try to design a similar DDA system in The Divinity: Original Sin 2.

In general, both Hamlet and the DDA system in this thesis modifies the game with the following process:

- Measure: Measure the player's performance
- Application: Take actions based on the player's performance to adjust the game
- Gather Data: Gather data and feedback to measurement function

Author(s)	Approach
Xue et al.	Probabilistic Methods
Pedersen, Togelius, and Yannakakis	Single and multi-layered perceptrons
Spronck et al.	Dynamic scripting
Hunicke and Chapman	Hamlet System
Hagelback and Johansson	Reinforcement Learning
Li et al.	Upper Confidence Bound for Trees and Artificial Neural Networks
Ebrahimi and Akbarzadeh-T	Self-organizing System and Artificial Neural Networks

3.1 FIGURE 1: List of DDA approachesDDA in Flow

Design and implement an effective DDA is not as simple as adding or removeing a couple of health potions because that can easily break the flow.[7] Thus, the DDA system should make sure that the players are still in the flow with a modified encounter. (*FIGURE 3*)

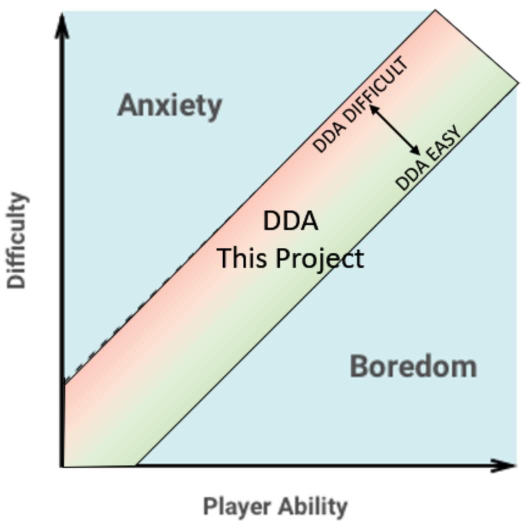


FIGURE 2: DDA in the flow channel

4 CONTROL TENSION WITH DDA ENCOUNTER DESIGN

4.1 Methodology

With the definition of "Tension," this thesis designs a DDA system for manipulating "Uncertainty" and "Emotional Significance" to influence the player tension.

The basic guideline of designing the DDA system is:

- Control player tension with Uncertainty
  - More Uncertainty creates Tension, and less Uncertainty eliminates Tension [8]
  - Uncertainty, in this case, refers to the probability of whether a player will win an encounter or not, however both have a chance to happen
  - Random enemy spawn location to control the Uncertainty
  - Control enemy count to control the Uncertainty
  - Control enemy types to control the Uncertainty
- Control player tension with Emotional Significance
  - Control player's inventory level (In this case, health) to manipulate the emotional significance for players (See Control Emotional Significance)

4.2 Design Process

The game chosen in this thesis is The Divinity: Original Sin 2, which is a turn-based game, and this thesis only focuses on the singleplayer campaign.

The first step is to predetermine the intended tension level as a reference. (*FIGURE 4*) In this thesis artifact, each encounter's tension level is ranging from 0.3 – 0.9 (due to the difficulty to diversify different tension levels with weak enemies, e.g, 0.1 tension level spawns 2 weak enemies, and 0.3 spawns 3 or 4 weak enemies, they are almost equally easy to player and tend to make the player feel boring.) and has three categories:

- Low-Tension Group (0.1 – 0.4)
- Mid-Tension Group (0.5 – 0.6)
- High-Tension Group (0.7 – 0.9)

Next, analyzing which mechanics can be modified dynamically in terms of the editor's technical capability and contribute to either "Uncertainty" or "Emotional Significance; Finally, the thesis consists of the following four parts:

- Level Design
  - Control Tension Curves
  - Design Crates for exploration
  - Design Interactable Environment
- Control Emotional Significance
  - Control Inventory Level
- Control Uncertainty
  - Control Enemy Types
  - Control Enemy Counts
  - Random Enemy Spawn Locations
- Provide Player with Help
  - Dynamic Route

Then, design a DDA system to manipulate or control the game mechanic, as well as using level design as a structural support.

After that, gathering data with game experience questionnaires and compare with predetermined tension level to prove how well the DDA system can handle.

It is worth noting that the process may undergo multiple iterations for balancing and refinement. Every time the DDA system is changed, the data needs to be re-collected and re-analyzed.

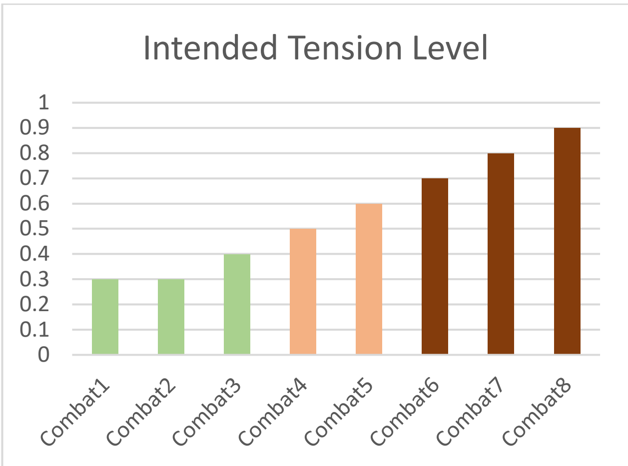


FIGURE 3: Intended Tension Level

5 LEVEL DESIGN

Level Design provides the ground up works for the DDA system to work properly. Such as provide a place (crates) for supplies to dynamically spawn into or allow both AIs and the player to play strategically by utilizing environmental elements (Oil/Water/Poison Barriers, Ladders, etc.) in the encounter.

5.1 Control Tension Curves

This thesis uses “Uncertainty” and “Emotional Significance” to generate tension states together; Encounters can influence “Uncertainty,” whereas the player’s inventory level can influence “Emotional Significance.” Thus, the design of the level is an arena-based layout to let the two parts closely work with each other. (Arena contributes to “Uncertainty” as well as the transition contributes to “Emotional Significance”) (*FIGURE 5*)

In other words, the “Arena” (Purple Area) represents any “data point” in the intended tension level chart (*FIGURE 4*) to provide “Uncertainty,” and the “Transition” (Area between two Arenas) represents the gap in between two combats in the chart, which not only trying to control the “Emotional Significance,” but also trying to avoid the paradox of suspense.[9]

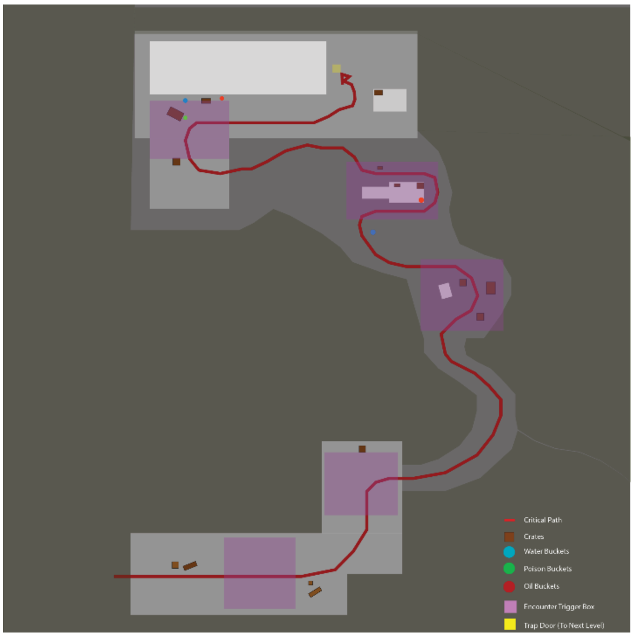


FIGURE 4: Part of the level paper map in this project

5.2 Design Crates for Exploration

Crates(*FIGURE 6*) in this thesis are mainly:

- For supplies to spawn into it, so they
    - Should avoid being destroyed
    - There should be multiple of them to avoid being predictable

5.2.1 Avoid being destroyed

According to the official API document[10], the editor of The Divinity: Original Sin 2 did not support checking the status of a crate; However, if a crate has been destroyed, then supplies will not be able to spawn inside it.

To avoid this, critical crates that are essential for the DDA system to spawn supplies to have high health so the players won’t accidentally destroy them during combat.

Another solution could be to put these crates into the transition area where they are far away from combat.

5.2.2 Multiple crates to avoid being predictable

In a real scenario in which a game may want to encourage players from exploration, the designers won’t put every supplies at the same place. So, the DDA system in this thesis can randomly pick up an available crate(which the player has not opened before) near the player to spawn items into it. Thus, this thesis often put multiple crates around the transition for players to explore and avoid the location of supplies from being predictable.

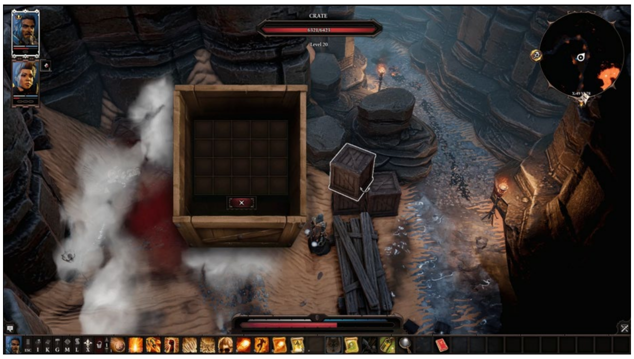


FIGURE 5: Crates in The Divinity: Original Sin 2

5.3 Design Interactable Environment

An important part of controlling “Uncertainty” is to randomly spawn enemies around the encounter area but still let them be meaningful. So this thesis put interactable barriers, ladders, and different verticality levels around the combat area. (*FIGURE 7*)

Both AI and the player can interact with these oil/water/poison barriers during the combat. Thus different enemy spawning location leads to an uncertainty of the outcome. (Win or lose)

FIGURE 6: Interactable Environment Design

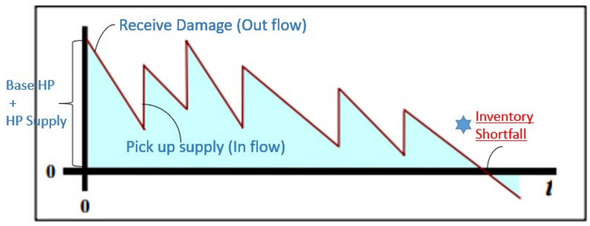
6 CONTROL EMOTIONAL SIGNIFICANCE

According to L, Moritz, and K, Stephan, high Emotional Significance indicates that the individual has a greater concern of a certain outcome.[11] For example, the player with lower health will often be more concerned about taking damage other than those who are at their maximum stats.

In other words, if we can design a system to control the player’s critical attributes. (i.e., health) Then the system may influence the emotional significance of the player, as well as control the player tension.

6.1.1 Control Inventory Level - Methodology

Inventory level is a model used in the Hamlet system for measuring the critical attributes(in the example above, health).[12] The model represents the relationship between the critical attributes and the time. (*FIGURE 8*)It is worth noting that the inventory level not just referring to the character's health, but also includes the health supplies in the character's inventory. When a player consumes health (outflow), the inventory level decreases and increases when the player picks up supplies or using skills to recover health (inflow).



Inventory level as it fluctuates over the period of time *t*. A shortfall occurs when demand surpasses supply.

FIGURE 7: An Inventory Level Model

6.1.2 Control Inventory Level – Process

In this thesis, the DDA system controls the inventory level's inflow by spawning potions into a random unexplored crate near the player. And the amount of outflow is controlled by the amount and types of enemies spawned in the combat. Together, the inflow and outflow controls the player's inventory level.

First of all, make a predetermined inventory level as a base reference. *(FIGURE 9, the white line*)

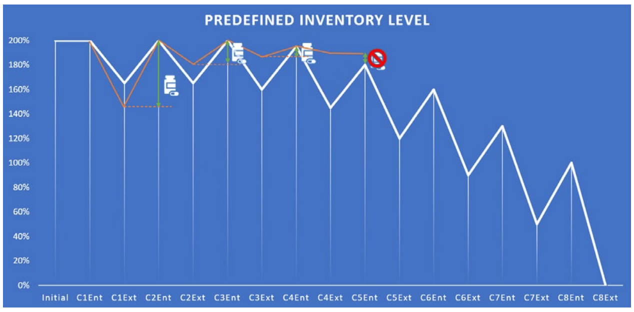


FIGURE 8: The predefined inventory level

Next, whenever a player's team leaves an encounter, the DDA system will measure the difference between the player's avg team inventory level and the expected inventory level at the beginning of the next combat. The difference represents the amount of potions needed in the transition between the two arenas. If the player has more inventory level than expected, then the DDA system will not spawn any potion. (*FIGURE 9, the orange line*)

7 CONTROL UNCERTAINTY

The enemy type, enemy spawn location, and enemy counts control "Uncertainty." Note that these aspects also contribute to the outflow of the player's inventory level (See Control Inventory Level - Process)

7.1 Enemy Spawn Location

The DDA system in this thesis is trying to spawn enemies at random locations within the combat area. If there are interactable environment elements available, the AI can take advantage of them as well. Thus the player can not predict where the enemies are and have to strategically adjust their position to perform either offensive or defensive moves.

7.2 Tension Group & Enemy Type

Encounters have three different tension groups with the tension level ranging from 0.1 to 0.9(*FIGURE 4*), respectively, they are:

- Low-Tension Group (0.1 – 0.4)
- Mid-Tension Group (0.5 – 0.6)
- High-Tension Group (0.7 – 0.9)

Meanwhile, the enemies also have three different groups

- Low-Tension Group Enemy
  - Less(nearly half) powerful than a character
- Mid-Tension Group Enemy
  - Equivalent powerful as a character
- High-Tension Group Enemy
  - More(nearly double) powerful than a character

Note that the term "powerful" is balanced by the turns an enemy needs to kill a player character versus the turns needed for the player character to kill an enemy. Thus, enemies from the mid-tension group should take the same or similar amount of turns to kill a player character as the player character does.

Also, each combat has both melee and ranged enemy types to fulfill different class combinations in a party.

The logic for spawning enemies follows the rules below:

- Low-Tension Group Encounter
  - Low-Tension Group Enemy
- Mid-Tension Group Encounter
  - Mid-Tension Group Enemy
  - Low-Tension Group Enemy
- High-Tension Group Encounter
  - High-Tension Group Enemy
  - Mid-Tension Group Enemy
  - Low-Tension Group Enemy

7.3 Enemy Counts

A stack pool based architecture controls the number of enemies to spawn in a combat. Each enemy type will consume certain stacks, and the DDA system will randomly spawn the enemy from valid enemy tension groups constantly until the stack pool gets fully consumed.

7.3.1 Enemy Types & Stacks

- Low-Tension Group Enemy
  - 1 Stack
- Mid-Tension Group Enemy
  - 2 Stacks
- High-Tension Group Enemy
  - 4 Stacks

Note the consumption of stacks of each enemy tension group matches 1:2:4, which also matches the stats of each enemy tension group. (4 Low-Tension Enemies ~= 2 Mid-Tension Enemies ~= 1 High-Tension Enemy)

7.3.2 Stack Pool

Three factors influence stacks available in stack pool:

- Player Counts
- Desired Tension Stacks
- Tension Bias

In general, the final tension stacks follows the equation below:

$$PreClampedStacks = 2 * (PlayerCounts + DesiredTensionStacks + TensionBias)$$

$$FinalStacks = Clamp(PreClampedStacks, MinStacks, MaxStacks)$$

The idea between the equation is trying to find a start point to modify from, in this case, the 0.5 tension level. After we found the Mid-Tension Level Combat, then we can either add more stacks to it to increase tension, or remove stacks from it to reduce tension. (Desired Tension Stacks)

Since an enemy from the Mid-Tension Group is almost as powerful as a player character, Each character facing one enemy from the Mid-Tension Group is considered as an unbiased Mid-Tension encounter.

Next, when the designer sets a tension level for an encounter, they also set the damage that the player team is expected to receive. The difference between the expected damage to the player team and the actual damage to the player team is then calculated. If the difference is positive after averaged out with all previous encounters (Actual received damage is less than expected), then the Tension Bias is also positive, vice versa.

It is worth noting that the difference between the actual received damage and expected damage is being averaged with all previous data, to avoid making the difficulty level unstable. I.e., in combat 1, the player team receives 10% more damage than expected, and in combat 2, the player received 10% less damage than expected, and now the player has 0 tension bias since the two difference evened out.

The reason for multiply by 2 is because every enemy from the Mid-Tension Group consumes two stacks. So three characters should have six stacks to spawn three enemies from the Mid-Tension Group.

Here are some examples:

1. 3 Characters, 0.5 Tension Level, 0 Tension Bias
   - 2 * (3 + 0 + 0) = 6 stacks
2. 3 Characters, 0.7 Tension Level, 0 Tension Bias
   - 2 * (3 + 2 + 0) = 10 Stacks
3. 3 Characters, 0.7 Tension Level, 2 Tension Bias
   - 2 * (3 + 2 + 2) = 14 Stacks
4. 3 Characters, 0.4 Tension Level, 0 Tension Bias
   - 2 * (3 – 1 + 0) = 4 Stacks
5. 3 Characters, 0.4 Tension Level, 2 Tension Bias
   - 2 * (3 – 1 + 2) = 8 Stacks
6. 3 Characters, 0.7 Tension Level, -2 Tension Bias
   - 2 * (3 + 2 - 2) = 6 Stacks

Cases 1 is an unbiased Mid-Tension combat, and cases 2 adds 2 bonus stack from Desired Tension Stacks, thus making the encounter more difficult. Case 4, in contrast, reduces the stacks to make combat easier.

Compare with the cases 2 and 6, the player in case 6 does not perform as good as the player in cases 2, so stacks are removed by Tension Bias to ease the combat.

Compare with cases 2 and 3, and stacks are added by Tension Bias to challenge the player more because they are performing greater than we expected.

7.4 Enemy Levels

The DDA system will set the enemy level as the average character level in the team.

This process does not consume stacks and is for balance purposes.

8 PROVIDE PLAYER WITH HELP

If the player's performance is not as good as we expected, there is a higher chance for them to die, on the other hand, if the player's performance is better than we expected, they might want to get more powerful items for next challenges. Thus we provide dynamic routes to help them

8.1 Dynamic Route

Dynamic Route is some parts of the level which is inaccessible at the beginning, when the player enters the trigger box ahead of the Dynamic Route area, the DDA system measures their Tension Bias, and thus unlock specific routes to help them.

There are two different routes available in this thesis, offensive routes and defensive routes. When the player's Tension Bias is greater or equal than 1, that means the player overall feels that the campaign provides less tension than we expected. Since the Tension Bias is positive, the next combat is more difficult. In this case, the offensive route provides them with weapons and gear but no health supplies.

On the other hand, when the player's Tension Bias is less than 1, they might feel the campaign provides more tension than we expected. Thus, the defensive route offers health supplies to boost up the inflow of their inventory level. (Decrease the emotional significance to decrease tension)

9 DATA & ANALYSIS (5 PLAYERS)

9.1 Flow

According to the flow theory[13], an essential factor to determine whether or not a player is in the flow is that those who are in the flow channel will lose the ability to sense the actual time elapsed in the real world.

During the test, the playtesters' estimated time elapse is compared with the actual time elapsed, and on average, they are 36.11% more than the player estimated. (*FIGURE 10*) So all playtesters are in the flow most of the time.

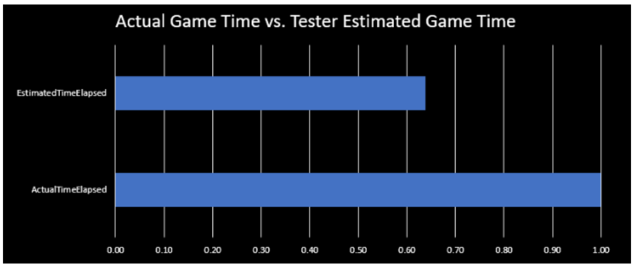


FIGURE 9: Player estimated vs. Actual time elapse

9.2 Inventory Level

In general, the inventory level of testers follows an expected curve.

In the example below(*FIGURE 10*), The blue line demonstrates the predetermined inventory level, and the orange line demonstrates the avg. playtester inventory level.

In general, the test data matches the overall predetermined data as expected. However, it is worth noting that the spike at the beginning of combat 7 was caused by the affection of defensive route.

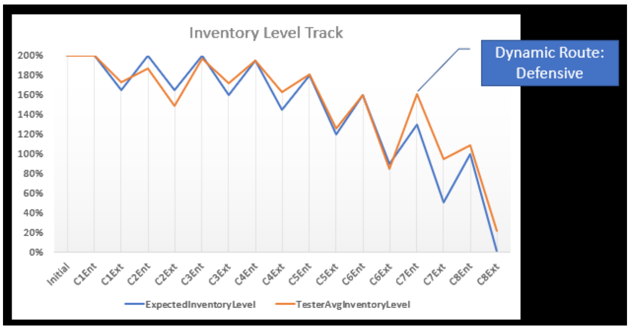


FIGURE 10: A playtester's inventory level vs. Predetermined Inventory level

9.3 Tension Level

Players with different skill levels experienced a similar tension experience, and the inventory level and tension level matches with each other.

The example below(*FIGURE 11*) demonstrates the tension level for playtesters on average, compares the data with the figure above(*FIGURE 10*). It is noticeable that in combat 2 the player feels more tension than combat 1 and 3. Which can be explained by the data in *Figure 11*. (The playtesters received more damage in combat 2 than in combat 1 or 3, which is caused by lacking previous combat data to average the tension bias, which leads to a harsh modification on the next combat at the beginning)

The tension level for combat 7 was lower than combat 6 and 8; Which is believed to be caused by the decreasing of the emotional significance. (Player get potions from defensive route)

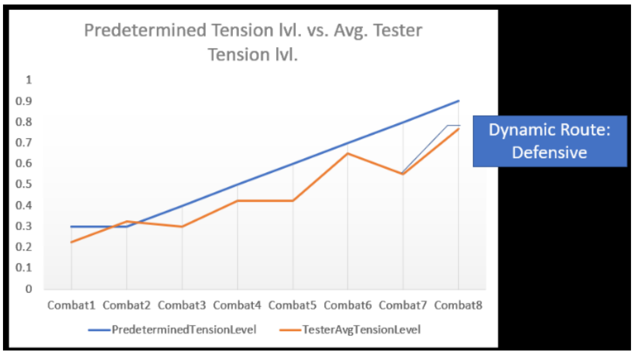


FIGURE 11: A playtester's Tension Level

10 CONCLUSION

This thesis introduces a DDA system into the Divinity: Original Sin 2 and tries to control the player's tension in a turn-based singleplayer game with two dimensions: "Uncertainty" and "Emotional Significance."

Respectively, "Uncertainty" is controlled by the DDA enemy spawn logic, and the "Emotional Significance" is controlled by the inventory level with inflow and outflow actions.

This thesis proved that the DDA approach is effective in controlling player tension and provide a similar experience for players with different skill levels.

It is worth noting that different players will have different definitions of tension groups, a combat with tension level 0.6 might be categorized as a 'mid tension combat' by some players, but others might consider it as a 'high tension combat'.

Also, players tend to have different emotional significance among the same factors. For example, some players will feel more tension than others when their inventory level decreased below a certain threshold. (for example, 50% whole team health)

11 REFERENCES

[1] Zohaib, M., 2018. Dynamic difficulty adjustment (DDA) in computer games: A review. *Advances in Human-Computer Interaction*, *2018*.

[2] Csikszentmihalyi, M., Abuhamdeh, S., and Nakamura, J., 1990. Flow.

[3] The Divinity Original Sin 2: Definitive Edition, Larian Studio, 2017

[4] Robin, H. and Vernell, C., 2004. AI for dynamic difficulty adjustment in games. In Proc. of the Challenges in Game AI Workshop, Nineteenth National Conf. on Artificial Intelligence, San Jose.

[5] Toward a general psychological model of tension and suspense, L, Moritz, K, Stefan, Front Psychol. 2015; 6: 79.

[6] Zohaib, M., 2018. Dynamic difficulty adjustment (DDA) in computer games: A review. *Advances in Human-Computer Interaction*, *2018*.

[7] Csikszentmihalyi, M., Abuhamdeh, S., and Nakamura, J., 1990. Flow.

[8] Toward a general psychological model of tension and suspense, L, Moritz, K, Stefan, Front Psychol. 2015; 6: 79.

[9] Toward a general psychological model of tension and suspense, L, Moritz, K, Stefan, Front Psychol. 2015; 6: 79.

[10] Larian.game. (2018). *Scripting - Divinity Engine Wiki*. [online] Available at: https://docs.larian.game/Scripting [Accessed 11 Feb. 2020].

[11] Toward a general psychological model of tension and suspense, L, Moritz, K, Stefan, Front Psychol. 2015; 6: 79.

[12] Robin, H. and Vernell, C., 2004. AI for dynamic difficulty adjustment in games. In Proc. of the Challenges in Game AI Workshop, Nineteenth National Conf. on Artificial Intelligence, San Jose.

[13] Csikszentmihalyi, M., Abuhamdeh, S., and Nakamura, J., 1990. Flow.

[FIGURE 1] Robin, H. and Vernell, C., 2004. AI for dynamic difficulty adjustment in games. In Proc. of the Challenges in Game AI Workshop, Nineteenth National Conf. on Artificial Intelligence, San Jose.

[FIGURE 2] Edited by Tianmou 'Jayden' Zhang, 2020, based on Csikszentmihalyi, M., Abuhamdeh, S., and Nakamura, J., 1990. Flow.

[FIGURE 3] A image chart created by Tianmou 'Jayden' Zhang demonstrating the intended tension level, 2020

[FIGURE 4] A level papermap created by Tianmou 'Jayden' Zhang demonstrating the intended tension level, 2020

[FIGURE 5] A screenshot taken by Tianmou 'Jayden' Zhang demonstrating the design of crates in the Divinity: Original Sin 2 Definitive Edition, Larian Studio, 2017

[FIGURE 6] A screenshot taken by Tianmou 'Jayden' Zhang demonstrating the design of crates in the Divinity: Original Sin 2 Definitive Edition, Larian Studio, 2017

[FIGURE 7] Robin, H. and Vernell, C., 2004. AI for dynamic difficulty adjustment in games. In Proc. of the Challenges in Game AI Workshop, Nineteenth National Conf. on Artificial Intelligence, San Jose.

[FIGURE 8] A image chart created by Tianmou 'Jayden' Zhang demonstrating the predetermined inventory level, 2020

[FIGURE 9] A chart created by Tianmou 'Jayden' Zhang demonstrating the result of test data, 2020

[FIGURE 10] A chart created by Tianmou 'Jayden' Zhang demonstrating the result of test data, 2020

[FIGURE 11] A chart created by Tianmou 'Jayden' Zhang demonstrating the result of test data, 2020