

**Variables adjusted by a Dynamic Difficulty System & Their
Relationship With Player Engagement**



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Abstract

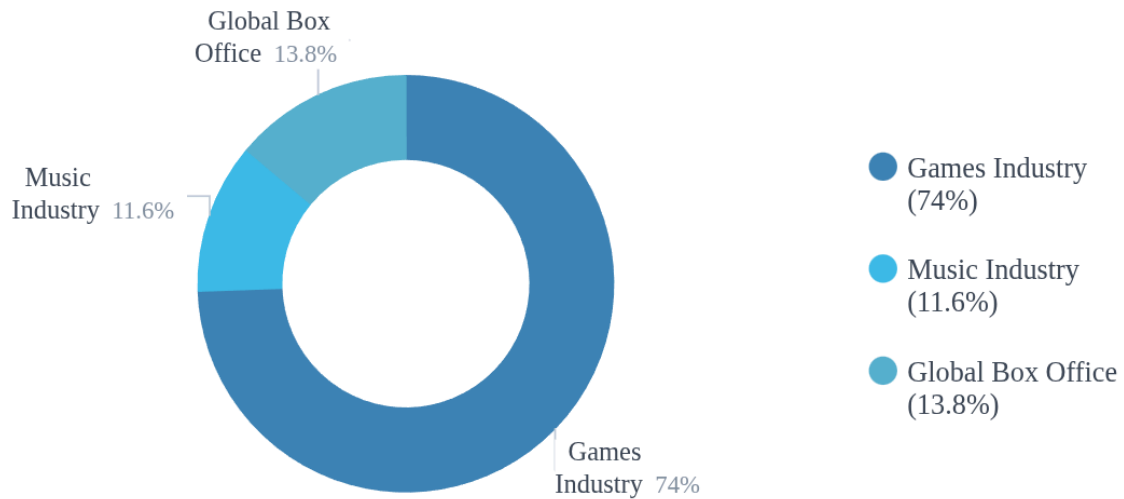
Despite extensive literature on Dynamic Difficulty Adjustment (DDA), a little amount of research examines which specific variables adjusted by a DDA system produces measurable differences in engagement. This study investigates and compares two variables (Amount of Zombies and Zombie Health) adjusted by DDA and their differences and outcome on engagement overall. Eight participants were divided into two groups, with subjective data and game statistics being analysed using the Mann-Whitney U test and Spearman's correlation. Results indicated that the amount of zombies produced higher flow, immersion and enjoyment scores. While health adjustment, reported higher frustration. On the contrary, perceived challenge was equally felt between the two groups. Findings were interpreted through Flow Theory, GameFlow, Bartle's Taxonomy and Self-Determination Theory, which suggested the emotional and type of difficulty matters just as much as the intensity of difficulty. While small sample sizes limited the reliability of findings, this study dives into the possibility that DDA design should consider not only how difficulty is scaled but what variable is being used and why.

Introduction

Games Overall

In 2024, State of Gaming report showcases the scale of the industry with 3.38 billion gamers, with a market value of \$184 billion. Outranking the music industry (\$28.6 billion) and global box office (\$33.9 billion) combined, despite making up less than 5% of advertising spend (Media Cat, 2024). With analysis on a 3.4% growth year on year (Michiel Buijsman, 2025). This insight provides evidence that games must be entertaining to outrank industry giants. But what really makes them fun?

Market Values



Appendix A - Adapted from Media Cat (2024)

What Defines Fun?

Ryan Barone (2025) suggests that fun is relative and often viewed in comparison to your available options. For example, remove your kids from their rooms in front of a nurtured game of Uno, they'll most likely be disengaged and find it boring. Now take those same kids out in a cabin in the wilderness with no Wifi, no games, no computers and all of a sudden Uno becomes the best thing around. This suggests that fun comes from your availability in your environment and that games transport us to new realities capable to shape the players interests and fun in a game.

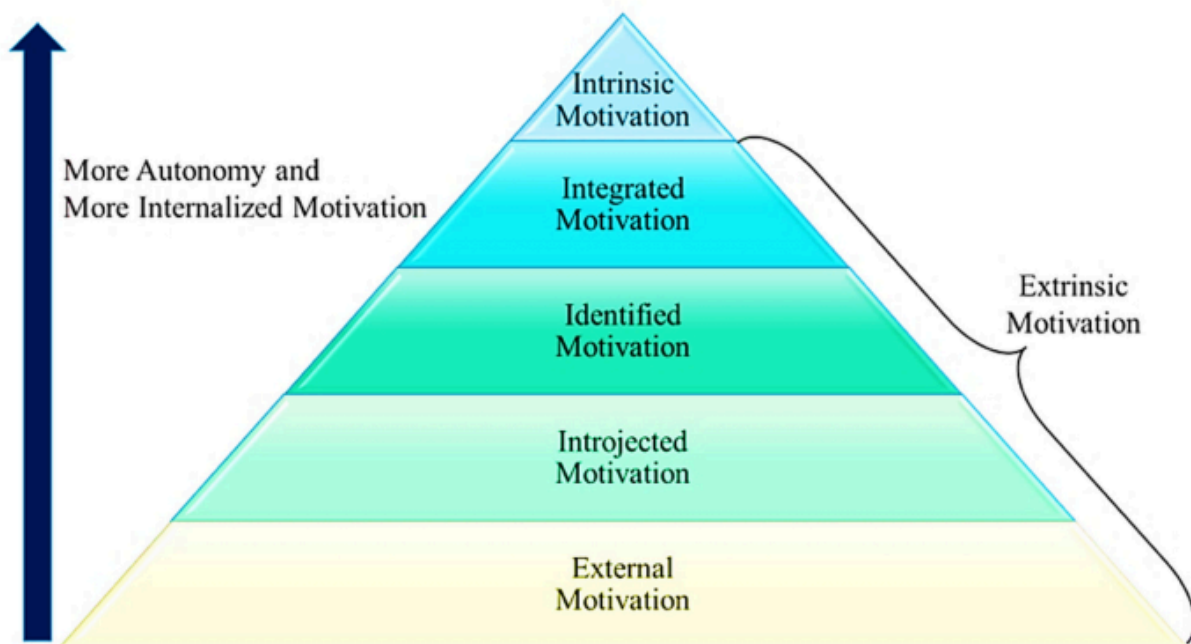
Furthermore Ryan Barone (2025) goes on to suggest that games satisfy our needs to achievement and recognition, keeping us interested with challenge which complements the skills of the player.

Research

Self Determination Theory

A common theory known as self determination theory (SDT) goes over the three core needs of human motivation: achievement, agency and social validation. A games maintained engagement through challenge directly satisfies the intrinsic needs for three core human motivators producing prolonged play and persistence.

SDT places motivation on a spectrum (Seen in **Appendix B**), intrinsic motivation and extrinsic motivation. Intrinsic motivation is fueled by doing something because it's enjoyable and fun. External motivation is doing something for a reward or to avoid problems. Internal motivation leads to better outcomes with links to persistence and overall engagement. (Ryan & Deci, 2000).



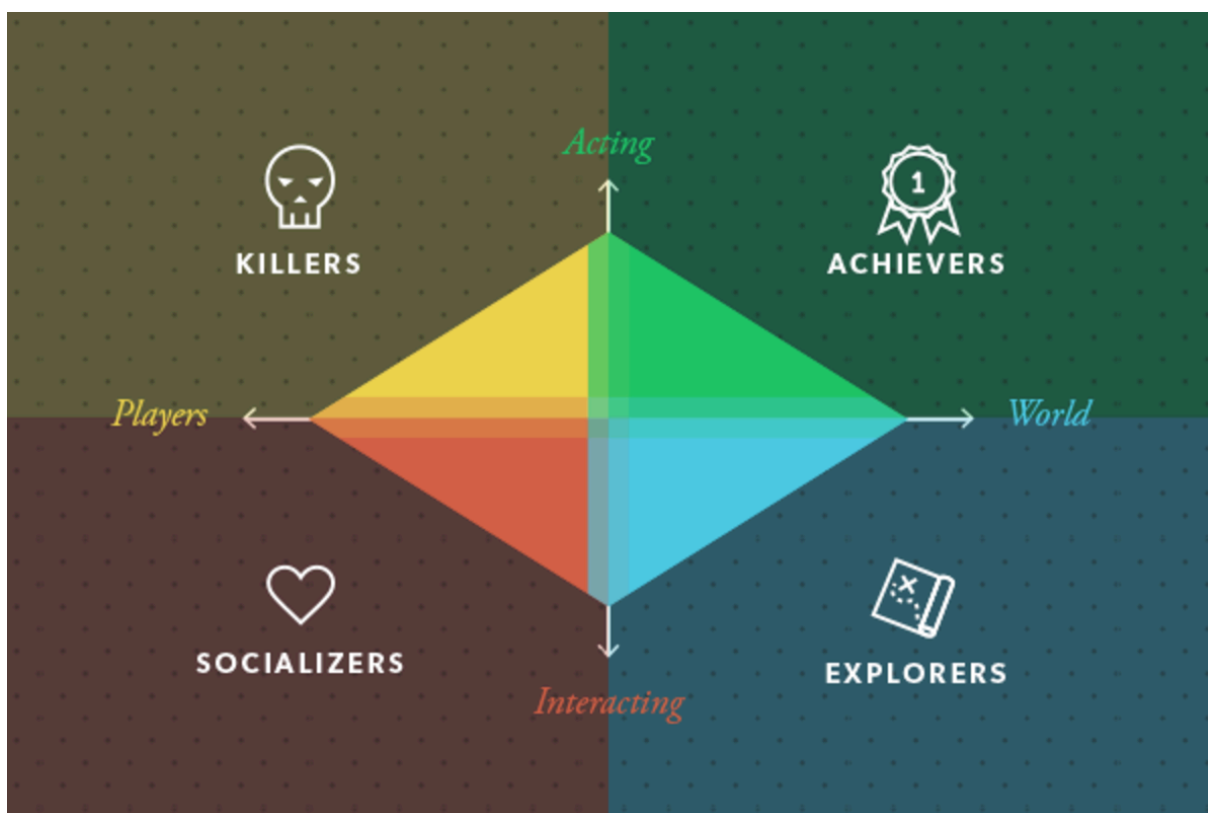
Appendix B (Nishimura & Joshi, 2021)

Richard's Player Taxonomy

Richard A. Bartle (2003) proposes a framework that allocates player types based on their motivations. Bartle (2003) identified four distinct player archetypes:

- ◆ Achievers
- ◆ Explorers
- ◆ Socialisers
- ◆ Killers

These types are laid out on a quadratic graph, this distinguishes a preference for acting on the world vs interacting with it and the second being player orientated vs world orientated.



Achievers

Achievers are often characterised by their drive to complete quests, advance through levels and hoard in game rewards. For this player type to flourish markers of progress can intrinsically motivate these types.

Explorers

Explorers orient towards discovery of the world, their engagement doesn't lie with winning but pushing boundaries and mechanics. These types of players often develop vast knowledge of the game they play, in rare cases often exceeding those of the original designers.

Socialisers

Socialisers are often the largest group, their participation in games are to build relations with other players. The game functions less of a challenge to overcome but a social platform.

Killers

Killers are labelled by their desire to overcome other players, satisfying their needs from the defeat of others. Bartle (2003) noted this was the least prevalent type. However this type of player may be much more common in modern gaming as games have shifted to a PvP focused route such as games like:

- ◆ Counter Strike 2
- ◆ PUBG: Battlegrounds
- ◆ Marvel Rivals
- ◆ Arc Raiders
- ◆ Rust

All games mentioned are PvP with hints of PvE focused, and are all at least top 10 ranking currently (Steam Charts).

Overall Bartle (2003) notes that player's do not occupy rigid categories but rather blend across different types depending on many factors. This suggests a player can fall under an achieving killer or an exploring socialiser and much more.

Flow Theory

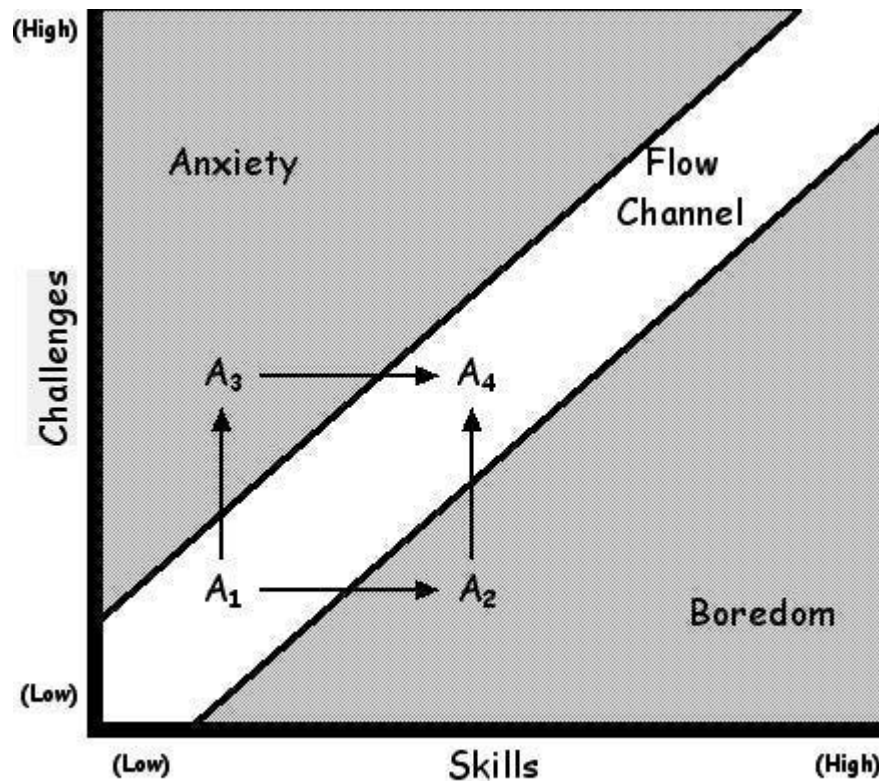
Flow theory, cited as the "Optimal Engagement" by researcher Mihaly Csikszentmihalyi, conducted with extensive research into what makes experiences enjoyable. Flow is said to be a experience so "gratifying that people are willing to do it for it's own sake, with little concern for what they will get out of it, even if it's difficult or dangerous" (Mihaly Csikszentmihalyi, 1990).

Flow contains eight key elements:

- ◆ A task that can be completed
- ◆ The ability to focus on the task
- ◆ The focus is possible because the task has clear goals
- ◆ That focus is possible because the task gives immediate feedback
- ◆ The ability to have a sense of control over actions
- ◆ An effortless involvement that removes awareness of frustrations of day to day life
- ◆ Concern for self disappears, but afterward a stronger sense of self manifests
- ◆ A sense of time is different / untracked

These eight key elements causes a deep sense of enjoyment that is so rewarding that people are willing to expend a great amount of energy just to reach flow (Mihaly Csikszentmihalyi, 1990).

Furthermore a requirement for achieving flow is the challenge of the task must closely match the individuals skill level (Appendix D). Mihaly Csikszentmihalyi suggests, that flow is most likely to happen in activities that present clear goals, feedback and require focused cognitive load with a set of well structured rules (Mihaly Csikszentmihalyi, 1990).



From *Flow: The Psychology of Optimal Experience* by Mihaly Csikszentmihalyi (page 74)

Appendix D (Mihaly Csikszentmihalyi, 1990)

Additionally the task at hand must be intrinsically rewarding, as mentioned in previous research SDT (Self Determination Theory). SDT tells us intrinsic motivation individuals engage in the task for their own sake rather than extrinsic goals. Games often present this with challenge, experience and progression.

Flow overall has been applied to a wide range of specialties since it's such a broad concept applicable to almost anything. However there is no widely accepted model of player engagement in games, there are elements such as game interface, mechanics, gameplay and narrative. These all lack a distinct single model for engagement in games.

Flow Theory Expanded: GameFlow

GameFlow a model developed by Penelope Sweetser (2005) for evaluating player enjoyment in games, drawing in heuristics from scattered pieces of research like, Disposition theory, Flow Theory and Transportation theory have all been proposed to explain enjoyment and engagement in activities.

While these models focus on specific aspects, they lack comprehensive explanations for enjoyment. Flow theory's model provides a universal perspective, focused on the concentration on task heavy objectives as it's main element. Flow serves as the foundation for GameFlow, a model made to validate player enjoyment in games. Flow, described as an experience that is gratifying that individuals engage in it for it's own sake based on the previously mentioned key eight elements.

GameFlow adapts this concept into distinct concepts:

- ◆ Games need to maintain player concentration through challenging tasks.
- ◆ Tasks should be challenging yet achievable with player's skill.
- ◆ Clear goals and feedback on task completion are essential for player engagement.
- ◆ Skill, clear goals and feedback together provide a sense of control to the player.
- ◆ Immersion in the game leads to a loss of awareness of reality and alters time perception.
- ◆ Social interaction, though not direct element of flow, it greatly impacts player enjoyment and is extensively discussed in literature.

Breaking these down we can filter down into a checklist like structure to effective fun in games. A game must capture: concentration, control, challenge, player skills, clear goals, feedback, immersion and social interaction.

Elements like concentration, player skill, social interaction and immersion are up to the player to meaningfully engage. Whereas control, challenge, clear goals and feedback are all provided by the game itself. Fulfilling all key elements will make for an engaging enjoyable experience.

Dynamic Difficulty History

Fisher & K. Kulshreshth (2025) explains players come with vastly differing skill levels, gaming experience and daily mood. An easy game might feel dull, a game too hard becomes frustrating. Fixed difficulty fail to meet these needs, DDA provides a versatile solution by adapting gameplay in real time based on player performance.

A good experience is representative of a game designer using play testing to iterate on the design manually and polish the experience until flow can be achieved. However, as previously mentioned this fails to capture a wide audience as players have different flow states.

SDT (Self Determination Theory) has strong links with DDA solutions as by adjusting the challenge of the game to the player's skill it directly supports the competence of the player. This reinforcement of the player's developing skill is required for maintaining engagement further feeding into their intrinsic needs.

History of Dynamic Difficulty

Arcade Machines

Adapting game difficulty traces back to 1970s and 1980s. These games featured mechanics which adjusted on the fly, not to benefit the player but for commercial reasons. As players survived longer games like Space Invaders and Tetris increased it's speed and complexity of enemies. These adjustments kept gameplay fresh and unique, breaking the monotony and nudged players towards a quicker demise while playing. This encouraged repeat play, with the financial interest of constant spending to get a newer high score.

Arcade games are seen as primitive compared to the new titles released today, but these system introduced a new key idea, "challenge can and should respond to player behaviour". This real time reaction from the game laid the seeds of modern adaptive difficulty systems, even if it was driven by capital gain rather than user experience Fisher & K. Kulshreshth (2025).

Bringing Games To The Home

As games became more mainstream transitioning from the arcade to the home, developers began offering personalised experiences also known as "Fixed difficulty" settings. This came into the form as Easy, Medium or Hard as a way to give players more control. This drove in more longer player and narrative driven experience. However this was under the assumption the player knew how hard the game would be before playing. This assumption would prove limiting for new and experienced players Fisher & K. Kulshreshth (2025).

Modern Games And DDA

One modern example of a distinct DDA system would be Left 4 Dead 2's AI Director 2.0. This system controlled enemy spawns, item placement, map paths based on player stress, health and speed. This system was the game master, ensuring a unique experience that increased in difficulty when the players were doing well and provides relief whenever they are overwhelmed.

This system overall paced the game dynamically monitoring a "Stress" level. This was accumulated with a group of statistics like:

- ◆ Proximity to Zombies
- ◆ Zombie Kills
- ◆ Damage Taken

This stress level would adjust the frequency of hordes and special infected spawn rate to create an intense yet manageable experience. This freshness made the game unpredictable when it came to random encounters, extending playtime greatly.

The AI director also adjusted things like environmental changes beyond just spawning zombies. It would modify map layout, including placing barriers (cars, debris and blockades) to alter the pathing of players as well as changing the game's atmosphere by changing lighting and weather.

Items and resources would be placed dynamically providing more resources whenever the team is struggling to assist them. It would also limit them if players are already doing well.

Overall Left 4 Dead 2's AI Director is a gold standard example of good DDA, often praised for it's ability to encapsulate player's in deep flow.



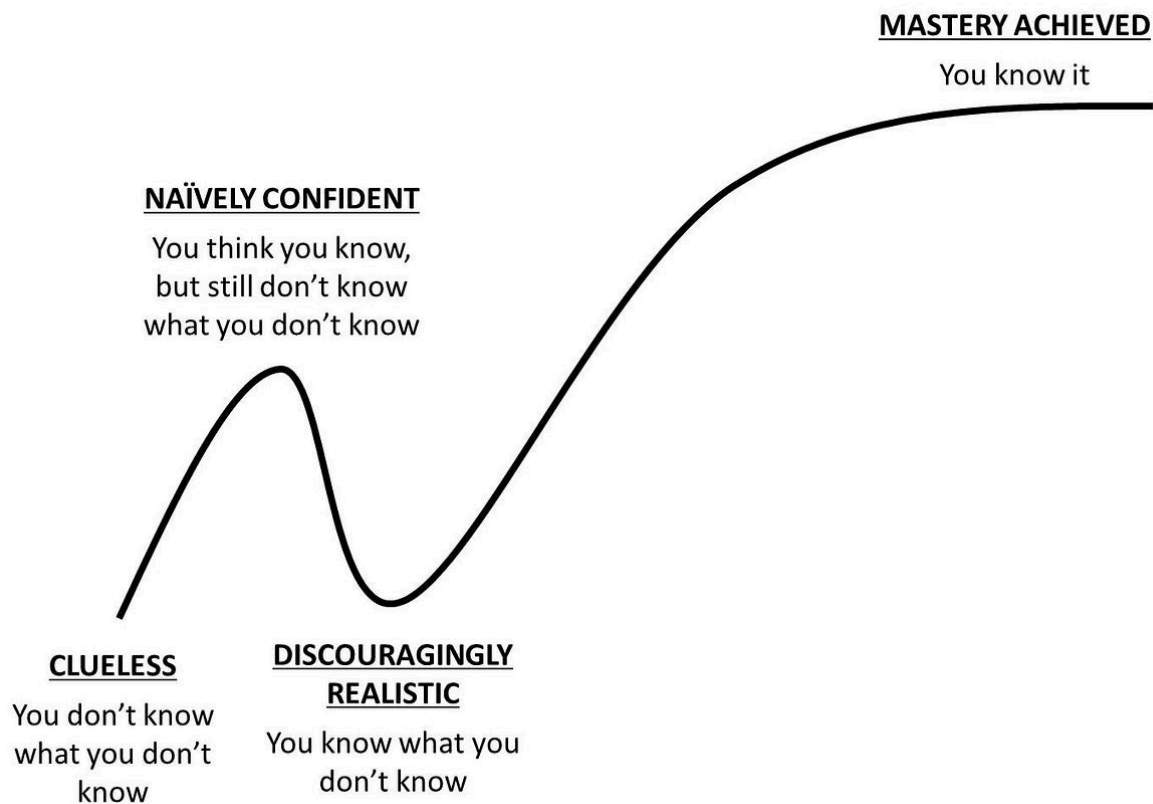
Appendix E (HCI Games Group)

Learning Curves

In the gaming sphere, the phrase "Learning Curve" is often brought up when a discussion regarding a challenging game is critiqued for being too hard. A learning curve is often displayed as a graph which represents the relationship between how proficient someone

may become at a given task and the amount of experience (Volkovas et al., 2019).

This links back to the GameFlow model above. Elements provided by the game: challenge, clear goals and feedback are all variables that shape the learning curve a player experiences, the player may also shape their own learning curve based on their own motivations and goals. Difficulty can then be defined as the amount of skill required to accomplish a goal in the experience.



Appendix F (Vin Clancy, 2017)

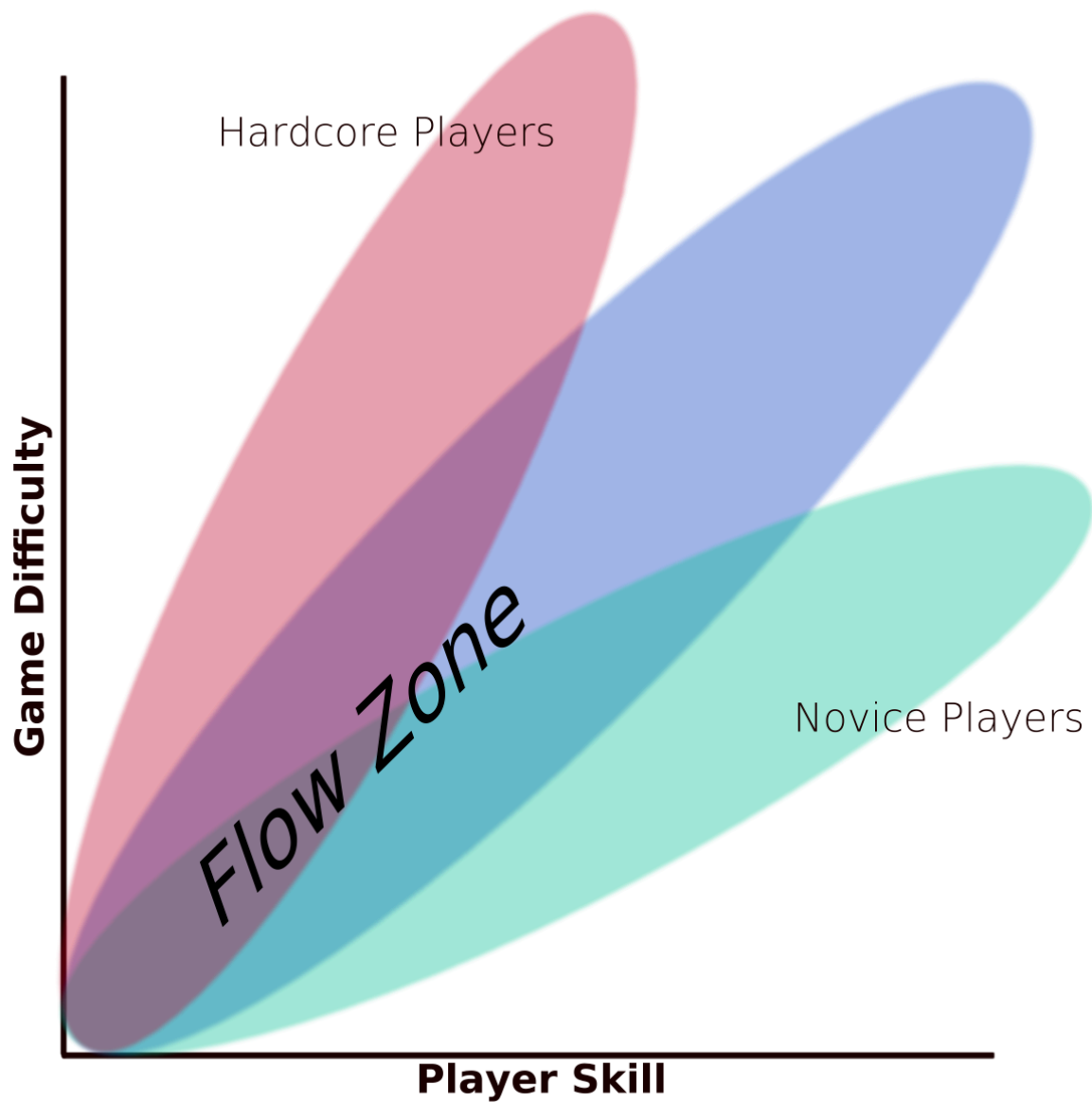
Introduction to Dynamic Difficulty Adjustment (DDA)

Dynamic Difficulty

Traditionally game designers came up with fixed methods, "Easy", "Medium" or "Hard". But this one size fits all approach doesn't capture the full range players require.

These outliers require a flexible adaptive system that responds to individual needs. A DDA solution offers promise. Rather than locking players in fixed challenge levels, DDA adjusts the game in real time. Tailor made difficulty can help players be much more engaged in the game, this is further corroborated with previous research showcasing the relationship between challenge and player skill further engaging players.

This graph represents the types of players you may find, with their varying flow ranges being different from one another, depending on the type of player. DDA can adjust the game difficulty respectively to the players own flow zone.



Different Players Flow Zones

(Chen, 2007) *Image adapted from Chen's own work*

Potential Downsides

Unlike fixed difficulty, DDA systems require time and effort from design and programming to achieve effectively. Failing to hide the difficulty changes can lead to player disappointment with some expressing DDA as "Cheating" as the "Challenge" doesn't feel real

(Denisova & Cairns, 2019). SDT (Self Determination Theory) explains that human motivation is driven by three core ideas, one of which is achievement, which can be tarnished with the thought of the game babying the player.

Whenever player's are aware of the DDA system, they may exploit it's assistance against it. Racing games had the term "Rubber Band" adjustment where the AI may not respond in time causing a noticeable jump in difficulty, breaking immersion and allowing players to "game" the system with pacing exploits (Robin Hunicke, 2005).

Overall this requires a full proof DDA method that actively assist the player, but isn't noticeable and runs without the player's knowledge. Done correctly can produce a result where player's flow state is easily enabled and prolonged throughout play.

Fixed Difficulty

Fixed difficulty refers to select modes or none at all, with studios like FromSoftware making difficult games without the option to change it, however traditionally modes like "Easy", "Medium" or "Hard" usually suffices. These options scale the game's challenges throughout relying on the design for added difficulty as the player adjusts and learns. Research suggests this is quite a viable option as SDT (Self Determination Theory) showcases giving a player agency and choice can often support and become a major motivator.

Potential Downsides

Fixed suffers when the player's learning curve far exceeds the intended design of the game, creating a boring and disengaging experience. Player's have also been cited to feel more immersed when they know the world around them is changing in difficulty based on their actions (Denisova & Cairns, 2019), this is backed up by GameFlow, as this feedback from the game can further engage the player. As mentioned fixed modes like "Easy", "Medium" or "Hard" not fitting outliers can often deter gamers from prolonged engagement (Fisher & K. Kulshreshth, 2025).

SDT (Self Determination Theory) showcases two types of motivation, intrinsic motivation and extrinsic. Player's may feel pressured or extrinsically motivated to selected a harder difficulty so they may showcase their skills, however player's may not be up for the challenge and can cause them to disengage.

Overall fixed difficulty is perfect for quick development with the aim of balance being done during the design / play testing phase and to never be touched, but can fail when experienced players or even quickly adapting players play.

Types of DDA Metrics

DDA is effected by a metric which scales the difficulty accordingly. Well known types are performance based and physical real life reactions using EEG, heart rate and facial expression monitors.

Performance Based

Performance based DDA is the most common implemented form. In essence it measures player statistics ranging from health to player position. Variables adjusted by the performance based system often include enemy spawn rates, health values, damage output, projectile speed and quick time events.

Early performance based methods adjusted enemy behaviour based on player success rate, creating the foundation that still underpins most modern implementations. Examples like Resident Evil and Left 4 Dead were pioneers in using DDA to enhance the player experience by adjusting challenges such as enemy AI behaviour, spawn rates and combat intesnity based on player performance (Milijana Komad, 2023).

However, limitations exist, performance alone does not capture insight into the player's own psychological state. A frustrated player can achieve a high score without enjoying the experience. While performance based DDA is straightforward, it neglects emotional needs of the player limiting the ability to sustain engagement. Going further into the research performance based DDA will be used.

Physiological And Emotional Metrics

However, unlike performance based DDA which infers player state from what they do, physiological and emotional DDA attempts to measure what they feel. Well established measuring methods for gathering data regarding "feel" are as follows:

- ◆ Heart Rate (HR)
- ◆ Galvanic Skin Response (GSR)
- ◆ Heart Rate Variability (HRV)
- ◆ Electrodermal Activity (EDA)

On the other hand these don't capture enough of the complex human feel, and can only measure specific aspects of emotion. A spike in arousal could indicate excitement or frustration and the system wouldn't be capable of reliably discerning from the two (Croissant et al., 2023).

Practical issues arise with this type of DDA, in order to gather these metrics players must use biometric sensors which are often intrusive. This can lead to a loss of immersion during play and overall engagement.

This type of DDA has promise with recording player feel, however it's harder to use personally and requires setup unlike performance based DDA which is baked into the game's code. Furthermore with it's inability to recognise the difference between being excited or scared makes appropriate changes difficult.

Research Gap

Recent Research And Gaps

Literature surrounding DDA captures the system as a whole, failing to inspect which elements drive engagement more than others. This piece of research aims to answer which select variables effected by DDA promote player engagement more than others, scoring which is most effective.

Development

Prototype Design

The prototype will be developed as a simple wave based zombie shooter, in which the player must survive as long as possible. A waved base structure was selected due to it's ability to provide incremental feedback and reward, defined by a clear goal to survive. This is critical requirements for flow to occur. Penelope Sweetster's (2005) GameFlow model requires an activity to have clear goals and immediate feedback, and lastly to maintain balance between player skill and challenge. A survival waved based shooter satisfies all three of these conditions, waves provide clear goals, continuous feedback and the DDA system works to maintain the challenge vs skill balance as the player improves over time.

Why Zombies?

Zombies were chosen as the enemy for participlal reasons. Their AI is simple to implement and easily understood, and with most media portraying zombies with hordes and group behaviour aligns with wave based encounters. Pair that with an already successful title like Left 4 Dead 2 and their AI director it shows a game like this is viable for a good DDA solution and testing.

Dynamic Difficulty Adjustment

For this prototype the DDA system will control two adjustable parameters, zombie spawn amount and zombie health. These were selected as the DDA's ability to adjust difficulty. This keeps complexity down overall. Other parameters were thought about like, horde size, movement speed and strength. But due to scope and keeping development and testing simple those will have to be sidelined.

At the end of each wave the DDA system will refresh, using the player's statistics during the previous wave it'll determine the difficulty for the upcoming wave. Hunicke (2005) goes on to suggest that without special consideration, difficulty adjustment risks

disrupting the player's immersion. This is further backed up by previous research on the potential flaws of a DDA system. Adjustment on a per wave basis unlike real time often align with player expectation of the zombies getting stronger each wave, keeping them immersed throughout and not hitting a random power spike while fighting.

Resources

Previously mentioned aspect of the prototype being, survival shooter. Resources are required to be managed, those being: health regeneration and ammo. Health regenerates over time when the player isn't taking damage, this regeneration rate is adjustable by the DDA system. Ammo is gained by going to crates at certain randomly spawned locations. These two resources were picked intentionally, research into DDA shows that difficulty enhanced engagement, but only when the player can process and respond. Research showcases by limiting the resources it reduces the cognitive load on the player, lowering the risk of disengagement. Too many resources to track may lead to frustration and anxiety.

Player Statistics

For the DDA system to adjust the challenge we'll need to calculate the player's current "Skill" level. These statistics were used to carry out that task:

- ◆ Damage taken (Reduces Difficulty)
- ◆ Zombie kills per minute (Increases Difficulty)
- ◆ Shot accuracy (Increases Difficulty)
- ◆ Damage dealt (Increases Difficulty)

Each statistic will carry a weight that contributes to the final adjusted difficulty or variable also known as "Skill". DDA systems relies on feedback using these statistics. Feeding these into models that adjust variables such as enemy health and spawn rate can achieve our goal of maintaining flow, reducing boredom and frustration.

Mechanics

The games mechanics must be interesting to encapsulate the player in a flow like state and make the game's goals achievable. Penelope Sweetser (2005) suggests the game must provide four elements:

- ◆ Control
- ◆ Challenge
- ◆ Clear goals
- ◆ Feedback

Mechanically to create an experience that captures the player in a flow state it'll need to satisfy all these requirements.

Shooting And Running - Control

In order for the player to take on incoming zombie waves, they're given a gun to shoot and the ability to sprint. These two mechanics directly satisfy Sweetser's (2005) requirement for control, giving the player a method of agency over their survival. The ability to reposition during large waves, prevents the experience from feeling overwhelming and giving the player a sense of ownership in their current situation while keeping the challenge present.

Wave Structure - Clear Goals And Challenge

Zombies arrive in sets of waves in increasing sizes. This provides the player with a clear and immediate goal each round, survive the wave. This satisfies both the challenge and clear goals required in GameFlow's model. Each wave is a small objective that the player can work toward, preventing frustration. The DDA system then works using this wave structure, adjusting the zombie spawn rate and zombie health between waves to ensure the challenge remains matched to the player's assumed "Skill" level.

Health Regeneration And Wave Counter - Feedback

Health regeneration activates after the player avoids damage for a set duration, this provides positive feedback based on good performance. When the player is playing well and avoiding being hit, health is given, rewarding the player for good play. Additionally feedback is provided through the UI, showing the player their current wave number. This feedback loop keeps the player informed of their overall performance without interrupting their flow, directly satisfying Sweetser's (2005) requirement for feedback.



The above image displays the prototype, with wave, health and ammo being three distinct UI elements, meanwhile zombies charge at the player. Green boxes displayed as ammunition scattered around the arena

Methodology

Research Design

Subjective Data

Flow is a subjective experience, this creates a challenge when it comes to recognising when flow has been achieved metrically (Martin & Jackson, 2008). Given the subjective nature the most common way to measure flow relies on self reporting methods rather than performance data alone.

Flow research relied on a semi structured interviews and experience sampling where participants documented their experiences during or immediately after a task (Lonczak, 2021). While these provide rich qualitative insight, they interrupt play, directly breaking flow.

To address this, researchers developed a validated self report scales post session. Dubbed the Flow State Scale 2 (FSS-2) developed by Jackson & Eklund (2002), it measures flow mapped to previously mentioned Flow Theory's elements. Furthermore The Game Experience Questionnaire (GEQ) was developed in the context of games, measuring immersion, competence, flow and tension using Likert scale responses (Fitzgerald et al., 2020). Both tools are widely used in DDA research as they capture the subjective experience without interrupting play.

This study adopts similar methods, with questions drawn from GEQ to measure participant engagement and flow state. This allows findings to be compared against existing research while remaining in scope for this study.

Factual Data

While self report methods like GEQ capture how player's felt, they fail to capture what players did. To address this, the study adopts a mixed methods approach, combining quantitative gameplay data with subjective self report data to construct a picture of the player's engagement.

Gameplay statistics are recorded automatically by the DDA system throughout play. The metrics capture include: session length, kills per minute, shot accuracy and waves survived. These statistics cover objective signs of engagement. Prolonged play and constant kill rate suggests the player was challenged and motivated to keep playing, aligning with previous research on Flow Theory's requirement that challenge must closely match player skill. Furthermore drops in accuracy may indicate the difficulty exceeding the player's skill level, pushing them to frustration, exiting flow.

These quantitative metrics are cross referenced against participants GEQ scores. This is used to strengthen the confidence in the findings and to point out contradictions. This combined approach is consistent with methods used in existing DDA research where performance data alone is considered insufficient to capture the full player experience (Croissant et al., 2023).

Questionnaire

Participants were asked questions using Google Forms. GEQ uses a 5 point Likert scale from 0 (Not at all) to 4 (Extremely).

Participants were asked the following questions:

Bartle's Taxonomy:

- ◆ What type of player are you (Select Two):
 - ◆ Killer
 - ◆ Socialiser
 - ◆ Achiever
 - ◆ Explorer

Flow And Immersion:

- ◆ I forgot everything around me
- ◆ I lost track of time

Challenge:

- ◆ I felt skillful
- ◆ I felt challenged
- ◆ I had to put a lot of effort into the game

Frustration:

- ◆ I felt frustrated
- ◆ It felt like a struggle

Enjoyment:

- ◆ I enjoyed the game
- ◆ I found it tiresome

These questions provided by GEQ directly correspond to the anxiety and boredom zones which are present in Flow Theory. A participant who reports high frustration scores along side poor performance would suggest the difficulty exceeded their skill level, pushing them out of flow. On the other hand, high boredom scores with strong performance metrics would suggest the challenge was insufficient for the participant.

This study is designed to investigate which variables adjusted by a Dynamic Difficulty system have the strongest relationship with participants engagement. A between subject design will be employed during testing to avoid carry over effects from each test. Exposure to different versions of the game may influence their perception of other versions, introducing bias (Raluca Budiu, 2023).

Participants

(8 Participants)

■ = Experienced Gamers
■ = Average Gamers



DDA - A

(4 Participants)



DDA - B

(4 Participants)



With a prototype featuring little adjustments like variable weighting to test engagement, it may not be as conclusive to a participant who may have experienced the experiment before. Participants were informed about what data is collected and they're reassured that no personally identifiable information would be stored, making all responses to surveys and game data honest and away from personal scrutiny.

Data Gathering

General Data Protection (GDRP) it gives the study a guideline how to approach handling data. Techniques like, data minimisation, only collect necessary data, anonymisation, removing identifying information, enhancing honesty and participant protection. Lastly, consent. Testing participants unwillingly can lead to ethical concerns (GDRP EU, 2019).

To ensure this piece of research follows GDRP, data was gathered from participants using google forms and gameplay data. Game sessions only recorded the screen with no audio or camera.

Effective data resides as a combination of quantitative data (what the players did statistically) and qualitative (why they did it) to create an overview of the player experience. Google forms will be employed as my qualitative data method and the game being my quantitative.

Furthermore the participants are told the google forms will only be checked after everyone has finished testing, this allows participants to be honest and truthful during their answers without the worry of the researcher linking anonymised data to them.

Participants

Who Are The Participants

The study itself was shared via word of mouth outreaching to friends to take part, data was collected in a period of 5 days with a collective of 8 participants. Participant were a mix of average to proficient gamers ranging from ages 18-25.

Why These Participants

Participants were chosen to be only gamers due to small sample size of 8 participants proves to be a problem, scoping the study down into an audience who are more likely to encounter the system will provide more telling results.

Procedure

This study was conducted by sending participants an executable version of the game. Before participants could take part, all .exe file names were named identically as to prevent the participant from drawing conclusions causing bias.

Participants were encouraged to play the game in their own time, without the researcher's presence. This allowed the participants to fully immerse themselves in the game without any outside interference. At the end of the testing period participants were asked to fill the google form, this allowed the fresh experience not to leave their mind afterward.

Furthermore, participants weren't told they're testing a dynamic difficulty solution but just playing a zombie FPS, and their goal is to survive as long as possible. Research states a good DDA system is one that isn't noticed, telling participants about the involvement defeats the point and may lead to increase exploitative behaviour.

Ethics - PLESI

Professional Issues

Developers are required to create balanced and engaging experiences. DDA system need thoughtful design and time to avoid being noticed by players. A poorly implemented DDA system can undermine the player's trust in the game. Testing such a system must be thorough to ensure the system responds correctly across all varying skill levels without being detected.

Legal

Data collected from participants during testing must comply with GDPR. This study records gameplay statistics and anonymous survey responses from google forms, with no personally identifiable information stored.

Ethical

Participants are deliberately not informed that they are testing a DDA system to prevent bias influencing results and behaviour during play. This is mild deception, which is often standard for behaviour game research. To address this, participants are fully debriefed at the end of the session, informed of the deception and why it was required. An ethics form was completed (See **Appendix H**).

Social

DDA systems have a wider implication for how players experience challenge and achievement in games. There is a social debate around whether adaptive difficulty undermines genuine skill, however, on the other hand making it more accessible to wider audiences including less experienced players.

Results

Raw Data

This is the data collected across the two DDA conditions during the study. Group A consisted of participants playing the prototype with zombie spawn rate only adjusted by the DDA system, while Group B consisted of participants playing with zombie health only adjusted by the DDA system.

Subjective Data

Table 1: Group A Quantitative Results (Zombie Spawn Rate)

Question	P1	P2	P3	P4	Mean
<i>I forgot everything around me</i>	3	3	4	2	3
<i>I lost track of time</i>	3	2	2	2	2.25
<i>I felt skillful</i>	3	3	2	2	2.5
<i>I felt challenged</i>	3	2	3	3	2.75
<i>I had to put a lot of effort in</i>	2	2	3	3	2.5
<i>I felt frustrated</i>	1	1	2	2	1.5
<i>It felt like a struggle</i>	1	2	2	2	1.75
<i>I enjoyed the game</i>	4	3	3	3	3.25
<i>I found it tiresome</i>	1	1	1	2	1.25
What type of player are you?	Killer	Explorer	Achiever	Socialiser	Achiever

Responses recorded on a 0-4 Likert scale 0 - (Not at all) 4 - (Extremely).

Table 3: Group B Quantitative Results (Zombie Health)

Question	P1	P2	P3	P4	Mean
<i>I forgot everything around me</i>	2	2	2	1	1.75
<i>I lost track of time</i>	2	2	1	1	1.5
<i>I felt skillful</i>	3	2	2	1	2
<i>I felt challenged</i>	3	3	3	3	3
<i>I had to put a lot of effort in</i>	2	3	3	4	3
<i>I felt frustrated</i>	2	2	3	3	2.5
<i>It felt like a struggle</i>	2	2	3	3	2.5
<i>I enjoyed the game</i>	3	3	2	2	2.5
<i>I found it tiresome</i>	1	2	2	3	2
What type of player are you?	Achiever	Explorer	Killer	Killer	Achiever

Responses recorded on a 0-4 Likert scale 0 - (Not at all) 4 - (Extremely).

Table 3: Group A & B Averages by category

Averages	Flow & Immersion	Challenge	Frustration	Enjoyment
Group A	2.5	2.6	1.75	2.88
Group B	1.75	2.88	2.5	2.38

Factual Data

Table 4: Group A Quantitative Statistics (Zombie Spawn Rate)

Game Statistics	P1	P2	P3	P4
Session Length (Min)	14	13	11	10
Kills (Per min)	13	10	11	11
Shot Accuracy (%)	67	50	42	46
Waves Survived	26	29	19	23

Table 5: Group B Quantitative Statistics (Zombie Health)

Game Statistics	P1	P2	P3	P4
Session Length (Min)	13	12	10	9
Kills (Per min)	10	12	9	9
Shot Accuracy (%)	61	47	53	39
Waves Survived	25	21	19	17

Baseline Analysis

Group A (Zombie Spawn Rate) outperformed group B on flow and enjoyment. Furthermore they scored higher on flow and immersion (2.50 vs 1.75 Mean results), enjoyment (2.88 vs 2.38 Mean results) and less frustration overall (1.75 vs 2.50 Mean results). This suggests by adjusting the number of enemies compared to higher health enemies creates a more rewarding experience overall.

Game statistics showcase Group A players survived slightly longer and played slightly longer sessions compared to Group B.

Data Analysis Methods

In order to examine whether zombie spawn rate or zombie health produced stronger engagement outcomes, this study aims to employ a combination of quantitative and visual analysis.

Mann-Whitney U Test

Comparing engagement scores between the two groups, a Mann-Whitney U test was used. This test works by comparing every participant's score in Group A against every participant's score in Group B, counting how many times each group scores higher. This was chosen due to the data being based on a Likert scale, making it more suitable for a standard average comparison (Elliot McClenaghan, 2022).

Flow And Immersion

Group A, whose zombie spawn rate was adjusted by the DDA, reported higher flow and immersion scores (Median = 3) compared to Group B, whose zombie health was adjusted instead (Median = 2). This suggests that spawn rate adjustment could be more effective at producing conditions needed for flow to occur. GameFlow (2005) showcases the need that the challenge must closely match the player's own skill for flow to take place. Adjusting the number of enemies scales the challenge with amount, which seems to feel more responsive compared to each enemy being harder to kill. Furthermore Flow Theory (1990) identifies a loss of time as a key indicator for flow, this is showcased in Group A's higher score.

Challenge

Group B reported similar challenge scores (Median = 2.5), Group A (Median = 2.5). This suggests both DDA solutions were successful in creating meaningful challenge. Fisher & K. Kulshreshth (2025) explains that a good DDA system must avoid making the game feel either too easy or too hard, as this may cause a reduction in engagement. Similar scores indicate that both groups were within a good difficulty range, even if the type of difficulty isn't the same.

Frustration

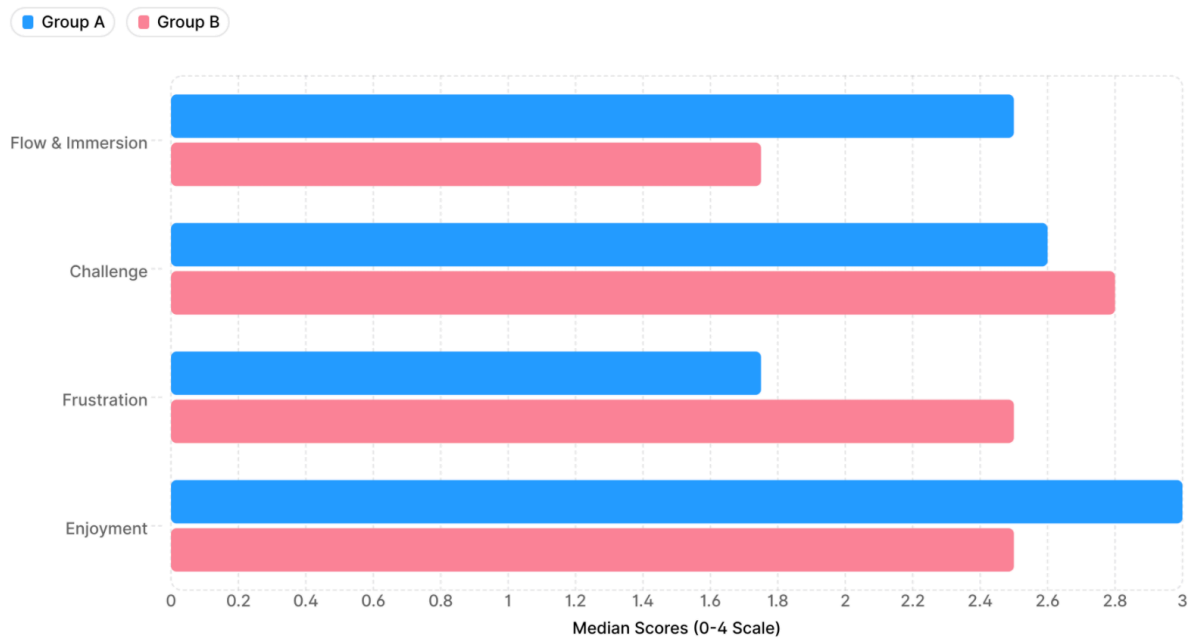
As challenge was evenly matched, it goes on without saying that Group B reported higher frustration scores (Median = 2.5) compared to Group A (Median 2). When zombie health increased, player's were required to put more effort into a single kill without any change in pace, which may feel unrewarding. This is highlighted by Left 4 Dead 2's AI director, which calculated the player's stress to ensure difficulty was kept intense but manageable. Group B's higher frustration score suggests that the higher health on zombies may have pushed players out of flow state. SDT (2000) supports this, as players may feel undermined of their perceived control of outcomes during play when zombie become more unkillable.

Enjoyment

Group A's enjoyment reported higher scores (Median = 3) compared to Group B (Median 2.5). SDT (2000) suggests players feeling competent and in control contributes to enjoyment. Adjusting the number of enemies may feel more rewarding than increasing health, as player's can still achieve kills at a familiar rate rather than feeling like each enemy is a grind. Bartle (2003) further supports this, suggesting players who fall under the achieving or killer type may find more enjoyment defeating more weaker enemies, giving a faster sense of progression and dominance. Given the nature of the prototype being a zombie shooter with survival as it's main goal, it's within reason to suggest that achiever and killer types were likely prevalent, making higher spawn rate DDA more satisfying.

Summary

Overall Appendix G compares the median engagement scores for both groups across all four dimensions. Group A consistently reported higher scores on flow and immersion and enjoyment, while Group B reported higher scores on challenge and frustration, most notably on the frustration part where the difference between the groups is the largest, comparable to flow and immersion.



Appendix G

Spearman's Correlation

To explore the relationship between the game's statistics and player's overall engagement, a Spearman's correlation was conducted across all eight participants. The Mann-Whitney test, which tests two groups against each other, this type of data analysis examines whether performing better in the game links to feeling more engaged. Furthermore similar types of data analysis like Pearson's correlation wasn't chosen due to the small sample size and the data being based on a Likert scale.

Wave Survived And Enjoyment

A correlation was found between waves survived and enjoyment scores, suggesting that players who survived longer tended to report higher enjoyment. This aligns with SDT (2000), which argues when a player feels competent which contributes to enjoyment. Players who survived longer felt a greater sense of achievement making the experience overall more enjoyable regardless of which DDA solution they participated in. Group A's participants survived longer waves on average than Group B, which aligned with the higher enjoyment scores.

Kills Per Minute and Flow

A moderate upward correlation was found between kills per minute and flow, suggesting that players eliminating enemies at a faster rate tended to cause the players to feel more immersed.

Shot Accuracy And Challenge

Shot accuracy showed a small upward correlation, challenge scores suggests that accuracy of the player had little relationship of how the challenge felt. This finding suggests that the challenge in the prototype was driven less by shooting performance but more so by the pressure of the situation, like the volume of enemies. Csikszentmihalyi (1990) suggest that challenge isn't just about skill but overall cognitive load on the task at hand.

Session Length And Frustration

Session length showed a negative correlation with frustration scores. Players who played for longer tended to report less frustration. This suggests that the DDA must have been working as intended, as it can draw from much more data. Players who engaged enough to keep playing were less likely to feel annoyed, while those who stopped early may have found the game to be more difficult. Fisher and Kulshreshth (2025) tell us that a well made DDA system should keep the player in a state of engagement throughout without tipping into frustration. The correlation suggest this was achieved for some participants more than others.

Furthermore learning curves could've played a role in the player's ability to sustain themselves throughout longer play sessions as they become more familiar with the game.

Results Analysis

With both Mann-Whitney U Test and Spearman's correlation, a pattern emerged suggesting that zombie spawn rate adjustment produced stronger engagement overall compared to zombie health adjustment. Group A reported higher scores on flow, immersion,

enjoyment while reporting less frustration than Group B. Group B reported higher challenge scores alongside the higher frustration, this suggests that increasing zombie health may have pushed players beyond their flow zones, reducing enjoyment and flow.

Spearman's correlation further supports this, showing that players who performed better by surviving more waves and achieving higher kill rates, reported stronger engagement scores across the multiple stated dimension. This suggests that the DDA system was more effective at maintaining the skill to challenge balance.

Discussion

This study's goal was to examine variables adjusted by a DDA system had a different effect on engagement overall. Two selected variables were zombie spawn rate and zombie health. Based on the results and analysis the spawn rate adjustment scored higher on engagement. Zombie health adjustment produced higher levels of frustration despite having similar levels of perceived challenge. This showcased variables selected for adjustment by a DDA system is not about the challenge aspect, but the player's experience.

Spawn Rate Being More Engaging

One finding in the analysis highlights Group A's zombie spawn rate, which showed stronger engagement scores than Group B. This is important because both groups reported similar levels of challenge, meaning the difference in engagement was not the results finding the game more difficult, but the type of difficulty.

Bartle's Taxonomy (2003) explains why spawn rate felt more satisfying for this player base. Given that the prototype was a zombie shooter with survival as the primary goal, it's reasonable to suggest that achiever and killer types were prevalent during play. Furthermore Richard Bartle (2003) reinforces this idea as the type of player is defined by context and mood. Facing a higher volume of weaker enemies feeds directly into the motivations of these types of players, producing a more frequent reward experience compared to spending more time on a single high health enemy.

SDT (2000) helps explain why zombie health produced more frustration. SDT argues that feeling competent and in control is a fundamental intrinsic motivator. Undermining this motivation may lead to less engagement, as shown in the play time. When zombie health is increased, players must use more effort per kill without any meaningful change in pace. This creates a feeling where the player is working harder but not feeling more capable, this undermines the feeling of competence that SDT identifies as a source of engagement.

Study Limitations

This study has a few limitations regarding researcher being present, small sample size and the isolation of DDA elements.

Sample size of 8 participants split into a pair of 2 groups to test isn't sufficient to produce concrete results also known as statistical significance. Statistical significance is often referred as the probability that the results are by chance. As a result the study cannot 100% represent how a higher sample size outcome, however this doesn't invalidate the results given, as current findings should be labelled as exploratory.

Furthermore participants played the prototype without the researcher present, while beneficial for reducing observer bias, it means there was no way to monitor or verify the conditions in which the participants played. Some factors like device used, environmental distractions and mood on the day they tested could have influenced results.

The study also tested only two DDA variables, which were isolated. In reality DDA systems often adjust multiple variables simultaneously. This produces a more versatile and responsive experience. Testing only two variables may not properly reflect how DDA with variables would behave.

Future For This Project

The future if this piece of research was to be further developed would benefit from larger sample sizes, allowing for statistical power needed to draw conclusive results. Furthermore a wider range of DDA variables should also be explored like:

- ◆ Enemy Speed
- ◆ Weapon Damage
- ◆ Wave Timers

Future studies should also consider recruiting and categorising participants using Bartle's Taxonomy (2003). This study suggests that player type may meaningfully impact how DDA is perceived.

Conclusion

This study overall produces early evidence that variables selected for a DDA system to influence isn't only just the level of difficulty the player will experience, but the emotional quality and type of difficulty. Spawn rate adjustment produced more engaging and enjoyable experience for participants compared to zombie health adjustment, despite producing similar levels of perceived challenge.

These findings align with already established theories like Flow Theory, Self Determination and Bartle's Taxonomy, suggesting that DDA systems design shouldn't only consider how difficulty is being adjusted but what is being adjusted and why.

Appendix

Appendix H - Ethics Form

UNIVERSITY OF HUDDERSFIELD
SCHOOL OF COMPUTING AND ENGINEERING

PROJECT ETHICAL REVIEW FORM

Applicable for all research, masters and undergraduate projects

Project Title:	Variables Adjusted by a Dynamic Difficulty System & Their Relationship with Player Engagement
Student:	Christian Beffield
Course/ Programme:	Game Development (Production)
Department:	SCEN
Supervisor:	Abu Berat
Project Start Date:	01/11/2026

ETHICAL REVIEW CHECKLIST

	Yes	No
1. Are there problems with any participant's right to remain anonymous?	<input type="checkbox"/>	<input checked="" type="checkbox"/>
2. Could a conflict of interest arise between a collaborating partner or funding source and the potential outcomes of the research, e.g. due to the need for confidentiality?	<input type="checkbox"/>	<input checked="" type="checkbox"/>
3. Will financial inducements be offered?	<input type="checkbox"/>	<input checked="" type="checkbox"/>
4. Will deception of participants be necessary during the research?	<input type="checkbox"/>	<input checked="" type="checkbox"/>
5. Does the research involve experimentation on any of the following?		
(i) animals?	<input type="checkbox"/>	<input checked="" type="checkbox"/>
(ii) animal tissues?	<input type="checkbox"/>	<input checked="" type="checkbox"/>
(iii) human tissues (including blood, fluid, skin, cell lines)?	<input type="checkbox"/>	<input checked="" type="checkbox"/>
6. Does the research involve participants who may be particularly vulnerable, e.g. children or adults with severe learning disabilities?	<input type="checkbox"/>	<input checked="" type="checkbox"/>
7. Could the research induce psychological stress or anxiety for the participants beyond that encountered in normal life?	<input type="checkbox"/>	<input checked="" type="checkbox"/>
8. Is it likely that the research will put any of the following at risk:		
(i) living creatures?	<input type="checkbox"/>	<input checked="" type="checkbox"/>
(ii) stakeholders (disregarding health and safety, which is covered by Q9)?	<input type="checkbox"/>	<input checked="" type="checkbox"/>
(iii) the environment?	<input type="checkbox"/>	<input checked="" type="checkbox"/>
(iv) the economy?	<input type="checkbox"/>	<input checked="" type="checkbox"/>
9. Having completed a health and safety risk assessment form and taken all reasonable practicable steps to minimise risk from the hazards identified, are the residual risks acceptable (Please attach a risk assessment form – available at the end of this document)	<input type="checkbox"/>	<input checked="" type="checkbox"/>

STATEMENT OF ETHICAL ISSUES AND ACTIONS

If the answer to any of the questions above is yes, or there are any other ethical issues that arise that are not covered by the checklist, then please give a summary of the ethical issues and the action that will be taken to address these in the box below. If you believe there to be no ethical issues, please enter "NONE".

NONE

STATEMENT BY THE STUDENT

I believe that the information I have given in this form on ethical issues is correct.

Signature:  _____ Date: 20/04/2026





AFFIRMATION BY THE SUPERVISOR

I have read this Ethical Review Checklist and I can confirm that, to the best of my understanding, the information presented by the student is correct and appropriate to allow an informed judgement on whether further ethical approval is required.


Signature: Abu Berat _____ Date: 06/05/2026


References


Tools / Assets Used:


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- <https://www.adobe.com/express/>  - Visual Creation
- <https://visualize.graphy.app/>  - Graph Maker
- <https://sketchfab.com/3d-models/free-stylized-dark-fantasy-zombie-v1-9e8ec26242d3467ca75314a84c43eb24>  - Zombie Model
- <https://infimagames.gumroad.com/l/fps-tutorial-source-files>  - FPS Template


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