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SANTA CRUZ

**THE SCIENCE OF LEVEL DESIGN:
DESIGN PATTERNS AND ANALYSIS OF PLAYER BEHAVIOR
IN FIRST-PERSON SHOOTER LEVELS**

A dissertation submitted in partial satisfaction
of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

COMPUTER SCIENCE

by

Kenneth M. Hullett

September 2012

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ABSTRACT

Kenneth Hullett

The Science of Level Design: Design Patterns and Analysis of Player Behavior in First-Person Shooter Levels

Level designers create gameplay through geometry, AI scripting, and item placement. There is little formal understanding of this process, but rather a large body of design lore and rules of thumb. As a result, there is no accepted common language for describing the building blocks of level design and the gameplay they create. This dissertation presents a set of level design patterns for first-person shooter (FPS) games, providing cause-effect relationships between level design patterns and gameplay. These relationships are explored through analysis of data gathered in an extensive user study.

This work is the first scientific study of level design, laying the foundation for further work in this area. Data driven approaches to understand gameplay have been attempted in the past, but this work takes it to a new level by showing specific cause-effect relationships between the design of the level and player behavior.

The result of this dissertation is a resource for designers to help them understand how they are creating gameplay through their art. The pattern collection allows them to explore design space more fully and create richer and more varied experiences.

DEDICATION

When playing a game, the goal is to win, but it is the goal that is important, not the winning.

- Reiner Knizia

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CHAPTER 1

INTRODUCTION

Level designers create gameplay through geometry, AI scripting, and item placement. There is little formal understanding of this process, but rather a large body of design lore and rules of thumb. As a result, there is no accepted common language for describing the building blocks of level design and the gameplay they create. This research creates a science of level design based on design patterns for first-person shooter (FPS) levels and data analysis to show cause-effect relationships between level design patterns and gameplay.

Level design is often viewed as an artistic endeavor, so the applicability of purely scientific approach may be considered controversial. This research argues that level designers employ design patterns while creating FPS levels, whether advertently or inadvertently. Furthermore, analysis of gameplay data can show distinct patterns of behavior in different situations. If we control for all factors besides the design of the level, we can claim that significant observed differences are due to the level design.

To show these cause-effect relationships, we conducted a user study and performed analyses of the collected data. The user study explores what effects the patterns, and variations within the patterns, have on players' in-game behavior. Based on

deviations from the expected results, we are able to adjust the theory, improving our understanding of the relationships, and increasing the usefulness of the taxonomy as a tool for level designers. For each pattern explored in depth, we created multiple instances of the pattern, each with a different set of affordances – for example, with a sniper location, some instances were high, some low, some with good cover, some without, etc. Based on our surveys of existing FPS level design, we expect a lower sniper location to have less of an effect on the level’s pacing; we should observe less of an effect than we would when subjects encounter a higher sniper location. These instances are placed in the user test levels played by the subjects. From the data collected during the user study we can determine how gameplay is affected by the pattern, and if this is different from what we expect.

This research is necessarily reductionist in its approach. In practice, design patterns are rarely distinct, instead overlapping with other patterns or elements to create varied effects. Nonetheless we will argue that design patterns provide a useful analytic framework for thinking about level design in a scientific way. The lowest possible segmentation of level design elements, the actual placement of individual walls, floors, items, and entities, is far too granular to elicit any understanding of designer intent or to observe an effect on player behavior. The highest level, a complete level, is far too coarse, as FPS levels generally contain multiple subareas with different gameplay objectives. Design patterns are a small enough unit that a clear distinct

purpose can be elicited, but not so small as to be overwhelmed with details of pixel-by-pixel placement of objects and geometry.

1 THE FIRST-PERSON SHOOTER GENRE

FPS games are combat-oriented games where the player engages other characters with a variety of projectile and melee weapons. The player navigates a 3D world while looking through the eyes of the main character (i.e., a first-person point of view), though some games where the camera follows the player character (third-person shooter or TPS) have similar gameplay and are generally considered to be in the same genre.

FPS games are one of the most popular genres of commercial digital games, with many published titles on multiple platforms. Seven of the top-ten all-time best-selling games for the Xbox 360 are FPS games [1]. Due to the processing power needed to render realistic-looking 3D environments, FPS games are often credited as a driving force behind technological advancement in personal computers and gaming consoles.

Beyond entertainment, FPS games have been used for a variety of training and other serious game applications. One of the most notable is America's Army [2], a training and recruitment game released by the US Army [3]. Its intent is to provide a realistic simulation to familiarize recruits with modern Army combat procedures. The platform has been used as the basis for more advanced Army training programs.

As a popular and broadly relevant genre, any research that improves our understanding of FPS games is likely to have significant impact. There is also a large body of in-depth analysis which can be drawn upon, including books and articles on FPS design in general and level design specifically. While the results of this study are specific to FPS games, the techniques we propose are generalizable to other game genres.

FPS games are also a desirable genre for this study as the level design is a major component of the game and has a significant impact on the player's experience. Levels in commercial games are designed largely by hand and play tested extensively by designers to create specific gameplay effects. It would be difficult to conduct research of this nature on a genre of games where the level design was not as impactful. Furthermore, while the player's experience is by the level design, the mechanics of the game allow for enough variation in individual choice that these impacts are apparent.

For this research, we have chosen to focus on single-player levels, though multiplayer is increasingly becoming the dominant gameplay mode. In multiplayer, players are generally playing against other players, rather than environmental challenges created by the designer. For this reason, it would be more difficult to conduct an experiment like the one described here for multiplayer levels. However, it is likely that level

design does have an impact on gameplay in multiplayer FPS. Early exploration of patterns specific to multiplayer level design is described in Appendix A.

2 LEVEL DESIGN

The precise definition of a level varies by game and genre, but it is generally thought of as a subdivision of a game. Specifically, it is a space where gameplay occurs. While the mechanics of the game define the choices available to the player, the design of a level defines what the player experiences at any given point. It is through level design that level designers craft gameplay experiences for players.

Levels for FPS games are generally designed for single- or multi-player play, but not both. Single player levels tend to be a linear sequence of challenges the player must overcome to reach the final goal, whereas multi-player levels are designed to create areas for player-vs.-player combat to occur.

While level geometry is the most noticeable aspect of the level designer's work, other considerations are important in the creation of gameplay. Level designers place objects in the world, including weapons, ammunition, and power-ups. They must be sure to provide enough so the player can complete the level, but not so much as to remove all challenge. They also place Non-Player Characters (NPCs), both friendly and enemy, and use AI scripting to control their behavior.

When designing an FPS level, there are many factors the designer must consider, including challenge, pacing, and ease of navigation. Though many FPS games have been made, and numerous books have been written on the subject [4][5][6][7], there is little formal understanding of their level design. The existing literature conveys design lore and industry practice without exploring how levels create gameplay.

Experienced level designers draw from their extensive knowledge of existing games when they create a level. They have an intuitive feel for what features they should include in a level to create different types of gameplay. They may imitate and adapt elements they've observed in other levels. Presently, there is no structured way for experienced designers to pass on this knowledge to less experienced designers. A more formal framework would improve designers' abilities to communicate design ideas as well as provide a reference for possible features to incorporate into levels.

For example, one of the design patterns identified is a sniper location (see Chapter 3). This is an elevated position from which a character can engage other characters in relative safety. There are numerous variations on sniper locations, including their height, amount of cover available, and whether it is intended for use by either the player or an enemy NPC. The effect of an enemy NPC-occupied sniper location is to slow the pace of the level – the player must move slowly and be more cautious to avoid taking fire. While we can predict this behavior based on our understanding of FPS gameplay, it is unknown if the effect is consistent in all cases, or how it is

affected by variation within the pattern. Would the effect be less if the sniper location was lower, as it would be easier for the player to engage the enemy NPC? User tests where a number of subjects play levels with different instances of sniper locations will provide empirical evidence of these relationships.

The taxonomy of design patterns is a useful tool for improving designers' abilities to communicate design ideas and as a reference for possible features to incorporate into levels. However, the process by which it was created is necessarily subjective. Designers' intentions in using certain features may vary, and how players react to the patterns may vary.

3 DESIGN PATTERNS

As described above, our user studies are focused on single player levels. While we have explored design patterns in both multi- and single player levels, level design necessarily has a greater impact on single player gameplay, as the players' only interaction is with the environment, rather than with other players. As such, this research is primarily focused on the design patterns developed from analysis of single player levels. The patterns are described in terms of their intended use, effect on gameplay, and variations within the pattern. Examples from popular commercial games are given.

The use of design patterns to describe levels is inspired by design patterns used in both software engineering and architecture (the latter of which also inspired the former) [8][9]. A set of design patterns form a language for describing design practices in the domain. Duffy et al. [10] characterize patterns in software engineering by the following:

- “Noticing and naming the common problems in a field of interest,
- Describing the key characteristics of effective solutions for meeting some stated goal,
- Helping the designer move from problem to problem in a logical way, and
- Allowing for many different paths through the design process.”

This research adapts these characteristics to the domain of level design in FPS games. For level designers the problem is creating an entertaining and engaging experience for the player, and the solution is in how they design the level. We adapt the above to define characteristics of a pattern language for the domain of level design, described in detail below:

- **Noticing and naming common structures that produce specific types of gameplay**

The taxonomy presented in this dissertation was created by identifying design patterns in levels and the gameplay they produce. Examining existing levels and

inferring the intended gameplay is the most common means of identifying design patterns, but other methods were employed, including interviewing designers about how they design to elicit certain types of gameplay and reading books and articles that describe common practices.

- **Describing the key characteristics of these structures and how they affect gameplay**

In identifying the patterns, we noticed that significant variations exist within any given pattern, and those variations have an impact on the gameplay produced. As examples of patterns are identified, variations and their effects are noted, resulting in a more complete detailed view of the pattern and its parameters.

- **Helping the designer address level design concerns in a logical way**

Armed with knowledge of level design patterns, the designer can tailor a level to the desired gameplay. For example, if a designer wants to change the pace of a level, they can add or alter instances of patterns that are known to affect pacing. If, during gameplay tuning, they discover a problem in a level, they can use the taxonomy to modify existing patterns to address the issues.

- **Allowing for different approaches to create the desired gameplay**

The taxonomy identifies different design patterns that will affect gameplay in similar ways. If the designer wants to create a certain type of gameplay, they can identify multiple elements in the taxonomy that would be suitable, and pick one that is appropriate for that instance. They are not limited to repeatedly using the same patterns in the same ways; they can use different patterns, or variations with patterns.

4 RESEARCH QUESTIONS

The goal of this research is to use data analysis to develop the science of level design through a deeper understanding of FPS level design and how it creates gameplay. The research questions can be broken down into questions about design patterns, player behavior, and the applicability of the work.

- **RQ1: Are level design patterns useful for developing levels, communicating ideas, and teaching about level design?**

We have already identified level design patterns to create a language for describing levels. The application of design patterns to FPS levels and the patterns themselves are described in Chapter 3. These descriptions provide insight into the designer's intent and the gameplay that will result.

It should be possible to take an existing level and describe it extensively in terms of design patterns. We give an example with a level from Bioshock [11], a popular

commercial FPS. Such description often reveals sections of a level that are not describable with the existing taxonomy, leading to the elicitation of a previously undescribed pattern. Through study of FPS levels we can improve and expand the pattern collection.

Besides expanding the pattern collection, it is important to validate the effects of the patterns. The results of this study have helped close the loop and improve the descriptions of the patterns and their gameplay effects. The end result of the study is a set of patterns that has been shown to create specific behavior in the player.

- **RQ2: Can we use data analysis to understand player behavior in FPS levels?**

To test the cause-effect relationship of the patterns and their variants on gameplay, it is necessary to understand player behavior. What exactly does it mean, for example, when the tension of a level is increased? How is this reflected by the player's in-game actions? Can this be observed and reported? While previous user studies provide some guidance, it was necessary to develop methods for identifying and classifying player behavior.

How this was done in this research is described in Chapter 5. Subjects' in-game behavior was studied in the video recordings of their level play-throughs and the logged gameplay data. This was correlated with the pattern variants that the subjects encounter to see what the effects are.

- **RQ3: Do the identified design patterns and their variants create the intended gameplay effects?**

Patterns are used in levels to affect gameplay – for example, when a player encounters a choke point where they have an advantage over enemy NPCs, the expectation is for increased pace and reduced challenge. This should be reflected in the player’s behavior by traits such as engaging enemy NPCs more aggressively, using weapons more frequently, making less use of cover, and moving more quickly. In validating these relationships, we are developing the science of level design. Chapter 5 describes the user study we ran to explore these cause-effect relationships and Chapter 6 explains the results of the analysis.

If the expected behavior occurs when a player encounters a design pattern variant in a level, then the theory is validated. In the example above, when the player encounters the choke point, their behavior should be close to our expectations. If for some variation of the choke point, they instead begin moving more slowly and playing cautiously, then there is something about that instance that is creating different gameplay. We can identify what affordances of the pattern vary from other instances and adapt the pattern description to match the observed results.

To fully explain the impact of this research, this document is broken into multiple chapters. Chapter 2 covers related work in the existing literature on level design and data analysis in games. Chapter 3 presents the taxonomy of design patterns that we

have developed for this research. Chapter 4 explains the major sources of data in games and their impact on game development. Chapter 5 describes the user tests performed, and Chapter 6 details the results. Chapter 7 summarizes the findings and the contributions of the research.

CHAPTER 2

RELATED WORK

There are three broad streams of work related to this research. First, previous work on applying design patterns to games in general and level design specifically. Second, previous work on exploring, understanding, and communicating about level design in general, mostly from an industry perspective. Third, previous work on understanding player behavior and how data analysis can be used to identify such behavior. These three areas are described below.

1 DESIGN PATTERNS

The use of design patterns to better understand levels is inspired by their use in software engineering [9], which were in turn inspired by design patterns in architecture [8]. Kreimeier was among the first to adapt the concept of design patterns to the domain of digital games by identifying game design patterns [12].

Björk et al. extend this work by studying how players interact with games and how entities in a game interact with each other [13]. They identify over 200 patterns in game design ranging from the basic building blocks of games, such as the game world, to abstract concepts like player collaboration and immersion. The patterns are organized in broad categories such as “Patterns for Goals” and “Patterns for Narrative Structure.” Patterns are described in terms of how they are used, the choices a

designer must make when using them, their consequences and relationships to other patterns. These patterns do not specifically deal with level design, but do relate to some level design concerns, such as balancing, goals, locations, and objects.

For example, one pattern identified by Björk et al. is **Pick-ups**, described as “elements that exist in the game world and can be collected by players.” They go on to describe how pick-ups are used in a variety of games and the considerations a designer must make when choosing whether to include them or not. They describe general consequences of pick-ups, but they do not describe the immediate effects they have on a player’s behavior or the flow of a game. The level design patterns presented in this dissertation address these considerations.

Björk et al. suggest four ways patterns can be used to support game design: idea generation, structured development, solving design problems, and communication. The level design patterns identified in this dissertation support these same uses.

Another application of design patterns to games is Plass et al.’s study of educational games [14]. They identify common patterns in educational games that increase enjoyment and engagement in players. These are high-level conceptual goals for designers to pursue, not patterns of mechanics as in Björk et al.’s work, or patterns of level design as presented in this dissertation. Examples include “Constructing things is fun and helps learning” and “Time and resource constraints make games fun and

can improve learning.” These patterns were discovered through observational studies and interviews with children playing educational games.

2 LEVEL DESIGN

There are many books on level design written from an industry perspective. They discuss common practices and provide instruction on tools for aspiring level designers. In his book, Co takes the reader through the process of designing an FPS level, from brainstorming initial ideas, building the level using Unreal Editor, to testing and improving the level [6]. While useful references, neither this work, nor similar books by Bryne [4], Clayton [5], or Feil et al. [7] present deep analysis of how level design creates gameplay.

For example, Feil et al. describe the importance of overall pacing in a level. They discuss how a rhythm of rising and falling tension can contribute to the overall flow of a level without providing methods for creating these effects. Similarly, they discuss strategic considerations of terrain, such as access and height advantage, but do not discuss how they create gameplay. In contrast, the work presented in this dissertation provides specific, concrete idioms of level design described in terms of their direct impact on gameplay.

Several shorter works examine single aspects of level design, from both academic and industry perspectives. The aspects examined can be broadly categorized as relating to

gameplay – pacing, tension, and challenge – or space – spatial configurations and how the player navigates.

2.1 PACING

Pacing is the density of actions taken by the player in a level. Coulianos proposes methods to analyze and improve level pacing [15]. Designers can plot the expected pacing as a sequence of gameplay elements. Playtesting can then be used to see how closely the player's experience matches the designer's expectations, leading to a series of iterative changes until the designer is satisfied.

Davies also explores aspects of level pacing and suggests techniques designers can use to control pacing [16]. For example, the player's impetus to move is a key aspect of game pace, which the designer may want to increase or decrease. Movement impetus can be increased by elements such as a time limit or a threat from behind, or decreased by an obstacle or NPC interaction.

2.2 TENSION

Tension is the mental strain a game can create in the player as they struggle to survive or complete objectives. Level designers use tension to affect pacing. For example, NPCs can create tension by urging the player to move through the level faster. Its use is examined in depth by Wright [17], who conducted a study with subjects playing one of three levels that used NPCs to create tension differently. Completion times as well as the subject's subjective impressions were compared to evaluate the methods.

He found that urgency imparted from a friendly NPC was the most effective method, while chasing or being chased by enemy NPCs were less effective.

2.3 CHALLENGE

In his study of what makes games fun, Malone identified three main elements: challenge, fantasy, and curiosity [18]. All three of these are useful to level designers, but challenge is the most critical. Malone found the best way to create challenge is to provide clear goals whose attainment is uncertain. If the goal is unclear, the player will become frustrated. If the goal is too easy to attain, the player will become bored. Furthermore, if the goal is long range, there should be feedback given to the player that communicates progress towards the goal.

2.4 SEGMENTATION

Segmentation is a broad concept that can be applied to the examination of levels both in terms of gameplay and space. It refers to methods for breaking down aspects of the game into smaller elements. Zagal et al. [19] describe three types of segmentation: temporal, spatial, and challenge. Temporal segmentation is closely related to pacing, as increasing or decreasing the length of time allowed for gameplay can affect tension and challenge. In terms of spatial segmentation, levels themselves are a form of this, but they can be segmented internally as well. As a player moves into a distinct section of a level, their behavior may be affected. For example, moving into a large arena with enemy NPCs will increase tension and difficulty. The third type of segmentation,

challenge, also relates to pacing. Breaking up the challenges presented to the player allows the designer to control the level pace.

2.5 SPATIAL CONFIGURATIONS

Within spatial segmentations, the configuration of the environment is also a key concept in level design. Chen et al. compares level design to the architectural design that is used in real world buildings [20]. When designing a building, the architect includes architectural devices to create specific effects, such as customizing a space to a particular use. The authors identify some architectural principles that level designers can apply to create spaces for gameplay, including having a clear path through the level, how to use different spatial organizations such as linear or hub-and-spoke, or including unique elements to break up the design.

An examination of how space is used in team-based multi-player FPS levels was presented by Güttler et al. [21]. They identified common spatial configurations and how they contribute to gameplay. The key elements they studied are collision points and tactical choice. In a team multi-player level, the designer provides multiple routes through the level, allowing players the chance to make a strategic decision. The choice of route determines where in the level the two teams will eventually clash; these collision points are the major contested spaces where the game is played.

There are some significant empirical studies that evaluate the effects of level design on gameplay. Gee studied the use of dead-ends in FPS levels [22]. He identified ways

in which dead ends are used and built example levels that included them or not. Subjects were observed playing levels and their preferences and playing time were reported. Results indicated that dead ends did not negatively impact FPS levels.

An empirical study by Gonzales explored directional choices in FPS levels [23]. Similar to the Gee study, they identified different techniques for presenting alternate routes and performed user studies on a set of representative levels. Survey responses and subject observations contributed to their conclusion that choice improves player immersion, as the lack of choice in a linear level can break the illusion of being in large, dynamic world.

2.6 NAVIGATION

A key use of spatial configuration in levels is in providing navigational cues to the player. This is particularly true in FPS levels as they are generally large, complex environments. Nerurkar examines some means level designers use to aid player navigation [24]. Some, such as maps and navigation markers, are separate from the level design, but many are a function of the level design. Examples include features that attract the player's attention, use of light and contrast, and directions from NPCs.

Hoeg performed an empirical study of player navigation and player types in FPS levels [25]. He identified elements that designers use to influence pathing decisions, including lighting, sound, and resistance, and formed a theory about how Bartle's player types [26] would react in each case. He constructed a level with multiple

decision points, using different navigation cues. Subjects' player types were determined by a survey, and their routing choices were recorded while playing the level. The results were compared to see if the theory was consistent with the player's behavior. They found that some elements, such as placement of doors and motion, had strong correlation, whereas other factors had weak or no correlation.

3 PLAYER BEHAVIOR

There are some examples of academic work that uses data analysis from games. Dixit et al. performed user tests and created visualizations of the collected data to better understand where users' attention was focused during gameplay [27][28]. This has direct implications for game design by helping designers understand the best places to place clues for players.

Kim et al. presented TRUE, a system for collection and visualization of data from user studies, and presented a case study of its use in Halo 2 [29], a popular First-Person Shooter (FPS) game. They specifically were looking for unintended difficulty increase introduced during development. Through user tests, they collected data on player deaths and opinions on difficulty. They were able to identify several unbalanced elements in the game and correct them before release.

Weber et al. and Lewis et al. both used data mining techniques on large amounts of collected data. In the former, over 5000 replays of expert StarCraft matches were

used as training data for a machine learning algorithm for predicting strategy [30]. The strategy predictor became a component of a StarCraft playing bot, thus helping to improve game AI. The latter work presents a case study of large-scale data collection and interpretation of World of Warcraft repositories for better understanding of player behavior [31]. They analyzed how long it took players from each class to reach level 80 (the highest level) in order to empirically evaluate whether the game design is balanced, and confirm or refute common folklore surrounding the game.

Articles in industry-focused publications like Gamasutra suggest that the use of data in the game industry as a means to improve design is increasing. Some key examples are presented below.

Russell examined the combat design in Uncharted 2 [32][33]. They studied both the previous game in the series as well as iterated on the design of their current game. Levels were played repeatedly, and the data collected informed design changes.

Adent discussed the development of Forza Motorsport 3, particularly the importance of always having a stable, playable build, and how that feeds into the iterative development of the game [34]. Constant playability means a constant stream of data for the designers to study and make changes accordingly.

Van der Heijden examined the usability testing done for Swords & Soldiers [35]. They describe the key questions the developers hoped to answer, the set up and

testing process, and what they learned. In particular they were interested in improving the interface design and used eye-tracking data to see where players' attention was focused.

Another example of usability testing is in Thompson's article on Halo 3 development [36]. They describe the extensive playtesting performed to improve the playability and balance of the game. Large numbers of players were observed and data was collected about how well they performed, leading designers to make adjustments. Players were also asked subjective questions about their level of enjoyment.

Another game in the Halo series, Halo: Reach, was subjected to a large beta test – over 2.7 million players and 16 million hours of testing [37][38]. The result was not only finding and fixing bugs, but also significantly tweaking the gameplay by adjusting factors such as weapon damage, reload times, shield recharge rates, etc.

CHAPTER 3

DESIGN PATTERNS

While our user study is primarily focused on the effects of design patterns in single player levels, we explored design patterns in multiple aspects of FPS games. Of particular relevance are the patterns for combat NPCs and for weapons. Weapon and NPC design in FPS games fall into a grey area between game design and level design. While they are aspects of the game mechanics, and therefore game design elements, they are greatly influenced by the work of the level designer. Tuning of weapons and NPCs generally occurs late in the development process, and is a function of the constructed levels. As the final tuning of these elements are dependent upon their placement and use by level designers, they can be considered an aspect of level design. As such, patterns for these elements are described here along with the single player patterns. Other pattern collections are presented in Appendix A.

1 SINGLE PLAYER FIRST-PERSON SHOOTER LEVELS

The descriptions of the patterns explain how they can be used, the concerns designers must address, and the gameplay created. The fields are listed below:

Description – A high level description of the pattern and the major design considerations.

Affordances – Aspects of the pattern that can be varied by the designer.

Consequences – A description of the gameplay the pattern creates.

Relationships – How the pattern interacts with other patterns.

Examples – Some examples from popular commercial games that illustrate the pattern.

The use of the term "affordances" in this research is a bit idiosyncratic. In the field of design, the word typically means "the perceived or actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used." [39] For example, the presence of a doorknob is an affordance that signals that a door may be opened. For this research we modify this definition slightly, so affordances are aspects of a pattern that can be varied by the designer ("perceived or actual properties") to alter the effect on gameplay ("how the thing could possibly be used"). Essentially, affordances are the knobs a designer can twist within a pattern to dial in different gameplay effects.

The patterns are grouped into one of four following categories based on the type of gameplay produced. The categories are Positional Advantage, Large-scale Combat, Alternate Gameplay, and Alternate Routes. These distinctions are not mutually exclusive, a pattern might be perceived as being in one category or another based on

its affordances. Furthermore, specific patterns may overlap, resulting in different effects and described in the relationships sections of each pattern.

- Positional Advantage – Spaces where one entity has an advantage over another.
 - Sniper Location – A protected, elevated location that overlooks some portion of the level.
 - Gallery – An elevated area parallel and adjacent to a narrow passageway.
 - Choke Point – A narrow area with no alternate routes, causing entities to be exposed to engagement as they move through.
- Large-scale Combat – Areas designed to facilitate combat involving large numbers of entities.
 - Arena – An open area or wide corridor.
 - Stronghold – A confined area with good cover and limited access points.
- Alternate Gameplay – Introduce new elements that break from the established mechanics of the game.
 - Turret – An area with a high-powered weapon where one side has a clear advantage.
 - Vehicle Section – Sections of alternate gameplay where the player drives or rides in a vehicle.

- Alternate Routes – Create alternatives for the player in how they approach the level.
 - Split Level – A corridor with an upper and lower section, where those on the upper section can attack those on the lower section.
 - Hidden Area – A small area off the main route that contains items for the player.
 - Flanking Route – An alternate path that allows characters to gain positional advantage.

1.1 PATTERNS FOR POSITIONAL ADVANTAGE

These patterns all result in one entity gaining an advantage in position over another entity. A positional advantage usually affords opportunities to attack other entities without being exposed to counter attack.

1.1.1 SNIPER LOCATION

Description:

Sniper locations are one of the most common patterns. A character in a sniper location can attack other characters with long-range weapons while remaining protected. Any elevated position that overlooks some portion of the level is potentially a sniper location. They may be intended for use by either players, NPCs, or both.

Creating a sniper location for use by an enemy rather than the player requires additional consideration. Enemies positioned in the sniper location may require special scripting to create the desired behavior; they should remain in place, using cover if available, and engage the player with long range weapons.

Affordances:

- The height of the sniper location over the main part of the level
- How large of an area is available for the sniper
- The amount of cover available for the sniper
- The size of the area that the sniper can cover from the sniper location
- How accessible the sniper location is from the area overlooked

Consequences:

When confronted with an enemy sniper location, the player is forced to make careful use of cover or seek alternate routes to avoid being exposed to fire. This can increase the tension and slow the pace of a level while creating a challenge for the player.

A player sniper location generally slows the pace of a level while lowering tension as the player is able to engage enemy NPCs without being exposed to enemy fire. However, if the sniper location is not isolated from the rest of the level, the player will have to defend the access point as well, increasing tension.

Relationships:

Sniper locations interact with many other patterns. They may be placed to cover an arena or a choke point. Most stationary turrets are also sniper locations. A shooting gallery is specialized type of sniper location. A sniper location with access may be a type of stronghold.

Examples:

In the level “Route Kanal” of Half-Life 2 [40], the player encounters an enemy sniper location, shown in Figure 1. It is high above the player’s position, but has very little cover. The player can engage the enemy NPCs, but is exposed and needs to be cautious.

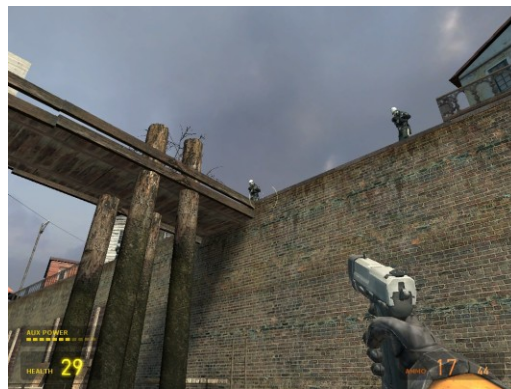


Figure 1: Sniper location in Half-Life 2

There is a sniper location in the level “Corinth River” of Killzone 2 [41]. The player is on an elevated walkway overlooking a medium-sized area containing enemy NPCs.

Both the player and enemy NPCs have cover, but by looking down from above, the player is able to locate the enemy NPCs and engage them.

1.1.2 GALLERY

Description:

A gallery is an elevated area parallel and adjacent to a narrow passageway. Characters in the elevated area can easily engage characters in the passageway.

Affordances:

- The length and width of the passageway covered
- The height of the elevated area above the passageway
- The amount of cover available in the passageway

Consequences:

A gallery is used by a designer to create a challenge for the player. The characters in the passageway are open to attack and need to use cover if available. If the player is in the elevated area, the intent may be to enable the use of special weapons like grenades.

Relationships:

Similar to sniper location, with the added element of covering a specific passageway characters are moving through.

Examples:

There is a gallery in the level “Urban Flight” of Half-Life 2: Episode 2 [42]. A friendly NPC is positioned overlooking a passageway enemy NPCs are advancing through towards the player. The friendly NPC is able to eliminate the most of the enemy NPCs before they reach the player.

The Halo 3 [43] level “Floodgate” features a gallery. The player has to move up a ramp with enemies positioned on the elevated area above. The player can attempt to engage with grenades, or move up the ramp quickly and engage with conventional weapons.

1.1.3 CHOKE POINT**Description:**

A choke point is a narrow area with no alternate routes. Typically, it is an entrance to a room, but a choke point could exist in an otherwise open area. As the player or enemy NPCs move through the choke point, they are exposed to attack.

Affordances:

- The width of the choke point opening
- The length of the choke point

Consequences:

If the player is moving through the choke point, they are exposed to enemy fire, increasing tension in the level. If enemy NPCs are moving through the choke point, the player is able to attack with little risk, reducing tension and challenge.

Increasing the width lessens the effects as more characters are able to move through at a time. Increasing the length can also reduce effects as characters have a place to retreat to.

Relationships:

A choke point may be used in conjunction with a sniper location, providing cover for the attacker.

Examples:

The player encounters a choke point in the level “Corinth River” of Killzone 2 [41]. They must move through a long, narrow corridor with some cover, while being engaged by enemy NPCs from both sides.

The level “Recovery” of Crysis [44] contains a choke point. The player has to move up a narrow path with minimal cover. To proceed, they must pass through a choke point defended by enemy NPCs operating a turret. The player is forced to use cover carefully until they can get close enough to engage them.

1.2 PATTERNS FOR LARGE-SCALE COMBAT

These patterns provide areas for combat gameplay, with the player either engaging large numbers of enemy NPCs or a single powerful enemy NPC (a boss fight).

1.2.1 ARENA

Description:

Easily the most common pattern, an arena is an open area or wide corridor where the player encounters some form of heavy resistance, either waves of enemy NPCs, or a boss fight. Designers should ensure that the player is not overwhelmed. Cover and items can be placed to allow the player to make continual progress towards their goal.

In a boss fight the player may have to find the boss’ weak spot, or hit it a certain number of times. The designer must communicate the method of defeating the boss to the player. For example, the player may be provided with a high powered weapon just before entering the arena.

Affordances:

- The size of the arena (length, width, height)
- The amount of cover available in the arena

Consequences:

If the player is outnumbered and lacks powerful weapons, they are forced to move deliberately and make use of cover. This increases challenge and slows the pace. If the player has a powerful weapon or is otherwise not seriously threatened, the effect is to increase pace as the player quickly eliminates large numbers of enemy NPCs.

Relationships:

An arena can contain sniper locations or turrets. Entrances to an arena may be choke points.

Examples:

The Gears of War [45] level “Trial by Fire” contains several arenas. One example is a room of medium width and length and a low ceiling. There is a significant amount of cover, which is used by both the player and enemy NPCs.

The level “Corinth River” of Killzone 2 [41] begins with a large arena. The player and friendly NPCs engage enemy NPCs in a space with medium width and depth,

with large amounts of cover. Some NPCs are positioned at elevated sniper locations with turrets.

1.2.2 STRONGHOLD

Description:

A stronghold is a confined area, generally with good cover. Characters in a stronghold can defend against attackers while remaining protected. A stronghold has limited access points so the defending characters can cover them easily.

Affordances:

- The size of the stronghold
- The amount of cover available in the stronghold
- The number and type of access points
- If defending/capturing the stronghold is a level objective

Consequences:

Generally a stronghold would be designed as a defensible location for the player. The effect is usually to reduce the pace of the level, but in some cases, a large number of entrances or advancing enemy NPCs can have the effect of increasing tension and challenge.

Relationships:

A stronghold can be considered a specialized type of arena or sniper location. Entrances to the stronghold may be choke points.

Examples:

The Halo 3 [43] level “The Covenant” contains a stronghold. The player is in a large open area and engages enemy NPCs entering through multiple entrances. These entrances are choke points that help keep the player from being swarmed by enemy NPCs, but it is challenging to cover them all at once.

There is an instance of a stronghold in the level “Fish in a Barrel” of Gears of War [45], shown in Figure 2. The player and friendly NPCs are in a central area with minimal amounts of cover while being engaged by enemy NPCs from multiple directions. The effect is challenging and high tension combat.

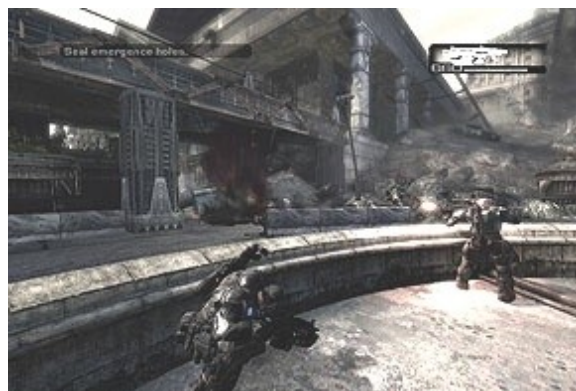


Figure 2: Stronghold in Gears of War

1.3 PATTERNS FOR ALTERNATE GAMEPLAY

These patterns are used to break up levels with sections of gameplay that differ significantly from the standard gameplay.

1.3.1 TURRET

Description:

A turret is a special, high-powered weapon that is usually fixed at a location. This overlaps with the placed weapon pattern, with the distinction that the level design pattern describes the space in which the turret is placed, while the weapon pattern describes the function of the weapon itself.

A turret may be operable by the player or NPCs, or be automatic. Since turrets are usually more powerful than standard weapons, care must be taken to insure that the turret does not unbalance the level. A common use of a turret is to create a challenge where the player has to carefully move from cover to cover.

Affordances:

- The size of the area covered by the turret
- The type of weapon used as a turret
- The amount of ammunition available for the turret
- If the turret is fixed or mobile

Consequences:

When the player is given a turret, the effect is to break up the level by providing an alternate gameplay state. Using a powerful weapon generally increases pace as the player is able to overcome enemy NPCs quickly.

Automatic or enemy NPC turrets have effects similar to sniper locations: player movement is limited, increasing tension and challenge while slowing the pace.

Relationships:

A turret may be placed in a sniper location. A turret may be mounted on a vehicle during a vehicle section.

Examples:

There is a turret in the level “Route Kanal” of Half-Life 2 [40]; a fixed, powerful weapon used by the player to engage several waves of enemy NPCs.

In the Gears of War [45] level “Fish in a Barrel” there is a turret operated by an Enemy NPC. The turret itself has little cover, but prevents the player from advancing through the arena. If the player uses a flanking route, they can eliminate the enemy NPC and operate the turret themselves.

1.3.2 VEHICLE SECTION

Description:

Vehicle sections are a form of alternate gameplay where the player drives or rides in a vehicle. The player may be able to shoot, either with a standard weapon or a special weapon mounted to the vehicle. Enemy NPCs may also use vehicles.

Affordances:

- Whether the player is a driver or passenger in the vehicle
- The type of vehicle available, including its speed, armament, and capacity
- Whether the vehicle section is linear or an arena
- The nature of the terrain: flat or undulating

Consequences:

The effect of a vehicle section is to break up a level by significantly altering the gameplay. Since vehicles are generally faster than normal movement, the pace of the level is increased. Challenge can be increased if the vehicle is difficult to control or the terrain is difficult to negotiate.

Relationships:

The vehicle may have a powerful mounted weapon with similar effects as a turret.

Examples:

Most of the level “Tsavo Highway” in Halo 3 [43] is a vehicle section. The player can either drive the vehicle or ride while using either standard weapons or the mounted turret. Parts of the level are narrow linear sections that have no enemy NPCs but are difficult to negotiate, while other sections are arenas with large numbers of enemy NPCs, also in vehicles.

There is a vehicle section in the Crysis [44] level “Recovery.” The player drives the vehicle down a narrow road. The narrowness and difficulty of controlling the vehicle create a challenge for the player. There are enemy NPCs that the player can engage with a mounted turret.

1.4 PATTERNS FOR ALTERNATE ROUTES

These patterns provide players with choices about how they want to engage the level.

1.4.1 SPLIT LEVEL**Description:**

A split level is a corridor with an upper and a lower section. Characters on the upper section can attack characters on the lower level. Players can choose the upper or lower route, or switch between them.

Affordance:

- The difference in height between the levels
- The degree of openness between the levels, in terms of empty space
- The number of paths between the levels

Consequences:

Allows for different strategies and can increase the pace of a level as the player moves back and forth between levels.

Relationships:

If the corridor is narrow, the upper section could be a gallery. Using one section to avoid enemy NPCs in the other section makes it a type of flanking route.

Examples:

There is a split level in the “Lowlife” level of Half-Life 2: Episode 1 [46], shown in Figure 3. The player is moving through a large open area with elevated passageways. The player must switch back and forth between the two paths to avoid the most powerful enemy NPCs.



Figure 3: Split level in Half-Life 2: Episode 1

The Halo 3 [43] level “Crow’s Nest” features a long split level section. The player may stay on the upper level and engage enemies on the lower level, or use the lower section and engage them directly.

1.4.2 HIDDEN AREA

Description:

An example of a hidden area is a small room containing a cache of items, often special weapons or power-ups. They do not necessarily need to be hidden, but are generally not trivial to find or access. Hidden areas are usually off the main route followed by the player. The intent is to reward players for exploration. The difficulty of finding or accessing a hidden area may be proportional to value of the reward.

Affordances:

- The ease of finding or accessing the hidden area

- What rewards are available in the hidden area
- Whether the hidden area is defended by enemy NPCs or not

Consequences:

If the player is reward given a powerful reward, the overall challenge of the level will decrease as they've gained a significant advantage. Too powerful of a reward may completely upset the level's balance. The pacing of the level will increase and tension decrease if the player the player is now able to move quickly without worrying about threats from enemy NPCs.

Relationships:

None

Examples:

The Half-Life 2: Episode 1 [46] level "Lowlife" contains a hidden area. Just off the main path, it contains an enemy NPC and a small reward. This rewards the player for doing additional exploration.

1.4.3 FLANKING ROUTE

Description:

An area with heavy resistance may contain an alternate route that allows characters to gain a positional advantage. Generally, enemy NPCs are positioned in the main corridor, while the player has the option to use the flanking route to get behind or alongside the enemy NPCs. A flanking route may be a separate corridor or elements of cover in a large arena.

Affordances:

- The position that can be reached by flanking
- The amount of cover available while flanking

Consequences:

A flanking route is used to provide the player with options in combat. Players who prefer direct combat may attack the enemy NPCs without using the flanking route, whereas players who prefer a more stealthy style may avoid the enemies and engage from the side or behind. When a flanking route is used the pace of the game is reduced as a difficult section is bypassed.

Relationships:

Flanking routes can exist in arenas. A flanking route might be a hidden area.

Examples:

In the level “Trial by Fire” of Gears of War [45], the player engages enemies in a wide, narrow arena with a flanking route down one side. While the enemy NPCs engage the friendly NPCs from a cover position, the player can use the flanking route to get move behind them and engage from a covered position.

Many of the arenas in the Killzone 2 [41] level “Corinth River” include flanking routes. For example, in one large arena with a large number of enemy NPCs, the player can move from cover to cover along the side of the arena, gaining a positional advantage on the enemy NPCs.

1.5 LEVEL ANALYSIS EXAMPLE

The expressive power of level design patterns is illustrated by describing an existing level in terms of the patterns. The game and level chosen, “Medical Pavilion” in Bioshock [11] has not previously been used in the examples given above.

This level is the second in Bioshock, and the first of significant length. The initial goal of the level is to exit the level and meet up with the friendly NPC who urges the player on throughout the level via radio messages. However, this goal is not straightforward; the player discovers the exit is locked and the key is held by the level’s main boss. The player must explore most of the level in order to gather items needed to engage the boss, then locate and defeat him. The level also contains some

side areas that are not necessary to complete to finish the level, but do provide additional items to help the player.

The first instances of patterns the player encounters are an *arena* in combination with a **turret**. The **arena** is narrow, long, and high, with an upper level from which enemy NPCs emerge. There is little cover available to the player, while the enemy NPCs have a moderate amount of cover. To compensate for the lack of cover, the **turret** is automatic, friendly, and mobile. It moves throughout the **arena** and engages the enemy NPCs, allowing the player to stay reasonably protected and engage the enemies. Though this section creates tension due to the large number of aggressive enemy NPCs, the pace remains low as the player doesn't have to move or act quickly.

After the **arena**, the player encounters a **stronghold** consisting of a small room. The room has only minimal cover, and a single, narrow entrance that is a **choke point**. The player can also be engaged by enemy NPCs in a nearby **sniper location**. The player can use the available cover and engage the enemy NPCs moving through the **choke point**. The pace and challenge of the level is increased in this section due to the large numbers of enemy NPCs engaging the player and the minimal amount of cover available.

The next section of the level is an **arena**. The room is long and wide, but has a low ceiling and provides ample cover for both the player and enemy NPCs. The cover creates multiple **flanking routes** throughout the **arena**. There are two automatic

enemy **turrets** in the room that initially prevent the player from moving, but later become friendly **turrets**. The effect on gameplay is initially an increase in tension and challenge, but the pace drops considerably once the *turrets* begin engaging the enemy NPCs.

This section ends with a small **hidden area** containing item rewards. This helps relieve the tension of the previous **arena** by giving the player an opportunity to relax while gathering items, and reduces the challenge of the following section as the player is restocked in terms of health and ammunition.

After this, the player encounters a series of small *arenas*, most containing enemy **turrets**, small numbers of enemy NPCs, and lots of cover. The effect is to establish a rhythm for the player: enter a room, find cover, disable the **turret**, engage enemy NPCs, collect items, and then move on. The player can set the pace as tension and challenge are low. In the middle of this sequence the rhythm is broken with a different type of **arena**. This one has many enemy NPCs and no cover. The player's rhythm is broken, temporarily increasing tension and pacing due to the surprise. The rhythm is then reestablished, reducing tension and pace. Some **hidden areas** are also in this section. The generally slow pace of this section creates an overall arc of falling and then increasing pace throughout the level.

The final section of the level is punctuated by two **arenas** containing boss fights. The first is a long, narrow space with **flanking routes** on each side. The boss is extremely

difficult to defeat with the player's weapons, and he can regenerate health. The effect is a very challenging and tense fight. Following the previous section of generally low pace, the first boss fight is the peak of the overall arc of the level.

After the first boss fight, the level concludes on a generally fast pace without too much challenge. The player encounters a wave of normal enemy NPCs in a small **arena** with no cover and a friendly automatic **turret**. Following this is a boss fight in a large **arena** with a lot of cover. While challenging, this boss fight is not as tense and fast paced as the previous. After defeating the boss, the player encounters an enemy NPC in a **sniper location** just before the end of the level.

1.5.1 DISCUSSION

While this level makes use of the majority of the design patterns described in this dissertation, it lacks any instances of the **split level** or **gallery** patterns. These patterns work best in levels with a high degree of verticality, which this level lacks. There are areas with vertical offset, but there are few large open areas where it would be appropriate to include these patterns. Including them would result in a more open, expansive level. Tight, constrained levels are more appropriate to the game's theme, and open areas would break that immersion. This level also lacks any **vehicle sections**. Again this does not fit with the level's aesthetic.

This example shows how level design patterns form a vocabulary for concisely describing a level. Without the terms introduced in this dissertation it would be difficult to describe a level in such a small space, and with such precision.

2 COMBAT NON-PLAYER CHARACTERS IN FIRST-PERSON SHOOTER GAMES

The work presented in this section is based on material originally developed in collaboration with Gabe Rivera.

The patterns presented in this section are for the enemy NPCs in FPS games. Enemy NPCs are controlled by the game engine and are the main source of conflict during gameplay. While they could be considered aspects of game design rather than level design, they are placed by designers and their tuning and behavior are highly dependent on how they are used. Designers can control not only where the NPC is placed but also the NPC's scripted behavior, how they are equipped, their level of health, their level of armor, and other variables.

For this research we explored elements that pertain to all NPCs within the shooter genre and then analyzed various games to see if NPCs consistently fell into patterns. Patterns were identified by observing NPC behavior and discerning which elements were combined in the same way within a number of games. Each pattern is accompanied by our observations about how it's used by designers to create gameplay, as well as a list of elements that define the pattern.

2.1 ELEMENTS OF A NON-PLAYER CHARACTER

Below is a list of elements that make up a NPC as well as a brief description of how they can be used by a designer to create gameplay during combat. These will be used in the pattern collection to categorize the specific patterns.

Movement Type – This describes the way the NPC will typically move in a combat situation. Many NPCs employ multiple Movement Types and can switch between them depending on the situation.

- **Flanking Intensive** – The NPC will move to attack from unexpected directions, i.e. the NPC tries to approach the player from a different side than where the player's attention is directed.
- **Passive** – The NPC will not move when attacking. Never straying too far from that location and available cover.
- **Slow Push** – The NPC will slowly advance on the position of the opposing force, usually in a straight line. This can be without the need for cover, but it is possible for the NPC to utilize cover while making its way forward. This main difference between this and Cautious is that it will constantly try to close the distance from its target and not try to stay away.
- **Rush** – The NPC will make a dash at a specific target without any regard for their safety, typically in a straight line. However, the main aspect of this movement type is that they will attack very fast and often try to close the distance between themselves and their target as fast as possible.

- **Cautious** – When used, it means that the NPC is opting to move around the battlefield but tries to maintain a distance from its target. Often trying to utilize cover when possible and not closing the distance when possible. This is different from a slow push because this NPC tries to maintain a specific radius around its target, without advancing.

Movement Range – This is how far the NPC will move during an engagement. This can be **Low**, **Medium**, or **High**.

Movement Frequency – This is how often the NPC will change their position during an engagement. This can be **Low**, **Medium**, or **High**.

Attack Frequency – This describes how often the NPC will initiate an attack. This can be **Low**, **Medium**, or **High**.

Weapon Type – The patterns include the following. They are described in more detail in the following section:

- Sniping Weapon
- Close Blast
- Assault Weapon
- Projectile
- Power Weapon
- Melee Weapon

Weapon Damage – A general indicator on how much damage the NPC will do to the player’s Health, Shields, or Armor. This can be **Low**, **Medium**, or **High**.

Armor/Health – This denotes how much damage the NPC can take before being killed. This will typically be linked to how hard the NPC is to defeat. This can be **Low**, **Medium**, or **High**.

Motive – This is an indicator of what type of combat encounter the NPC would create and shows its purpose to the designer. This hinges on three main factors that an NPC can affect:

- Challenge – The degree of difficulty within a combat encounter.
- Tension – The degree of mental stress the player experiences during a combat encounter.
- Pacing – The degree of movement that the player will engage in during a combat encounter.

A pattern can affect each of these three factors by creating a situation where they can be at **Low**, **Medium**, or **High**.

2.2 PATTERN COLLECTION

Below is a list of all the patterns that we have collected during our research. Each base pattern specifies the primary function of that general type, while each sub pattern denotes how that function is carried out.

- Soldier – An NPC that pressures the player from range.
 - Grunt – A weak enemy that attacks from a medium distance, often in groups.
 - Elite – A strong enemy that works to contain the player from a medium distance.
 - Grenadier – A weaker enemy that maintains long distance to encourage players to move forwards.
 - Sniper – An enemy that deals high damage from a long distance to force players to move carefully.
- Aggressive – An NPC that attempts to close the distance between itself and its target in order to increase pressure.
 - Suicide – An enemy that immediately rushes at the player, at the cost of its own life.
 - Swarm – An enemy that rushes the player in groups, but deals low damage individually.
 - Berserker – A strong NPC that deals a high amount of damage over a prolonged amount of time.
- Carrier – An NPC that will spawn more NPCs during an encounter.
 - Sacrifice – An NPC that creates more NPCs in the case of its own death.
 - Summoner – An enemy that spawns more NPCs at a distance

- Tank – An NPC that poses a significant singular threat and prevents the player from proceeding.
 - Stationary Tank – A slow-moving NPC that deals high damage at a long range.
 - Shield – An NPC with a large amount of armor, but only in a single direction.

The following sections detail all of the base patterns and at least one of their sub patterns.

2.2.1 SOLDIER

Soldier is a NPC that will pressure the player from long range. Its main strategy is to control the available space in the encounter. NPCs of this type make up the majority of units during an encounter. They are primarily used to control pacing by forcing the player to take particular paths through the environment. These NPCs will have a weapon type that is an Assault, Close Blast, Sniping, or Projectile.

2.2.1.1 Grunt

Description:

The Grunt is a weak NPC that will try to maintain a medium distance away when attacking. The main function this serves is to draw the player to forward through the level and increase the player's confidence. This pattern is distinguished by always

having medium movement range, medium movement frequency, and light armor. The motive of the Grunt pattern is to create a situation with low tension and low challenge.

Affordances:

- Movement type can be Slow Push, Flanking Intensive, or Cautious.
- Attack frequency can be either Low or Medium.
- Weapon damage can be either Low or Medium.

NPC Relationships:

The grunt has a special relationship with the Suicide pattern, because sometimes a grunt may change to the suicide pattern in the middle of an encounter.

Examples:

Halo: Combat Evolved [47] - The Grunt is a small unit that appears in every game within the Halo franchise. It has a low amount of Armor and is usually to be equipped with an assault weapon that does a low (Plasma Pistol) or medium (Needler) amount of damage. They exhibit the special relationship with the Suicide pattern in that they will self-destruct in times of desperation. The range it keeps is either short or medium but tries to pester the player by implementing the Cautious movement type.

During the campaign they primarily occur within encounters to create a lower challenge but increase the pace of the encounter. As a consequence, the player feels

more empowered and will pursue a route that contains a higher ratio of grunts compared to any other path. This occurs in the level The Pillar of Autumn; often the designers put grunts down a particular corridor to encourage the player to move in that direction. This signals to the player that it is the correct route to follow while lowering challenge, increasing the pace, and lowering player tension.



Figure 4: A Group of Grunts in Halo: Reach

Half-Life 2 [40] - The Metro Police Officer utilizes a Slow Push or Cautious Movement Type and primarily is equipped with an assault weapon, typically a sidearm. They will shift between the movement types in an effort to move a player forward. Typically this means that they will begin in a cautious movement type and, if they player doesn't pursue them, will move toward the player in order to get the player to move. This doesn't occur in any particular instance but can be seen where there are Metro Police Officers in levels such as Route Kanal or Water Hazard. In the game, they basically act as bait to simply pull the player forward. They are primarily

seen as the main enemy in the early game and are increasingly used as bait in the latter half of the game.



Figure 5: Two Metro police officers in Half-Life 2

2.2.1.2 Grenadier

Description:

The Grenadier NPC pattern distinguishes itself by being a weaker enemy that tries to stay a decent distance away in order to fire projectile weapons at the player. The main function that this NPC pattern is designed to do is to encourage the player to move through pressure made by the explosives. This serves as the antithesis of the Grunt NPC Pattern because this pattern increases challenge and tension to encourage the player to move as opposed to lowering it. The main traits that are required to distinguish this class are that they have a medium movement range, low movement frequency, a medium attack frequency, and a projectile weapon type. The motive of this pattern is to create a situation with high tension and high challenge.

Affordances:

- The Range can be either medium or long.
- The Movement Type can be Passive, Slow Push, or Cautious.
- The Armor can be either medium or low.

NPC Relationships:

None

Examples:

Gears of War [45] – The Boomer is a large unit that has a long range explosive weapon and medium grade body armor. It utilizes a slow push movement type and appears as a larger version of the typical locust drone soldier. It fires large explosives that force the player to evacuate their current cover position, unless they want to be hurt due to the splash damage. This increases the pace at which the player moves through the level by pressuring them.



Figure 6: A Boomer in Gears of War

Uncharted 2: Among Thieves [48] – A rocket soldier is a unit with a low amount of armor that maintains a passive movement type and deals with a projectile weapon type. It typically appears as a soldier in camouflage and bandanna that has an RPG with a band of ammo clips on its shoulder. It represents the typical Grenadier, staying as far away as possible by forcing the player to move with high damage explosives. Thereby increasing the player's pace through the level without directly exposing itself to danger.



Figure 7: A character being engaged by a rocket soldier in Uncharted 2:
Among Thieves

2.2.2 AGGRESSOR

Aggressor is a NPC that will immediately close the distance to the player in order to attack them with a Melee or Close Blast weapon. Its main function is to increase challenge in an encounter by pressuring the player. This type of NPC complicates the player's situation by forcing them to deal with an immediate threat at close range. Its presence also serves to increase player tension, because there is an increased amount of pressure from the player to kill it before it starts to move in and attack. Every sub pattern of this type has the Rush movement type, high movement range, high movement frequency, high attack frequency, and a Melee or Close Blast weapon type.

2.2.2.1 Berserker

Description:

The Berserker is a sub pattern of the Rush NPC pattern and distinguishes itself by being an enemy that will rush the player to deal a high amount of damage over a prolonged amount of time. The main function of this NPC type is to give the player a high amount of challenge over a short period of time. The high amount of damage they do, forces the player to deal with them immediately. All patterns of this type will have a high amount of weapon damage and since it is a derivative of the Rush NPC pattern it keeps the same requirements to stay within the Rush NPC Pattern. All NPCs within this pattern can have armor of any level. The motive of the berserker pattern is to create a situation with High Challenge.

Affordances:

- Type of weapon equipped.

NPC Relationships:

None

Examples:

Borderlands [49] – The Psycho wears a mask and the lower portion of an orange jumpsuit. He rushes the player at a high speed and wields a large hatchet that deals a high amount of damage when it hits. The unit will frequently attack the player and

will run across the entire battlefield in order to engage them. A couple of this unit type is usually put into larger groups of enemies in order to put more pressure on the player more by having a more aggressive enemy.



Figure 8: A Burning Psycho in Borderlands

Gears of War [45] – The Butcher is a large unit that appears throughout the Gears of War franchise, it carries a cleaver that it uses to strike the player with and has medium armor. It has a low speed but it will try to engage the player and rush toward him from any area on the battlefield. He will repeatedly try to attack the player as long as he/she is within its sight. The large, imposing presence serves to make it immediately noticeable on the battlefield and it will consistently make players prioritize it first because of the high level of damage it does.



Figure 9: A Butcher from Gears of War

2.2.3 CARRIER

Carrier is a NPC that will spawn more NPCs during an encounter. Their function is to increase the amount of tension that the player has by creating more enemies for the player to engage. The player knows that the number of enemies will keep increasing if the Carrier isn't dealt with. Therefore, the NPC's presence will be at the forefront of the player's mind throughout the battle since it is a threat that should be taken out early. Furthermore, the longer it stays alive, the more enemies the player will have to deal with; which increases the level of challenge. NPCs in this category will all have a high movement range, high movement frequency, and low armor. This is because the NPC doesn't want to get killed so there is a high movement frequency and range but designers want these to be killed fast so it's given a low amount of armor.

2.2.3.1 Sacrifice

Description:

Sacrifice is a sub pattern of the Carrier NPC pattern and is mainly distinguished by its ability to spawn enemies around its body upon death. The main function of this NPC is to increase the amount of tension within an encounter because the player will know that as soon as this NPC dies then they will immediately have to deal with more enemies. The common elements within all units of this pattern are a rush movement type, a high attack frequency, and a projectile weapon type. The motive of this pattern is to create a situation with a high amount of tension.

Affordances:

- None

NPC Relationships:

This NPC pattern can spawn NPCs of the suicide and swarm patterns.

Examples:

Dead Space [50] & Dead Space 2 [51] – The Pregnant Necromorph appears in both versions of Dead Space. It will explode when shot and maintains a low amount of armor. It spawns smaller swarming units when it is hit; furthermore, it rushes the player in hopes that it will explode close by. It will appear solo in the game but occasionally appears in larger heterogeneous groups. The threat of creating a larger

amount of smaller enemies increases the player's tension level, since the player will only release more enemies when they kill the pregnant necromorph.



Figure 10: A pregnant necromorph spawning units in Dead Space

Halo: Combat Evolved [47] – The Carrier Flood form is a carrier that has a low amount of armor and spawns units through an explosive weapon type at close range. It typically tries to assault the player in the middle of a battle when in a larger heterogeneous group. It increases the tension of the level because the player knows it can inflict a high amount of damage if it explodes nearby and only serves to create more enemies. This creates a situation where the player has to choose the best time to eliminate it in order to mitigate damage.



Figure 11: A Flood Carrier in Halo: Combat Evolved

2.2.4 TANK

A Tank is a NPC that will raise the tension and challenge for the player. This occurs because the tank poses a significant singular threat that is required to be beaten in order to progress. Tank NPCs are meant to slow player progress by being hard to overcome, which will slow the pacing of the game. As a consequence, this pattern's main distinguishing feature is the NPC's ability to take a large amount of damage through an enormous amount of armor or health.

2.2.4.1 Stationary Tank

Description:

The Stationary Tank NPC Pattern is a sub pattern of the Tank NPC pattern and is mainly distinguished in how it is a slow moving NPC that will cause an extremely high amount of damage at long range. The main function of this NPC is to increase the amount of challenge and tension for the player by creating a relatively stationary

threat to the player that is hard to remove. The common elements in this pattern are that all NPCs have a passive movement type, a high movement range, low movement frequency, high attack frequency, long range, and a power weapon as its weapon type. The motive behind this pattern is to create a situation with a high amount of tension, high amount of challenge, and a medium pacing.

Affordances:

- None

NPC Relationships:

This NPC pattern will sometimes switch to the Berserker NPC pattern for a period of time.

Examples:

Halo: Combat Evolved [47] – The Hunter is a Stationary Tank unit that employs almost every single category for the unit type. This is because it utilizes attacks at long range with its beam cannon and then falls to short range to melee attacks with its shield arm. It has an aggressive behavior as it will continuously assault the player, has a high armor value to make it hard to kill, and all of its attacks do a large amount of damage. Finally, this unit travels in pairs. The reason for this is primarily because they have weak points on their backs so they will cover each other. The Hunter provides a large challenge due to its powerful weapon and high armor. The tension

comes when a player is forced to try and kill one during a level, it is only increased by the fact that they appear in pairs.



Figure 12: A Hunter from the Halo franchise

Call of Duty: Modern Warfare 2 [52] – The Juggernaut is a Stationary Tank that employs a power weapon at long range. It maintains a passive movement type that slowly follows the player from any part of the battlefield but remains stationary when the player is in sight. It also has a very high amount of armor. It appears as a very large, heavily armored man with a white mask who is armed with a heavy machine gun. The Juggernaut provides a large challenge that the player has to overcome and so a large amount of tension will automatically develop. The fact that it's so hard to remove only increases this effect.



Figure 13: Two Juggernauts in Call of Duty: Modern Warfare 2

2.2.4.2 Shield

Description:

The Shield NPC is a sub pattern of the Tank NPC pattern and is mainly distinguished in how it has a high amount of armor but only in one particular direction. Their main function is to increase challenge and tension by creating a large, almost unstoppable force that slowly closes in on the player. The increase in challenge is because the player is then forced to rethink their strategy and flank in order to kill it. The increase in tension is derived from the fact that this NPC type will close in very slowly but is steadily getting closer to killing the player. The common elements shared in the NPC pattern are that it has a slow push movement type, a high movement range, and a medium movement frequency. The motive of a Shield NPC is to create a situation with a medium amount of challenge, high amount of tension, and high amount of pacing.

Affordances:

- The weapon type can be a side arm or assault.

NPC Relationships:

None

Examples:

Halo: Combat Evolved [47] – The Jackal is an example of a shield NPC because it has a high amount of armor where its shield is located and no damage is taken. However, the rest of the unit's body has a very low amount of armor resulting in numerous weak spots that its shield doesn't protect. The weapon that it uses is fairly short range so it must close the distance in order to do more damage. It does a relatively low amount of damage to the player as well and travels in either homogenous teams or heterogeneous teams; however it will never venture out alone. It is primarily used as a means to give more pressure to the player from a particular direction.



Figure 14: A Jackal in the Halo Franchise

Uncharted 2: Among Thieves [48] – The turtle NPC appears as a NPC that is equipped with a riot shield that blocks all damage from the front. Its primary method of offense is a machine pistol that can only be used at close range. It will engage the player from anywhere across the battlefield and will slowly try to close distance to the player's position (the more fire it's under the slower it goes). It has a medium movement frequency because it will pause from time to time. This unit serves to increase the tension in the player because it will move faster toward the player the less it's shot at. However, a player can only kill it by maneuvering around it and therefore not keeping it preoccupied. This situation creates a high amount of challenge that forces the player to continuously keep an eye on the unit.



Figure 15: A turtle unit in Uncharted 2: Among Thieves

2.3 EXAMPLE ANALYSIS

To show the usefulness of NPC design patterns we will use them to analyze a short encounter and generate a new enemy type. The level Winter Contingency in the game Halo: Reach contains an encounter in which the group is tasked with bringing a communications outpost back online. This sequence starts with the team landing in front of the communications outpost in order to secure the location.

After starting the level, the player encounters their first group of enemy NPCs in an Arena with Flanking Routes to the left and right. The NPCs that populate the arena are a small force of Grunts and Jackals. This encounter has a low amount of challenge and allows the player to gain a foothold without much effort. It is fairly easy for the player to move forward and incapacitate the Grunts, which fall under the Grunt NPC pattern. However, it is much harder kill the Jackals in a head on attack since they are a part of the Shield NPC pattern. The interplay between the Grunt and Shield patterns

help to create a much easier encounter for the player by driving them to explore the area and flank the Jackals.

The player goes into the encounter and immediately recognizes that most of the Jackals were located in the Arena, where the player is at a disadvantage. Since that place is the hardest to break through, the player is drawn to the left because the Grunts offer a lower level of resistance. The Grunts signal to the player this path is safer and encourages them to move through the Flanking Route. The player can now flank the exposed back of the Jackals, which has a pattern specific weakness of only being able to withstand a large amount of damage from one direction.

We can analyze this encounter and explain it through the enemy NPC patterns that we have created. The designers used Shield NPCs in order to bar the player's way from one direction and give the illusion of a higher degree of challenge. However, by adding in the Grunt NPCs it allowed them to encourage the player to move into an advantageous position. The interplay between these two types helped to create an encounter with a low amount of challenge but high amount of tension.

3 WEAPONS IN FIRST-PERSON SHOOTER GAMES

The work presented in this section is based on material originally developed in collaboration with Rob Giusti.

To define and discuss weapons, game and level designers have repurposed an existing classification system: the terminology used to refer to real-life weapons, terms such as “Sub-machine Gun” and “Sniper Rifle.” Though these classifications do easily explain the mechanics of the weapon, the use of such terminology fails to accurately describe gameplay behaviors and to encompass the fictional aspects of digital games.

Knowing how a particular weapon functions in real life does not actually give an accurate depiction of how the weapon functions within a game. For example, the shotgun in Halo has a much shorter effective range than its real-life counterpart. Many similar weapons fall into different weapon patterns depending on how designers implement them.

Though many action and adventure games use weapons, shooter games are affected by this lack of terminology more than others due to the fact that weapons are at the core of gameplay. In the vast majority of first-person shooters, the player's weapon never even leaves their view. In addition, weapons are the central method through which players interact with the world in these games.

With this pattern collection we hope to create a language that can be used to describe weapons in a way that encapsulates the gameplay behaviors that each pattern elicits. Each pattern is named in a way that aims to be inclusive of all weapons, fictional or nonfictional, that elicits similar player behavior.

We accumulated these patterns through analyzing weapons in popular and historically significant first- and third-person shooter games.

3.1 ASPECTS OF WEAPON PATTERNS

To provide a basis for defining patterns in weapon design, the following template will be used:

Name – A descriptive identifier used to refer to the pattern that is recognizable and imparts the core functionality of the pattern.

Description – A brief explanation of the typical features of a weapon derived from this pattern.

Affordances – Aspects of the pattern that can be varied between different weapons within the pattern.

Consequences – How use of the weapon pattern affects gameplay.

Level Patterns – Relationships between the weapon pattern and patterns in level design.

NPCs – Relationships between the weapon pattern and patterns in non-player character design.

Examples – Uses of the weapon design pattern from popular commercial shooter games.

Patterns contained within another are considered to be super- or sub-patterns of each other. Patterns are not mutually exclusive from each other; a weapon can fit multiple weapon patterns.

A large number of affordances can be considered universal among weapon patterns, including:

- How much damage the weapon deals
- The range of the weapon
- The area of effect of the weapon
- How often the weapon can be used ("Cooldown")
- How many times the weapon can be used before needing to be reloaded ("Capacity")
- How much ammunition a player can carry
- How carrying the weapon affects the player's movement
- How the weapon imparts damage to the enemy (On hit, delayed, continuous, etc.)

- Any special effects that the weapon has on the enemy
- Any special abilities that the weapon bestows

Repetition of a Universal Affordance within a particular pattern description signifies that pattern differs significantly within the pattern in that aspect.

3.2 PATTERN COLLECTION

3.2.1 SNIPING WEAPON

Description:

A weapon for engaging enemies from a long distance. These weapons do large amounts of damage per shot, have some sort of vision magnification system, and aim accurately. Sniping Weapons often reveal the player's location, hold limited amounts of ammunition, or require an extended reload period.

Affordances:

- The amount of view magnification that the weapon gives
- Additional difficulty in aiming the weapon accurately
- Any cues that reveal the player's location

Consequences:

Sniping Weapons encourage the player to maintain distance from enemies, engaging from long-range. They push players towards cover, which protect from groups of enemies.

Level Patterns:

Players with a Sniping Weapon fare best in Sniper Locations, which offer both good cover and a good view of locations where targets might be.

NPCs:

Sniper enemies are defined by having Sniping Weapons, however Stationary Tanks and Elites also sometimes utilize Sniping Weapons. Such enemies pressure players from a distance, forcing them to search for alternate routes.

Sniper Weapons allow a player to eliminate powerful Tanks and carriers without engaging them directly, but are less effective against Grunts and Rush enemies who attack in groups.

Examples:

An example of a Sniping Weapon is the Sniper Rifle in Halo 3 [43]. The weapon offers view magnification, has a capacity of four shots that can be fired in succession, and leaves a visible trail along a fired bullet's path to reveal the player's location.

In Ratchet and Clank: Up Your Arsenal [53], the Sniping Weapon has the added drawback of pulling the player from third-person perspective into first-person perspective and prohibiting the player from moving while in this view. The weapon balances itself out by dealing a very high amount of damage per shot.

The Huntsman from Team Fortress 2 [54] functions as a much different Sniping Weapon, allowing the player to trade in their guns and bullets for a bow and arrow. Since the weapon offers no view magnification to the user, it could be mistaken for an Assault Weapon, but the slow firing rate along with its difficulty in aiming and high damage per shot force the user into the same gameplay behaviors as the user of a sniper rifle.



Figure 16: A player using a Sniping Weapon in Halo 3

3.2.2 CLOSE BLAST

Description:

A Close Blast weapon fires in a quick and inaccurate manner as a means of hastily eliminating one or few enemies at a close range with a large area of effect. The large area of effect reduces the need for high accuracy. Shotguns, flamethrowers, and some submachine-guns are Close Blast weapons.

Affordances:

- Whether the weapon sends out single shots that diminish in strength over distance or multiple simultaneous shots that can each hit the target individually
- Whether the weapon is capable of hitting multiple targets in a single blast.

Consequences:

When given a Close Blast weapon, a player tends to use cover as much as possible. These weapons cause players to move tactically and strategically, minimizing distance in firefights before starting them.

Level Patterns:

Close Blast weapons are best fitted to Choke Points, where a player can engage targets at short range. Arenas with lots of cover are also advantageous.

Least preferable to Close Blast users are Arenas or Galleries without enough cover to protect the player from mid- and long-range attacks.

NPCs:

Close Blast weapons are often found in the hands of Berserker and Elite enemies, who seek to tactically catch the player in close-quarters.

A Close Blast weapon's area of effect is advantageous against Swarm and Carrier enemies, since the player can quickly eliminate targets in close vicinity to each other. Close Blast weapons are unable to harm protected enemies such as Snipers and Stationary Tanks.

Examples:

The shotgun from Goldeneye 007 [55] offers a prime example of a Close Blast weapon. At close range, the weapon has a large area of effect, but as distance increases the effectiveness of the weapon quickly drops off.

Though mechanically and aesthetically very different, a submachine-gun such as the one found in Half-Life 2 [40] functions very similarly to a shotgun. The weapon fires through a single clip very quickly, firing off the shots in an inaccurate cone. At a close range, a skilled player may be able to confidently engage two, maybe three,

soldiers before being forced to reload, while at medium range the weapon might not kill just one enemy with an entire clip of bullets.

In Team Fortress 2 [54], the Pyro class has a flamethrower, which fires a continuous stream of fire over a short distance. The weapon damages the enemy most when the player stays within the close range, and the weapon continues to deal a small amount of damage over time as long as the enemy stays on fire.



Figure 17: A Pyro using a flamethrower in Team Fortress 2

3.2.3 ASSAULT WEAPON

Description:

Mid-range weapons that fire fairly accurately and quickly, but deal low amounts of damage per shot. Many games contain multiple different types of Assault Weapons to fit different scenarios or player preferences.

Affordances:

- Whether the player can fire the weapon continuously (“Automatic”), must fire shots individually (“Semi-Automatic”), or has a mode that fires several shots in quick succession (“Burst-fire”)
- Whether the player can change affordances of the weapon within the game.

Consequences:

Due to their high firing rate, Assault Weapons heighten the pace and excitement of a level. Given their versatility, skilled players can confidently move through areas with little to no cover.

Level Patterns:

Assault Weapons perform well in Arenas and Split Levels, since the user can easily switch between targets in different directions.

NPCs:

Grunts and Elites often use Assault Weapons to pester the player from a distance, dealing small enough damage to be a threat but allowing the player time to react tactically.

Players can use Assault Weapons to easily combat Swarm enemies and Grunts, who often show up in large numbers. Assault Weapons allow the player to quickly take out low-threat enemies.

Examples:

Call of Duty 4: Modern Warfare 2 [52] gives players a variety of choice in Assault Weapons, showcasing the effects of slight modifications to an Assault Weapon's affordances. For example, the M4A1 is accurate and fires continuously, but deals low damage, while the FAMAS fires in bursts but reloads slowly.

The Halo series also contains a variety of Assault Weapons. The plasma rifle shoots a fast stream of energy bolts accurately at the player's aim. Instead of limiting shots per magazine, the weapon has a cool-down meter that must be managed, or else the weapon overheats and cannot be fired for a short period.

3.2.3.1 Sidearm

Description:

A weak Assault Weapon, usually used as filler until the player obtains a better weapon. These deal low damage but have large quantities of ammunition. Sidearms slow down the pace of the level and heighten challenge and tension.

Affordances:

- Whether the weapon uses any ammunition system or is an infinitely reliable backup weapon.
- Whether the weapon takes up space in the player's inventory or is always available.

Consequences:

Since the player is at a disadvantage to normal enemies, he or she will proceed cautiously and search the environment for better weapons. Forcing the player to fight powerful NPCs with only a Sidearm drastically increases tension.

Level Patterns:

A player with only a Sidearm will utilize cover and Choke Points to their advantage. The player is, however, vulnerable to enemy Sniper Locations and weak in Arena firefights.

NPCs:

Grunts with Sidearms often litter the battlefield in order to give the player easy targets, or to ease the player into the game early on.

When a player has a Sidearm, they are generally at a disadvantage against all enemies, and therefore they are more inclined to retreat from large threats and focus on taking on even Grunts tactically.

Examples:

In Half-Life 2 [40], the player is given a light pistol that does not do much damage, but ammo for it is plentiful throughout the game. If the player runs out of other weapons, they can revert to the pistol while they search for more ammo for other weapons.

Halo 3 [43] includes several Sidearm weapons, such as the pistol and plasma rifle, that do little damage on their own. In this game, however, two Sidearms can be wielded simultaneously, allowing the player to use the weapons more effectively as Assault Weapons. Wielding two weapons at once also has the drawback of prohibiting the player from using their grenade Thrown Projectiles, which are always usable when only using a single weapon.

3.2.4 PROJECTILE

Description:

Objects thrown or fired in a physics-defined arch. Most often, Projectiles are explosives that deal damage in a large area of effect. Projectiles are also associated

with long reload times and small capacities. Projectiles also often have a low amount of maximum ammunition.

Affordances:

- The range of the weapon
- If the effect is immediate or delayed
- The area of effect of the weapon
- Any special effects of the weapon

Consequences:

Projectile weapons are useful for circumventing cover. Also, they heighten the challenge through being more difficult to aim than other weapons.

Level Patterns:

Projectiles can be used to harm enemies in Sniper Locations or guarding Choke Points without directly engaging them. Players using Projectiles are often vulnerable to Split Levels and Galleries, due to ammunition limitations and a lack of sufficient cover.

NPCs:

Grenadiers, Elites, and sometimes Tanks use Projectiles to force the player out of cover and impose a greater threat.

Projectiles allow players to take on large groups of enemies, such as Swarms and Carriers, and fight against heavy enemies, such as Tanks and Snipers, without engaging them directly. The long recharge times and tendency for Projectiles to have large areas of effect make them less effective against Berserkers and Suicidals.

Examples:

The Demoman class from Team Fortress 2 [54] has a Grenade Launcher that allows the player to fire pipe bombs at enemies. These pipe bombs explode on impact with an enemy; otherwise the bombs roll for a few seconds before exploding.

In the Halo series, the rocket launcher is a weapon that is both a Launched Projectile and Power Weapon. The weapon launches a rocket at high velocity, creating a large explosion that can instantly kill targets, both those on foot and those in vehicles. However, the weapon carries very limited ammunition and takes up space in the player's limited arsenal.



Figure 18: A player firing Projectiles in Team Fortress 2

3.2.4.1 Thrown Projectile

Description:

A non-bullet object thrown by the hand of the player's character and categorized by short range and highly affected by gravity. Thrown Projectiles often have high damage or severe special effects, balanced by scarce ammunition.

Affordances:

- Special effects associated with the physical object of the projectile

Consequences:

The player is able to attack opponents who are behind cover, however they are forced to keep in mind their ammunition and range limitations.

Level Patterns:

Thrown Projectiles allow players to defeat an enemy guarding a Choke Point, or players on another level of a Split Level. In areas with long distances, such as Sniper Positions, or with enemies at multiple angles, such as Arenas and Flanking Routes, Thrown Projectiles are not very effective.

NPCs:

Elites utilize Thrown Projectiles in order to pressure players who are taking cover. Some Summoners use their spawned units as a sort of Thrown Projectile as a way of deploying them.

A player can use Thrown Projectiles much like normal Projectiles to attack heavy Tanks from behind cover. Thrown Projectiles are often more effective against solitary, close-range targets and less effective against loosely grouped Swarm and Grunt enemies.

Examples:

In Call of Duty 4: Modern Warfare 2 [52], the throwing knife is a powerful Thrown Projectile with harsh limitations. The weapon has a short range, however a hit with the knife immediately kills the enemy. A player also may only carry one knife at a time.

Halo 3 [43] offers players a handful of varied thrown projectiles. Fragmentation grenades can be thrown a good distance and rebound off any obstacles until they detonate after a set amount of time. Players also have the option of using plasma grenades instead, which attach themselves to level geometry and players on contact, but have a shorter range and smaller blast radius.

3.2.5 POWER WEAPON

Description:

A weapon that gives the player a clear advantage over other available weapons by either being incredibly powerful or by bestowing unique abilities. Major drawbacks may be present in order to balance the weapon against its obvious advantages.

Affordances:

- Special abilities that the player is bestowed with
- Drawback for using the weapon
- Circumstances for obtaining the weapon

Consequences:

Power Weapons increase pace and decrease tension in order to allow for the designer to create moments of low challenge. Power Weapons give the player a sense of equivalency when facing a vehicle or boss enemy.

Level Patterns:

Power Weapons might be a reward for players who explore to find Hidden Areas, or give players a fairer fight in otherwise overwhelming situations, such as Strongholds.

NPCs:

Power Weapons are usually limited to Tanks, but can also make Elites and Berserkers especially threatening to the player.

A player with a Power Weapon can quickly eliminate most enemies without much challenge. Elites and Tanks may be given ways to exploit the drawbacks of the player's Power Weapon.

Examples:

In Halo 3 [43], the Spartan Laser fires a powerful laser beam that instantly destroys anything in its path. It requires several seconds of "charge-up" time, during which it gives off a loud sound that reveals the player.

Call of Duty 4: Modern Warfare 2 [52] presents Power Weapons in a very different manner, through "Killstreak Rewards." These are given to players as rewards for achieving a certain number of kills in a single life, fueling the momentum of a successful player or team.



Figure 19: An airstrike in Call of Duty 4: Modern Warfare

A critical moment in every round of Super Monday Night Combat [56] is the battle over the annihilator, a Power Weapon that instantly destroys all enemy NPCs and deals a large amount of damage to all enemy players. The annihilator can only be used every five minutes, and in order to activate it a player must first have enough in-game money to pay for it. Then, they have to get to the activation point for the annihilator and remain there for a few seconds, completely vulnerable, in order to set it off.

3.2.6 MELEE WEAPON

Description:

Melee Weapons are hand-to-hand weapons, such as knives or bare hands. These weapons have slow firing rates, but often deal high damage. Melee Weapons discourage firefights that are at close range and reward players for using stealth.

Affordances:

- Relative strength of the weapon
- Limits on use

Consequences:

Melee Weapons allow players to react to Close Blast weapon attacks regardless of their other weaponry. In addition, focusing on using a Melee Weapon frees the player from the constraints of ammunition limits, or allows the player to keep fighting after running out of ammunition.

Level Patterns:

Melee Weapons favor small Choke Points and crowded Arenas. They can also be used to quietly make one's way into a Sniper Locations via access, or to sneak one's way through a Flanking Route without giving away the player's location.

NPCs:

Rush enemies are usually equipped with Melee Weapons in order make them more threatening at close range. Grunts and Elites sometimes have Melee Weapons in order to discourage players from getting too close to them.

A player with a Melee Weapon can more easily defend themselves against Swarms and Berserkers, as well as sneak up on Snipers and Elites. However, without easy

access, the player is vulnerable to Snipers who have the distance advantage, and the player is left with no effective way to engage a Sacrificial or Suicidal enemy.

Examples:

In Call of Duty 4: Modern Warfare 2 [52], the player has a combat knife weapon that can always be used to instantly eliminate an enemy. This encourages stealth and ensures that extremely close-range combat will never last long.

Among the many varied Melee Weapons in Team Fortress 2 [54] is the Übersaw, which can be equipped by the medic class. This melee weapon has a slower attack time, but charges up the player's special abilities when it hits.

Ratchet and Clank: Up Your Arsenal [53] gives the player two different variations on Melee Weapons. The first, the omniwrench, allows the player to hit enemies that are directly in front of them. The weapon can also be thrown like a boomerang to be used as a Thrown Projectile. The second weapon is the plasma whip, which does more damage, hits enemies in all directions around the player, and has a longer range. However, the use of the plasma whip is limited by ammunition, while the omniwrench has no such limitations.

3.2.7 PLACED WEAPON

Description:

A weapon placed in a stationary location, either by the user or by the level designer. The weapon acts independent of the user according to its own logic, even if the user is no longer present. Placed Weapons are categorized by having a large to medium area of effect, high damage output or a special effect over the area, and some method of activation.

Affordances:

- The method of activation of the weapon.
- If the weapon has a method through which opponents can deactivate the weapon.
- Any limitations on where the weapon can or cannot be placed.

Consequences:

The player gains a sense of control over a larger area.

Level Patterns:

Placed Weapons allow a player to easily defend a Choke Point or a Sniping Location through giving an effective way to defend a small area. They also allow a player to cover multiple entrances to a Stronghold simultaneously.

Placed Weapons are ineffective when Flanking Routes or large Arenas allow enemies to simply circumvent the area of effect. They are also not useful if the player needs to assault a Choke Point or Stronghold.

NPCs:

It is rare for NPCs to have Placed Weapons, but occasionally they can be found in the hands of Elites and Tanks.

Place Weapons are most effective against Aggressive enemies, whom the player can easily lead into the area of effect of a Placed Weapon. Shielded enemies, however, can often protect themselves against the efforts of a Placed Weapon.

Examples:

In Team Fortress 2 [54], the Engineer class can build a sentry gun that will automatically detect and fire upon enemies within its range. Enemies can destroy the turret by attacking it with normal weapons, but the Engineer can keep it alive by continually repairing it. Some areas of levels, such as spawn areas and capture points, cannot have sentry guns built upon them, as specified by the level designer, in order to prevent the weapon from being overpowered.

Throughout the world of Half-Life 2 [40], explosive barrels are scattered about. The player has the ability to pick these barrels up and place them as they please, setting up

traps in Choke Points or fortifying their defenses when tasked with guarding a Stronghold.

The Karl character in Super Monday Night Combat [56] has the ability to place a small, hovering robot called “Junior.” When an enemy comes within the short range of this weapon, it will follow that enemy until it either makes contact with an enemy or level geometry. Once that happens, it detonates, dealing a high amount of damage to a single target.



Figure 20: Placing a Junior robot in Super Monday Night Combat

3.3 EFFECTS OF WEAPON PATTERNS ON LEVEL DESIGN

By forcing the player to use particular weapons in certain parts of a level, the level designer utilizes the relationships between the weapon and level to best control the experience and gameplay.

For example, in the Ravenholm section of Half-Life 2, the player begins the level with a weak Melee Weapon, Sidearm, and Assault Weapon. The player progresses through Arenas and Chokepoints with a numerous number of Grunt and Swarm enemies, resulting in high tension and challenge. Later, the player fights Berserker and Carrier enemies, but acquires a Close Blast weapon and moves into Choke Points where the player has the advantage. The tension and challenge drop to give the player a respite and allow them to learn how to utilize the weapon. As the player proceeds, the level patterns become more Arenas and Split Levels, forcing the player to use weapons accordingly, bringing the challenge and tension back up for the climax of the level.

In multiplayer levels, weapon placement allows the level designer to direct players. The designer can hint at what weapons are best suited for a certain area, force players to carry an unsuitable weapon across an area to get somewhere where that weapon is more useful, or even make it more difficult to use a particular weapon from a particular location.

The multiplayer level Blood Gulch in Halo has Sniping Weapons atop each base at the ends of the map, overlooking large amount of the level and subtly hinting at the advantageous Sniper Position. A Power Weapon, the rocket launcher, is placed in the center of the map, forcing players to travel a long distance and expose themselves in order to procure the weapon.



Figure 21: The multiplayer level Blood Gulch in Halo

CHAPTER 4

UNDERSTANDING PLAYER BEHAVIOR

Key to this research is using analysis of data to understand the gameplay effects of the design patterns. As detailed in Chapter 1, this research is focused on examining patterns in key gameplay metrics to determine overall trends and how they are affected by the patterns and their affordances.

1 SOURCES OF DATA

The possible sources of data available to game developers are numerous; this section summarizes the most common forms of data.

1.1 INTERNAL TESTING

One of the earliest sources of data for game development teams is from their internal testing. This includes informal testing by the developers themselves and more formal testing by the QA team.

1.1.1 DEVELOPERS

The earliest testers of a game are the development team itself, and therefore are the earliest creators of useful data about the game. In the early development, teams create small prototypes to explore new ideas. While these prototypes are generally discarded

once the main development cycle begins, the lessons learned are an important in learning what works and doesn't work in the game.

Once the game is fully in development, the team will continuously be testing the game. Of particular interest to designers is the play balance of the game. Level designers will play levels to ensure that they have the correct difficulty level for where they appear in the game. Matching increasing difficulty to the players' increasing skill as they learn the game is key to keeping players engaged.

1.1.2 QUALITY ASSURANCE

The main objective of the quality assurance (QA) team is to find bugs and report them to the development team. Statistics from reported bugs are used to make production decisions in much the same way as they are used in traditional software development.

Many bugs are straightforward problems that the programmers, designers, and artists can easily address, but the QA team will often find problems with the playability of the game, including play balance issues. QA testers are often highly skilled game players, and continuously evaluate aspects of the game for difficulty, play time, and balance. Data collected from this playtesting can be used by the developers to make adjustments while the game is still in development.

1.2 EXTERNAL TESTING

External testing is testing done by players from the community, rather than members of the development or QA teams. Releases of the game used for external testing are generally instrumented to collect data about the players' actions in the game.

1.2.1 USABILITY TESTING

Usability testing is done with selected members of the target audience to better understand interactions with and reactions to the game. It is generally done under controlled psychological research protocols. To be effective, usability testing must be done late enough in the development cycle so that the game is representative of its final state, but not so late that it's costly to make changes.

In most cases, usability testing is the first time someone outside the organization plays the game. As the development and QA teams have been involved in the project for a long time, they are familiar with how the game is intended to be played and may not realize what is obvious or not to players. By putting a subject in a room and observing them play without instruction or interference, the development team can better gauge their expectations of how players will react to the finished game.

Typical outcomes of usability testing include the need for better tutorials to teach new players and clearer interfaces. Besides the qualitative assessment of players' reactions to the game, quantitative data about the players' specific actions can also be gathered.

1.2.2 BETA TESTS

A beta test is a release of a nearly-complete version of a game to a limited set of players. Beta testers are generally selected from a pool of players of previous games.

In the past, beta tests consisted of sending copies of games to members of the pool, waiting for them to play, and receiving back questionnaire responses and comments. However, with the increasing ubiquity of internet connected game machines, the beta version can be downloaded directly to the tester's machine and play data can be reported directly to the development team.

Beta tests can also contribute to the marketing of a game by giving players a preview of the game and building excitement about the release.

1.2.3 LONG-TERM PLAY DATA

While not actually testing per se, data gathered from players after a game's release can be an important source of data. Due to the increasing ubiquity of internet-connected game, development teams can easily collect player data indefinitely after release. If problems are found, teams can make changes and deliver a new version to players even after release.

Examples of useful data that can be obtained from long-term play include what achievements are earned, how quickly players progress, or preferred game play modes. One well known example of long-term play data are the Halo heat maps [57].

These show the locations of player deaths and kills by different weapons across all multiplayer maps. By examining these, the team can make adjustments for future releases.

Data from long-term play is particularly useful for maintaining play balance. A lack of balance may not have been appeared in earlier testing, but only becomes apparent after many months of play. An example would be an unanticipated dominant strategy. If, by observing play data, a team sees that a particular weapon has become favored, then they may want to adjust the balance to counter this.

Long-term data can also help teams plan the release of expansion content. When interest in a game starts to wane, developers can release new downloadable content that will entice players to continue playing. Also, examining at what point in their progress players start downloading new content can drive recommendation systems for future players.

Long-term play data is particularly impactful in the area of mobile and social game development. Developers like Zynga are increasingly data-driven and rely on data to make both design choices and to optimize games for monetization [58].

1.3 SUBJECTIVE EVALUATIONS

1.3.1 SURVEYS

While much of game metrics is focused on quantitative data, qualitative data is also important. Survey data can be collected along with the quantitative data collection during usability and beta testing. This data can be open ended, such as general questions about players' reactions to the game, or structured, such as rating various aspects of a game on a Likert scale.

1.3.2 REVIEWS

One source of expert data is reviews of games written by professional or non-professional journalists. The games industry is a large, international industry with hundreds of games released each year; game buyers consult reviews to determine what games are most worth spending their money on. By looking at reviews of their own and similar games, developers can decide what aspects to focus on to increase the likelihood of good reviews.

1.3.3 ONLINE COMMUNITIES

Gaming culture is increasingly involved and worldwide. Gamers don't play games in isolation; they comment upon and read other player's comments on various message boards and blogs dedicated to the subject.

Another aspect of online communities is expert players writing guides for new players. These guides, often called FAQs (from Frequently Asked Questions), are published at websites like GameFAQs.com. Information found in FAQs includes complete walkthroughs of games, strategy guides, maps, and character creation guides.

By monitoring the online communities populated by their players, development teams can get a sense of how their game has been received by the gaming community and how the audience's view of the game matches the design. If the walkthroughs miss some important aspect, then it was too hard to find. If players' assessment of the game's balance doesn't match the team's expectations, then the play balance may need adjustment.

1.3.4 POST MORTEMs

It is becoming increasingly common for industry-focused publications to publish game developers' post mortems after a game is released. This is a summary of what went right and wrong in the development process. By studying areas of development that were problematic in other projects, developers can better anticipate and avoid problems in their own projects.

CHAPTER 5

USER TESTS

To test the relationships between the level design patterns and player behavior we conducted a series of user tests. For these we constructed a set of levels that were designed explicitly to use instances of the design patterns. Additionally, the game engine was modified to record telemetry of the participant's in-game actions.

An initial pilot study was run to test the protocols and data collection. This pilot study used 10 participants playing 2 levels each. This led to several changes being made prior to the full study, which used 39 participants playing 5 levels each.

1 LEVELS

The levels for this study were specially made to explicitly use instances of the level design patterns. Each level had a primary creator, but much of the design process was collaborative. All levels were built in the Valve Hammer Editor.

Each level concept began with a brainstorming session to come up with an initial idea, which the primary level designer would then make a first pass on. After a week, the level designer would present their initial design to the group and receive feedback that would guide the continued development. After the levels were deemed complete

by the designers, a pass was made by another level designer to tune and balance the level, and by an artist that added textures and other aesthetic touches.

Following the philosophy of this work, the initial brainstorming sessions would start with explicit consideration of what patterns the level would contain. When choosing patterns, consideration would be given to the effect on the arcs of pace, challenge, and tension of the level. For example, if the previous pattern was one that would increase the pace, we would try to follow it with a pattern that decreased the pace. Figure 22 shows the initial patterns for RG03-03. The level begins with a Sniper Location that is controlled by enemy NPCs. This creates a high tension, high challenge, low pace situation for the player. This is followed by a Gallery where the player has the advantage, resulting in a generally low challenge, low tension situation that increases in tension and pace if the enemy NPCs successfully negotiate the gallery and begin engaging the player directly. Following this, the pace and tension are again dropped by presenting a player-advantage Sniper Location. And so on until it was agreed that there was sufficient action to be a complete level. Most levels contained 3-5 patterns.

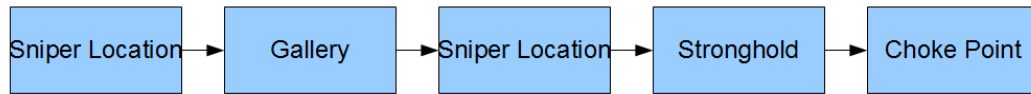


Figure 22: Initial Patterns for RG03-03

During the brainstorming process, we would also begin to craft a narrative that fit the patterns and would tie the level together. For RG03-03, for example, we wanted to use the Stronghold pattern, so came up with the idea of an enemy base being assaulted by the player. From this we worked back to the beginning, adding other patterns to create encounters with guards on the perimeter of the base.

With the patterns suggesting the overall arcs and a rough narrative in place, we could begin focusing on each pattern to determine which affordances would be appropriate for the desired gameplay. Continuing with the example of RG03-03, we knew we wanted the first Sniper Location to have an enemy advantage and be high challenge, high tension, and low pace. Providing good cover for the player helps slow the pace as it makes it likely they will make use of the cover to engage the enemy opportunistically. To help increase tension and challenge, the Sniper Location provides good cover for the enemy NPCs, making it more difficult for the player to engage them. Figure 23 shows detail for this pattern instance.

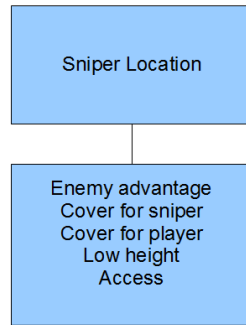


Figure 23: Detailed Affordances for Pattern SniperLocation-4

A total of ten levels were built for this project, two of which were used in the pilot study and an additional three were added for the full study. Table 1 shows the patterns in the levels used for the user tests. The two levels that were used for the pilot study were modified for the full study, so they are listed twice (two different versions) to show the changes. Level names follow the convention <initials of main designer><nth level made by designer>-<nth version>.

Table 1: Patterns in User Test Levels

Pilot Study					
GR01-06	Hidden Area	Flanking Route	Sniper Location	Stronghold	
RG03-03	Sniper Location	Gallery	Sniper Location	Stronghold	Choke Point
Full Study					
AY02-04	Arena	Choke Point	Sniper Location		

Baseline-02	Arena	Arena	Arena		
GR01-07	Arena	Sniper Location	Stronghold		
GR03-03	Sniper Location	Choke Point	Arena	Stronghold	
RG03-04	Sniper Location	Sniper Location	Stronghold	Choke Point	

1.1 ELEMENTS OF TEST LEVELS

Descriptions of the test levels and patterns therein depend on familiarity with the types of enemy NPCs, weapons, and items used by designers. Since the test environment is built on a Half-Life 2 mod, these elements are largely unchanged from the released game. This proved to be beneficial as all but one participant were previously familiar with Half-Life 2, minimizing potential effects from learning or unfamiliarity.

1.1.1 ENEMY NPCs

There were four different enemy NPC types used in the test levels. In order from least threat to most threat they were the metro police, combine soldier, shotgun soldier, and elite soldier.

1.1.1.1 Metro Police

The metro police officer (Figure 24) is the least difficult of the enemy NPCs in the test levels. They are a typical instance of the grunt pattern of combat NPCs. They are

typically armed with only a pistol, and sometimes only with the baton, a weak melee weapon. As they are generally used in patterns to create low challenge, high pace encounters they often appear singly or in pairs.

They are occasionally equipped with other weapons, e.g., in GR03-03 there is a squad of three metro police equipped with SMGs. They can also be implemented as an instance of the summoner pattern, as they can be set to deploy a manhack, a small flying drone that charges the player and engages with a melee attack (Figure 25).



Figure 24: Metro Police



Figure 25: Manhack

1.1.1.2 Combine Soldier

The combine soldier is the most common enemy NPC type in the test levels. They are faster and have more health than the metro police, but would still be considered an instance of the grunt pattern. They are generally equipped with SMGs and appear in groups of two or more. As they move quickly and use high rate of fire weapons, they are used to increase the pace and tension of a level.

They can also be set to throw frag grenades, making them instances of the grenadier pattern as well. They can be equipped with other weapons, for example, there is a pair equipped with AR2s in RG03-04. When equipped with shotguns they become shotgun soldiers.



Figure 26: Combine Soldier

1.1.1.3 Shotgun Soldier

The shotgun soldier is similar to the combine soldier except for being equipped with a shotgun. The different weapon generally creates different gameplay than the combine soldier. While the combine soldiers tend to move quickly and engage often, the shotgun soldier tends to close quickly and stand their ground, behavior more suited to the slower rate of fire shotgun. As such they may be used to decrease pace in a level.



Figure 27: Shotgun Soldier

1.1.1.4 Elite Soldier

The elite soldier is the most difficult of the enemy NPCs in the test levels. They are faster and even tougher than the combine and shotgun soldiers, making them instances of the elite NPC pattern. They are usually equipped with AR2s, a high-powered, rapid fire assault weapon. Besides its normal fire mode, the AR2 can also fire a slow but high damage attack. Elite soldiers often appear in groups of 4 or more, or singly in large groups of mixed enemy types. Due to their high threat level, they are used to increase tension and challenge in a level.



Figure 28: Elite Soldier

1.1.2 WEAPONS

The various weapons available in the user test levels may be used by both the player and the enemy NPCs. Enemy NPCs will use whatever weapon they are set up to use in the level design tool and are not limited on ammunition. Players, on the other hand, can choose what weapon to use, but are limited to the weapons and ammunition they

start with and find throughout the level. The designer may place weapons and ammunition in strategic locations throughout the level to encourage their use by the player. Players may also get weapons and ammunition as a reward for eliminating enemy NPCs.

Many of the weapons also have a secondary fire mode that has different effects from the primary fire mode, e.g., the grenade launcher on the SMG.

1.1.2.1 Crowbar

The crowbar is a basic melee weapon, a classic example of the melee weapon pattern. The player starts with a crowbar in every level in the full study. It does a small amount of damage and has a slow rate of attack. If a player uses the crowbar it may be an indication that the tension or challenge of a level is high, as the player has run out of ammunition for other weapons, or is actively trying to conserve ammunition.



Figure 29: Crowbar

1.1.2.2 Pistol

The pistol is the other basic weapon in the user test levels. Like the crowbar, the player always has access to this weapon from the start of every level. It is a fairly typical instance of the sidearm pattern. While it doesn't do much damage, it has a high rate of fire and a large ammo capacity. If the player is forced to rely on this weapon the likely effect is an increase in pace, as the player will have to move and engage quickly to eliminate enemy NPCs. They are usually carried by metro police NPCs.



Figure 30: Pistol

1.1.2.3 SMG

The sub-machine gun (SMG) is another very common weapon. It is the primary weapon used by the combine soldiers, the most common enemy type, so players are often able to pick up an SMG after eliminating a combine soldier. It does similar damage to the pistol, but has a much higher rate of fire and larger ammo capacity. It is not very accurate and used most effectively by firing short bursts at a close range.

As such, it is an instance of the close blast weapon pattern. When the player uses the SMG it generally has the effect of increasing pace.

The SMG has a grenade launcher as a secondary fire mode. Ammunition for this fire mode is rare in the user test levels, but when available to the player, the SMG is also an instance of the launched projectile weapon pattern.



Figure 31: SMG

1.1.2.4 .357

The .357 is a powerful, accurate, slow firing weapon. A head shot from the .357 will eliminate most enemy NPCs outright, while other shots will still do significant damage. It fits most closely to the power weapon design pattern, but its high accuracy allows it to be used as an instance of the sniper weapon as well. Due to the advantage it provides the player, it is placed sparingly in levels. When used by the player it has the effect of lowering pace and challenge.



Figure 32: .357

1.1.2.5 Shotgun

The shotgun is another powerful, slow firing weapon, though it is only useful at a much closer range due to its lower accuracy. The shotgun could be considered an instance of either the power weapon or a close blast design patterns. It has higher damage than the .357, and it has a secondary fire mode that increases damage even more. It is relatively rare in the user test levels; generally only as a pick up after eliminating a shotgun soldier NPC. Given the low rate of fire and low accuracy, it encourages a play style where players charge enemy NPCs and engage at close range. This is likely to decrease pace.



Figure 33: Shotgun

1.1.2.6 AR2

The AR2 is a high rate of fire weapon that closely fits the assault weapon design pattern. Each individual bullet doesn't do too much damage, but it has a large ammo capacity, high rate of fire, and is reasonable accurate over medium to long ranges, making it one of the best all around weapons. It is used sparingly in the user test levels, generally only as a pickup after eliminating an elite soldier. It has a secondary fire mode: a high damage single shot that will eliminate most enemy NPCs in one hit. If this fire mode is available, the AR2 fits the power weapon design pattern.



Figure 34: AR2

1.1.2.7 Crossbow

The crossbow has the highest damage of all weapons in its primary fire mode. It is also the most accurate at long range, making it a classic example of the sniper weapon pattern. It is equipped with a scope that allows the player to zoom in on targets and engage from a safe distance. Its extremely slow reload time and low ammo capacity balance its high damage and make it a poor choice for close combat engagements. In the user test levels, it is usually made available to the player at or near a sniper location instance, signaling the intended game play. Ammunition is generally limited. When used by the player it generally reduces the pace of the level as players will reduce movement to take advantage of the weapon and corresponding sniper location.

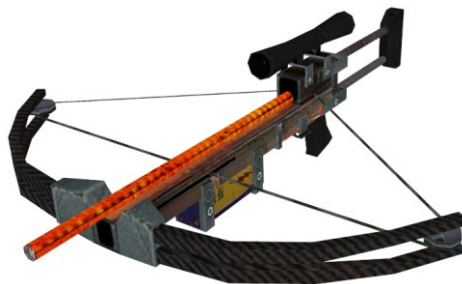


Figure 35: Crossbow

1.1.2.8 Frag Grenade

The frag grenade is a typical example of the thrown projectile weapon pattern. It delivers high damage, but as an area effect that is easily avoided due to its delayed effect. Frag grenades appear in the user test levels primarily when used against the

player by combine soldiers. They do sometimes drop frag grenades when eliminated, allowing the player to use them. However they are used so infrequently by players that they do not have a significant impact on the data analyses.



Figure 36: Frag Grenade

1.1.3 ITEMS

Various other items are placed in the levels by designers to aid the player. These include items that increase the player's health and armor stats and ammunition for various weapons. In addition to placed items, enemy NPCs sometimes drop weapons that the player can then pick up and use. In our data analysis we study item and weapon pickups by the player as an indicator of the pace of a level. Some examples of items are shown in Figure 37.



Figure 37: Example Items: (Clockwise from left) Suit charger, shotgun ammo, health kit, SMG grenade, Pistol Ammo

2 DATA COLLECTION

2.1 TELEMETRY

The game engine used for this study, Valve's Source SDK [59], has a built-in data logging system, but it needed to be heavily modified for our purposes. Several new event types had to be added to study player behavior in the needed detail, some of which required modifying other parts of the source code to track.

It was important to be able to track the participant's progress through the level. To record this, an event was added to the telemetry system to report player state at a regular interval. This event is triggered automatically when a timer expires (every 5 seconds in the pilot study and every $\frac{1}{2}$ second in the full study). It records the player's

position (X, Y, Z coordinates), their current health and armor levels, and what weapon they have equipped.

Since combat constitutes a major portion of the gameplay in a FPS, we want to track all combat actions involving the player. This includes whenever the player fires a weapon, when they do damage to an enemy NPC, and when they eliminate an enemy NPC. Furthermore, we need to track when the player takes damage and when the player is killed. When triggered, these events get logged along with the appropriate supporting information, such as player position, NPC position and type, damage dealt, weapon equipped, and the distance between the entities.

To track participants' actions within pattern instances, we logged events for entering and exiting patterns. This was accomplished by using the Source SDK's trigger system. In level design these are used to trigger events like opening doors or spawning enemies. For the user test we added additional triggers that did nothing but were named appropriately so we could track when the player entered and exited the pattern instance, as well as a level end trigger so we could track when the player successfully completed a level. We then added a trigger event to the data logging system that logged an event with the name of the trigger upon activation. Triggers were named PatternEnter-<pattern type>-<instance #> or PatternExit-<pattern type>-<instance #> so they could be readily identified in the data analysis phase.

Table 2: Logged Events

Event Name	Activation	Data Logged
LevelInit	Level begins (either initially or after a restart)	Level name
Trigger	Player touches trigger	Trigger name (PatternEnter, PatternExit, LevelEnd)
PlayerStatusReport	Timer expires (5 seconds in pilot, 0.5 seconds in full)	Player position (X, Y, Z), health, armor, weapon equipped
WeaponFired	Player fires weapon	Weapon type, primary or secondary, player position
WeaponHitEntity	Player's weapon hits enemy NPC	Weapon type, primary or secondary, damage, enemy type, distance, player position, enemy position
PlayerKilledOtherWeapon	Player eliminates enemy NPC	Weapon type, enemy type, distance, player position, enemy position
PlayerDamage	Player takes damage	Damage, enemy type, distance enemy position, player position
PlayerDeath	Player dies	Enemy type, distance, enemy position, player position
PlayerPickedUpItem	Player picks up pre-placed item	Item type, player position
PlayerPickedUpWeapon	Player picks up weapon dropped by enemy NPC	Weapon type, player position

2.2 VIDEO CAPTURE

While data analysis can provide a lot of quantitative information about player behavior, the qualitative information gained from content analysis also provides useful insights. In order to do content analysis we captured videos of each participant's playthrough. For this we used FRAPS [60], a commercial video capture program often used for digital game applications. One drawback of this system is that it does not support automatically starting video capture, requiring the study facilitator to start it manually for each level. This resulted in capture being started late or not at all for some levels in both the pilot and full studies.

3 PILOT STUDY

The pilot study used 10 participants who played two levels each. The participants were primarily recruited from graduate students involved in game research, many of whom were already familiar with the goals of the project. All participants used the same experimental setup: Dell XPS laptop connected to a widescreen TV and controlled by a mouse and keyboard. The order in which levels were played was alternated between participants; half played GR01-06 first, while the other half played RG03-03 first. All participants were given a list of common commands used in the game.

Prior to the study, each participant was asked a series of questions to gauge their experience with FPS games and digital games in general. These questions are listed in

Table 3 and a summary of responses in Table 4. The purpose of the survey was to justify excluding any participant with a low enough skill level to invalidate their data, but for the pilot study, all participants proved to be experienced FPS players.

Table 3: Pilot Study Participant Survey Questions

1. What was the last game you played?
2. How many hours a week do you play games?
3. What percentage of your gaming time is spent playing shooter games? (How many hours a week do you play shooter games?)
4. What is your favorite shooter game?
5. On a scale of 1-10, how would you rate your skill level with shooter games?
6. Have you played games in the Half-Life series before? Which ones?

Table 4: Pilot Study Participant Survey Responses

Average hours per week spent playing games	12.8
Average percentage of gaming time spent playing shooter games	34%
Average self-assessed skill level (1-10)	6.65
Percentage of participants who had previously played games in the Half-Life series (including Team Fortress 2, Counter Strike and other Source SDK games)	100%

3.1 LESSONS LEARNED

The purpose of the user study was to identify any problems in the protocols or data capture system and address them prior to the full study. As such, there were minor adjustments made throughout the study, and several major ones made after.

In the participant survey (shown in Table 3), question 3 was originally "How many hours a week do you play shooter games?", but "What percentage of your gaming time is spent playing shooter games?" proved to be a more straightforward question, and generally received quicker and more precise responses. Since this question immediately followed "How many hours a week do you play games?" it made more sense as a follow-up question. Participants only had to give one estimate of the number of hours, after which it was easier to break that number down as a percentage. For Table 4, the responses for participants asked the first phrasing of the question were adjusted to the equivalent value in the second phrasing.

Another question that participants had difficulty forming succinct responses to was #4, "What is your favorite shooter game?" For the full study, we changed the wording to "Do you have a favorite shooter game?" Participants in the full study tended to give quicker and more precise answers to the second phrasing. Though it was phrased as a yes/no question, participants generally named their favorite game without further prompting.

For the pilot study, participants were asked to play two levels during which data and video were being captured. Early participants were also given the option of first playing a test level for a few minutes without data or video being collected to acclimate to the game. All early participants took this option, and played part of an arbitrarily selected level from the 8 not being used in the pilot study. We stopped giving participants the option to go straight into the study levels and began asking them all to play a test level first. In order to equalize the participants' experience, we selected Baseline-01 as the test level played by all participants, though we continued to not collect data or video for this level. This proved successful, so we made Baseline-02 (the next iteration of Baseline-01) the first level played by all participants in the full study, and began capturing data and video.

A major insight gained from the pilot study was that the difficulty of the levels was much too high, even for experienced players. As is typical in game development, the designers become too familiar with and skilled at the game to objectively gauge its difficulty. As such, participants who were not as familiar found the levels to be extremely difficult. GR01-06 proved to be extremely difficult, resulting in 21 deaths among the 10 participants, or 2.1 deaths on average. 14 of those came in the extremely difficult FlankingRoute-1 pattern instance, the first one encountered in the level. RG03-03 was also unexpectedly difficult, with 1.3 average deaths on per player. The new iterations of these levels used in the full study, GR01-07 and RG03-04, were significantly rebalanced, and resulted in less than 0.5 average deaths per

player each. All the levels used for the full study were rebalanced and tested externally before the full study.

Based on the early analysis of the data captured during the pilot study, several changes were also made to the telemetry. In the pilot study, we were capturing the distance from the player to the enemy NPC for combat actions like `PlayerDamage` and `WeaponHitEntity`, but we also wanted to be able to show these combat actions in the visualization tool like we did for the player's path through the level. This required adding the player's and enemy NPC's positions to the logged event. We also wanted to be able to analyze non-combat data as well, so we added the `PlayerPickedUpItem` and `PlayerPickedUpWeapon` events. Both proved to be a good measure of player exploration in the full study data analysis.

Various incremental improvements were also made to the test protocols, such as having a single script to run all the test levels and forcing the game to exit once the participant completed a level, instead of requiring the study facilitator to shut it down manually.

4 FULL STUDY

The full study used 39 participants playing five levels each. The participants were primarily recruited from undergraduate students at UCSC. The experimental setup was largely the same as in the pilot study, with one major exception: instead of

playing on a widescreen TV they played on a 23" computer monitor. This allowed for uniform test conditions regardless of location. The monitor and laptop could be taken anywhere convenient for the participants, rather than forcing them to come to the room where the TV is located.

The full study used five levels rather than the two in the pilot, one baseline and four full levels. All participants played the baseline level first, but as in the pilot we wanted to vary the order of the other levels. A script was written that generated all possible permutations of the four full levels, and selected the order based on the participant number given by the facilitator. As there are 24 possible permutations of four levels, all orderings were used at least once, and most twice.

As in the pilot, each participant was asked a series of questions to gauge their experience with FPS games and digital games in general. The new questions are listed in Table 5. Besides the changes mentioned in section 3.1, some questions received minor rewording. Again, the purpose of the survey was to justify excluding any participant with a low enough skill level to invalidate their data, but all participants proved to be sufficiently skilled. A summary of participant responses is in Table 6. On average, the full study participants played fewer hours per week, but spent more of their time playing shooter games, and gave themselves higher skill ratings.

Table 5: Full Study Participant Survey Questions

1. What was the last game you played?
2. About how many hours a week do you play games on average?
3. About what percentage of that is spent playing shooter games?
4. Do you have a favorite shooter game?
5. On a scale of 1-10, how would you rate your skill with shooter games?
6. Have you played games in the Half-Life series before?

Table 6: Full Study Participant Survey Responses

Average hours per week spent playing games	10.4
Average percentage of gaming time spent playing shooter games	47%
Average self-assessed skill level (1-10)	7.15
Percentage of participants who had previously played games in the Half-Life series (including Team Fortress 2, Counter Strike and other Source SDK games)	95%

Besides the difficulty re-balancing described in section 3.1, many levels were shortened for the full study. After the numerous participant deaths in the pilot study, it

was clear that shorter levels were desirable, as the impact on the player and the collected data due to the restart would be reduced. Since participant would have to restart the level from the beginning each time they died, multiple restarts were undesirable. If a large number of participants restarted a level, there would be significantly more events logged in the first part of the level than in the later sections. This is potentially biasing for two reasons. First, the amount of data for each pattern could vary considerable, with earlier patterns being played more often. Second, on subsequent play throughs, participants have already seen the level and know what to expect, resulting in different behavior than on the first play through.

CHAPTER 6

RESULTS

This section presents the results from our user study. To show the effects of design patterns in FPS levels on gameplay, we built levels explicitly using patterns and performed quantitative and qualitative analyses of player behavior. The primary facets of player behavior are pace, tension, and challenge. To study how they are affected by level design, we must first identify what metrics are related to which facet so we can measure the change.

1 KEY METRICS

The metrics considered in this study can be divided into three broad categories: movement, combat, and support. Movement metrics include the speed and distance of movement, as well as the player's use of cover. Combat metrics include frequency of combat actions, the distance at which they occur, accuracy, and damage done. Both player and enemy NPC actions are considered. Support metrics include the player's health and armor levels, the number of items and weapons they collect and the frequency of the collections, as well as weapon preferences. Metrics recorded within a pattern can be compared to the metrics for similar patterns, to other patterns, or to a level overall to determine how player behavior is affected by the design of the level.

To measure the effects on pace, tension, and challenge, we considered which metrics were most strongly tied to these facets. For each facet we considered what metrics we would expect to change, and in what ways, when the facet is increased or decreased. Table 7, Table 8, and Table 9 show how the metrics are expected to change for each facet.

When looking at pace (Table 7), the focus is on how quickly the player is taking actions. As such, the frequency with which the player moves, and how far they move between each measurement are good metrics. In terms of combat actions, the frequency of engagements, be they firing weapons, hitting enemy NPCs, or killing enemy NPCs, is indicative of pace. Weapon and Item collection frequency is also tied to pace, as is the preference for high rate of fire weapons such as the SMG and AR2.

Table 7: Metrics Affecting Pace

Metric	High Pace	Low Pace
Movement Distance	Larger	Smaller
Movement Percentage	Higher	Lower
Engagement Frequency	Higher	Lower
Preference for High Rate of Fire Weapon	Increased	Decreased

Item Collection Frequency	Higher	Lower
Weapon Collection Frequency	Higher	Lower

Tension is about the mental stress the player is experiencing. When tension is high, the player is less able to consider consequences and make good judgments. A tendency to "freeze up" and reduce movement percentage is indicative of high tension. In combat engagements, accuracy would be affected by tension, as well as the player's tendency to charge into or retreat from enemies. In a high tension situation, players would be less likely to manage their weapon selection, while in low tension situations they are more likely to seek to take advantage of long-range weapons.

Table 8: Metrics Affecting Tension

Metric	High Tension	Low Tension
Movement Percentage	Lower	Higher
Distance Change During Engagement	Retreating	Closing
Accuracy	Lower	Higher
Preference for Long-Range Weapons	Decreased	Increased

When challenge is high, players are more likely to make use of cover, whereas when challenge is lower, players feel freer to move about without fear of consequence. Player deaths, damage, the frequency they take hits, and the distance they are hit from are all tied to challenge. In response to a challenging encounter, a player is likely to prefer more powerful weapons.

Table 9: Metrics Affecting Challenge

Metric	High Challenge	Low Challenge
Movement Distance	Smaller	Larger
Player Deaths	Increased	Decreased
Player Damage	Increased	Decreased
Frequency of Player Hits	Faster	Slower
Distance Player Hit from	Increased	Decreased
Preference for Powerful Weapons	Increased	Decreased

Table 10 shows all the patterns in the full study levels, and Figure 38 through Figure 41 show the levels and patterns.

Table 10: Patterns in Full Study Levels

Level	Pattern	Affordances
AY02-04	Arena-1	Medium size, good cover, medium resistance
	ChokePoint-1	Enemy advantage, wide, heavy resistance, no cover
	SniperLocation-1	Player advantage, high, good cover, no access
GR01-07	Arena-2	Small size, good cover, heavy resistance
	SniperLocation-2	Player advantage, low, no cover, access
	Stronghold-1	Enemy advantage, small, good cover, access
GR03-03	SniperLocation-3	Player advantage, high, good cover, no access
	ChokePoint-2	Enemy advantage, narrow, light resistance, good cover
	Arena-3	Large, minimal cover, light resistance
	Stronghold-2	Enemy advantage, good cover, minimal access
RG03-04	SniperLocation-4	Enemy advantage, low, access
	SniperLocation-5	Player advantage, good cover, no access
	Stronghold-3	Enemy advantage, large, minimal cover
	ChokePoint-3	Player advantage, narrow, heavy resistance, no cover

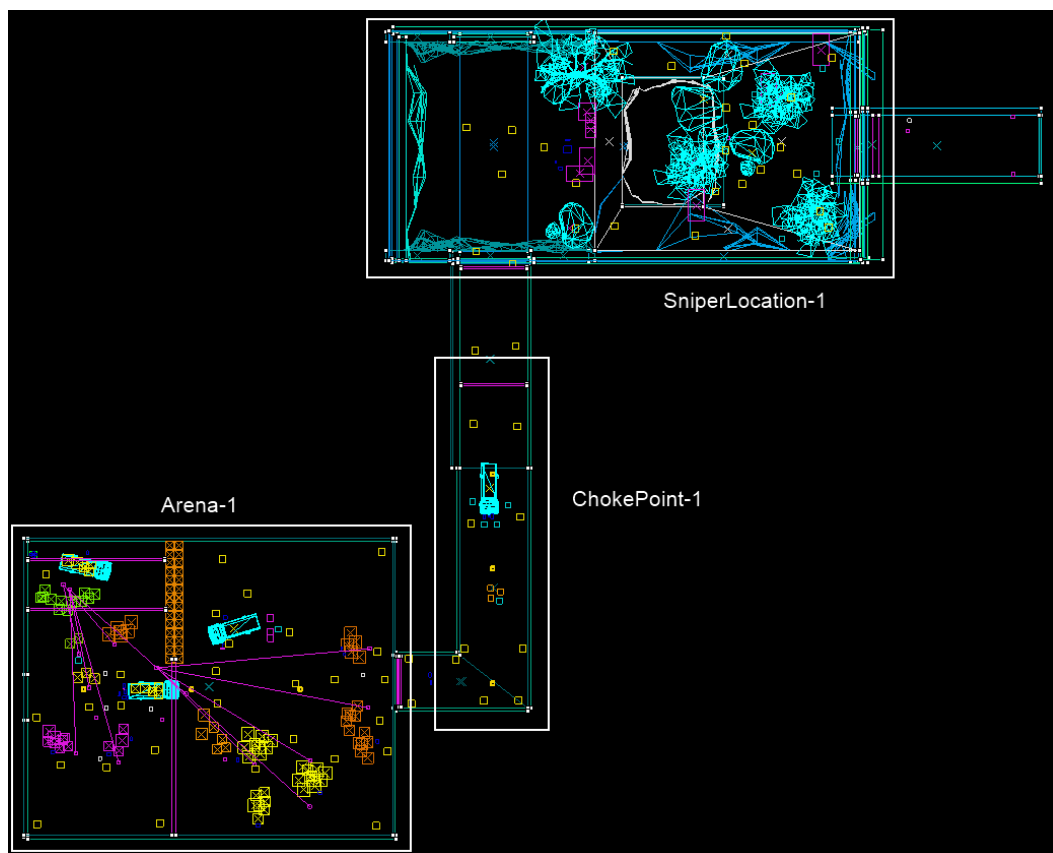


Figure 38: AY02-04

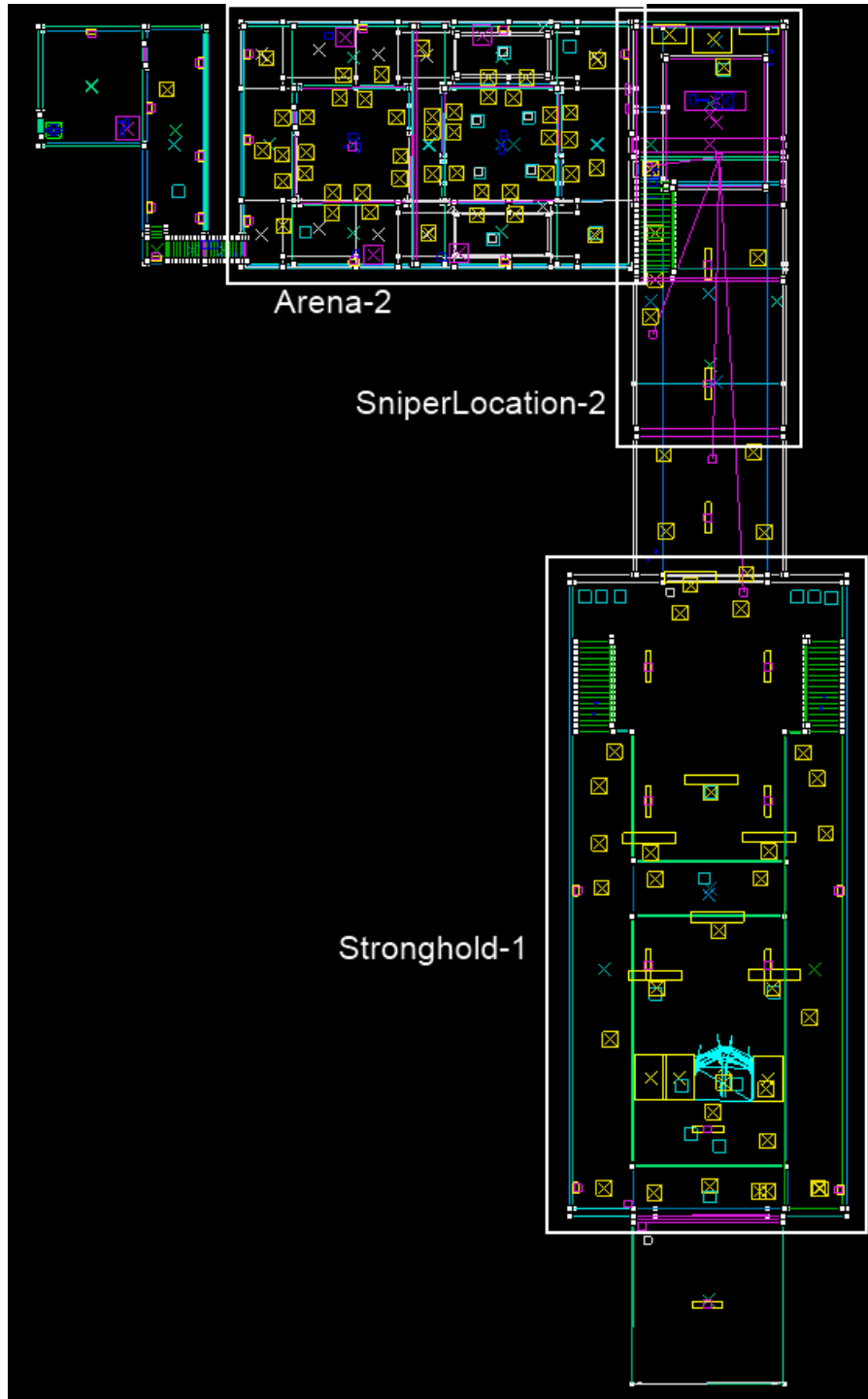


Figure 39: GR01-07

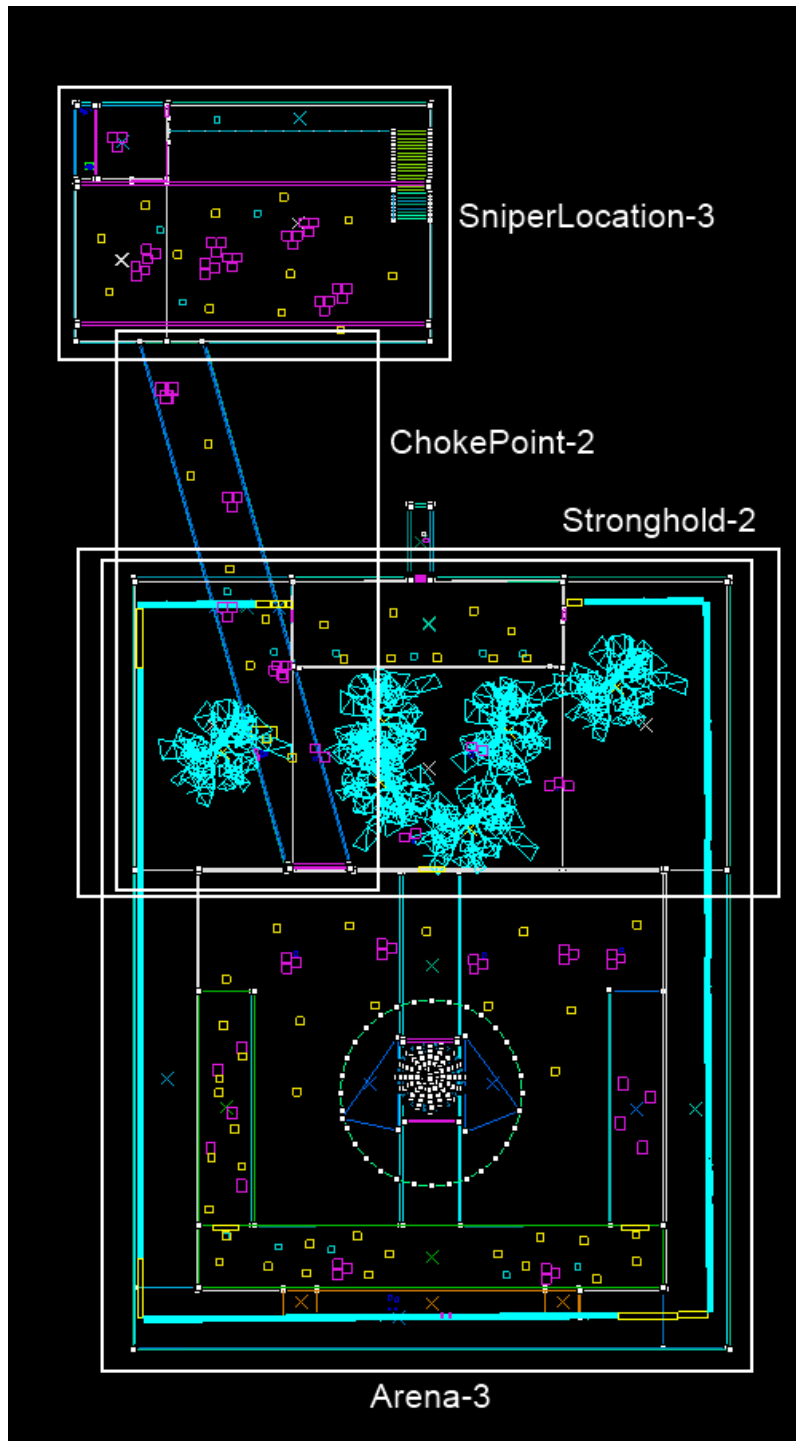


Figure 40: GR03-03

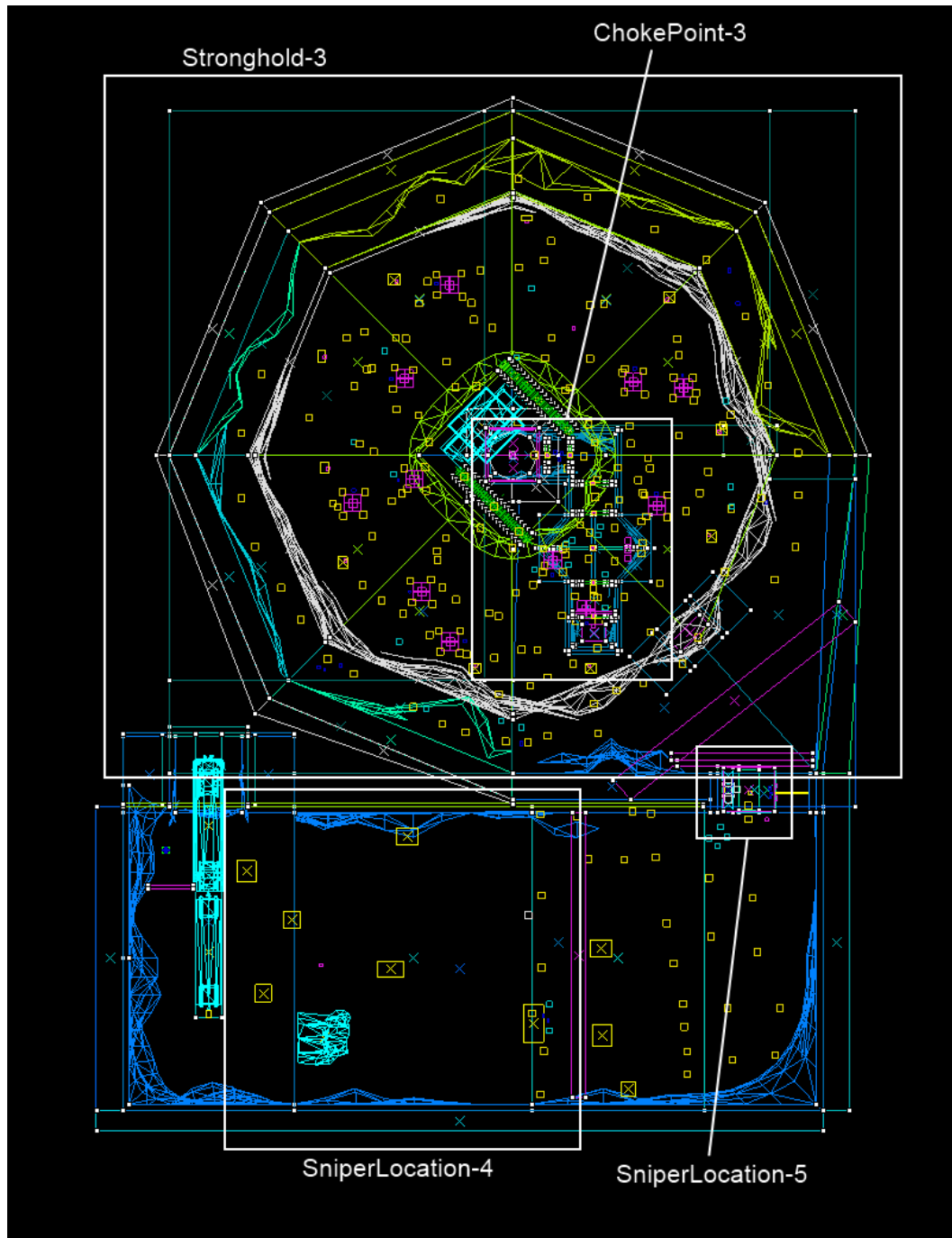


Figure 41: RG03-04

2 DATA ANALYSIS

Following the user tests, we examined the data to draw conclusions about the effect the patterns had on player behavior. We compared player behavior in a pattern to the level overall to see what deviation from the baseline was apparent. We also calculated the p-value for each metric using the Student's t-test [61]. Generally, the threshold for significance is a p-value less than 0.05, meaning less than a 5% chance that the two sets of data could have come from populations with the same mean and standard deviation.

2.1 SNIPER LOCATION

Sniper locations are one of the more common patterns in FPS levels. There were 5 different sniper locations in the 5 levels in the user test. Each was designed with different intended gameplay effects.

Table 11: Intended Gameplay Effects, Sniper Locations

Pattern	Pace	Tension	Challenge
SniperLocation-1	Decrease	Decrease	Decrease
SniperLocation-2	Increase	Increase	Decrease
SniperLocation-3	Increase	Decrease	Decrease
SniperLocation-4	Decrease	Increase	Increase
SniperLocation-5	Decrease	Decrease	Decrease

2.1.1 SNIPERLOCATION-1

SniperLocation-1 is a wide, high, well-covered, player-advantage position that overlooks a small area containing 5 combine soldiers. The enemy NPCs have no access to the sniper location and a crossbow is available for pick up in an obvious location. This combination of affordances was selected by the designer to lower the pace of the level, as the player is likely to take advantage of the sniper location to engage the enemy NPCs from the protected location, taking care to make accurate shots with the crossbow or other long-range weapon. The height of the sniper location and lack of access contribute to the reduction of tension as there are no significant threats to the player. As the enemy NPCs have little cover or other means to counter the player's advantage, the challenge is reduced.

Table 12: Key Metrics in SniperLocation-1

Metric	Overall	Pattern	p-Value
Movement Distance	61.8	59.7	0.41
Movement Percentage	18.2%	16.8%	0.35
Enemy Hit Distance	556.3	980.0	1.1×10^{-19}
Enemy Killed Distance	616.9	1003.9	2.6×10^{-17}
Player Fired Frequency	0.9	2.3	4.1×10^{-4}

Enemy Hit Frequency	2.1	3.0	0.0068
Enemy Killed Frequency	8.5	6.1	0.0046
Player Deaths	4	1	n/a
Player Damage	4.0	10.2	0.0025
Player Hit Frequency	7.3	8.4	0.71
Player Hit Distance	541.3	1345.7	7.2×10^{-6}
Accuracy (all weapons)	22.6%	49.1%	1.9×10^{-5}
Crossbow Preference	10.0%	32.8%	7.9×10^{-6}
Crossbow Accuracy	51.3%	51.3%	1
.357 Preference	30.1%	15.3%	4.9×10^{-4}
.357 Accuracy	75.9%	30.7%	3.8×10^{-7}
SMG Preference	46.1%	39.0%	0.21
SMG Accuracy	17.9%	6.4%	1.9×10^{-12}
Item Collection Frequency	8.5	3.3	0.012
Weapon Collection Frequency	15.4	16.1	0.88

The movement distance and frequency are lower in the pattern than in the level overall, but the difference isn't significant. A larger difference would suggest a reduced pace as players would move less (possibly using cover more) in the pattern and more slowly when they did, but that doesn't appear to be the case in this pattern. Engagement frequencies, however, are significantly lower, consistent with a reduced pace. Player fired, enemy hit, and enemy killed times are longer, suggesting players are taking more time to line up shots. The high rate of fire SMG was still the most preferred weapon, suggesting that players were not inclined to take advantage of the sniper location advantage by using the long range but slower firing crossbow.

The minimal effect on movement percentage suggests a minimal effect on tension; players were not experiencing enough additional mental stress that they were unwilling to move, but were not so free of tension that they moved without fear of consequence. The increase in overall accuracy suggests a tension decrease. The lack of a significant preference for the long-range weapons is also inconsistent with the expected gameplay. Players are using the provided crossbow, but only 33% of the time. This suggests that players are either not picking the crossbow up, or are preferring other weapons. The other long-range weapon available in the level, the .357, was used less than in the pattern than in the overall level. The data here suggests an overall increase in tension, contrary to the designer's intent.

The small increase in movement percentage suggests an increase in the use of cover, but not so much that players are feeling threatened. While players took more damage and at a greater distance, they took hits at a lower frequency and died less. While preference for the powerful crossbow weapon was increased, the preference for the .357 was decreased, leaving the overall effect on challenge unclear.

Table 13: Expected v. Observed Changes in SniperLocation-1

Trait	Expected	Observed
Pace	Decrease	Decrease
Tension	Decrease	Increase
Challenge	Decrease	Indeterminate

While the expected decrease in pace occurred in this pattern, the effects on the other aspects of player behavior were unclear. The data suggests an increase in tension as players were not aggressively closing on enemy NPCs and were generally less accurate. The height, availability of cover, lack of access, and availability of a long range weapon were intended to create a low tension situation, but it's likely that the large number of enemies in a small space had the opposite effect - players felt threatened and compelled to overcome the threat as quickly as possible.

While the effect on challenge is less clear, the intent of creating a low challenge situation was not realized. Players were generally able to eliminate the threat from the enemy NPCs without much difficulty, but the engagement was more balanced than the designer intended.

2.1.2 SNIPERLOCATION-2

SniperLocation-2 is a low, accessible, player-advantage sniper location. After the player drops in from above and eliminates the one enemy NPC currently in the sniper location, an assault of six combine soldiers engage the player. The enemy NPCs will enter the sniper location if the player does not cover the access. The need to cover the access creates a high pace, high tension situation as the player struggles to overcome the advancing enemy NPCs. However, it is not particularly challenging due to the position advantage and the presence of the high powered crossbow weapon.

Table 14: Key Metrics in SniperLocation-2

Metric	Overall	Pattern	p-Value
Movement Distance	46.5	40.2	0.03
Movement Percentage	10.8%	6.8%	0.002
Enemy Hit Distance	427.7	513.8	0.17
Enemy Killed Distance	520.2	570.4	0.45

Player Fired Frequency	0.9	3.8	0.05
Enemy Hit Frequency	1.9	8.8	0.1
Enemy Killed Frequency	9.1	22.1	0.06
Player Deaths	19	0	n/a
Player Damage	3.7	2.7	0.09
Player Hit Frequency	3.9	2.0	0.005
Player Hit Distance	404.0	276.0	0.02
Accuracy (all weapons)	26.0%	38.0%	0.02
Crossbow Preference	17.9%	43.7%	4.1×10^{-7}
Crossbow Accuracy	70.8%	55.6%	0.004
.357 Preference	21.7%	13.1%	0.02
.357 Accuracy	68.5%	25.8%	2.3×10^{-7}
Pistol Preference	12.3%	4.2%	5.2×10^{-5}
Pistol Accuracy	59.8%	10.9%	6.9×10^{-13}
SMG Preference	36.3%	35.9%	0.9

SMG Accuracy	19.3%	17.6%	0.6
Item Collection Frequency	12.6	26.0	0.07
Weapon Collection Frequency	12.8	24.5	0.04

The lower movement distance and frequency in this pattern indicate a reduction in pace. Frequency of combat actions was lower, also suggesting a lower pace. Preference for the high rate of fire weapons, the pistol and SMG, were either reduced or relatively unchanged. Item and weapon collection frequencies were also lower, overall suggesting that the pace was lowered in this pattern.

The decrease in movement percentage is consistent with an increase in tension as players are under too much stress to maneuver. Overall accuracy was minimally increased, and preferences for long-range weapons were opposing - preference for the crossbow was increased (due to the player automatically picking it up when dropping in to the pattern), while preference for the .357 was decreased. Overall this suggests an increase in tension.

Though GR01-07 was the second most difficult level in terms of player deaths, there were no player deaths in SniperLocation-2. Players took hits from enemy NPCs at shorter range, indicating a greater willingness to be exposed to risk. Players also took

slightly less damage and at a lower frequency than in the level overall, consistent with the expected decrease in challenge.

Table 15: Expected v. Observed Changes in SniperLocation-2

Trait	Expected	Observed
Pace	Increase	Decrease
Tension	Increase	Increase
Challenge	Decrease	Decrease

The data indicates an effect on pace in this pattern that is inconsistent with the designer's expectations. The assault force was supposed to move in quickly, forcing the player to respond quickly as well. However, the area covered by the sniper location is long and lacks cover, allowing players to eliminate the incoming enemy NPCs one by one, rather than creating the large combat situation as intended.

2.1.3 SNIPERLOCATION-3

SniperLocation-3 is a high, large, well covered player advantage sniper location with no access. Players overlook a large area containing three metro police, plus another metro police in the sniper location. No long range weapon is provided, the player is only equipped with the pistol and crowbar. Given the advantage of the position, the

relative weakness on the enemy NPCs, and the position of the pattern at the beginning of the level, the designer's intent to create a fast paced, low tension, low challenge experience for the player to start the level.

Table 16: Key Metrics in SniperLocation-3

Metric	Overall	Pattern	p-Value
Movement Distance	61.1	47.9	2.4×10^{-6}
Movement Percentage	21.0%	13.2%	3.0×10^{-6}
Enemy Hit Distance	645.3	499.0	0.0003
Enemy Killed Distance	581.5	404.4	0.0001
Player Fired Frequency	1.3	1.0	0.1
Enemy Hit Frequency	2.8	1.7	0.004
Enemy Killed Frequency	11.1	8.4	0.2
Player Damage	3.8	2.8	4.4×10^{-7}
Player Hit Distance	670.0	563.1	0.02
Player Hit Frequency	7.1	4.5	0.09
Accuracy (all weapons)	37.9%	54.3%	3.1×10^{-5}

Movement distance was significantly reduced by the pattern, as was movement percentage, suggesting more use of cover, which is not consistent with the intended increase in pace. The engagement frequencies are lower, though the effects are not significant for player firing and enemies killed. Since weapon preference and item collections can't be compared the effect on pace is unclear.

The lower movement percentage might suggest higher tension, but accuracy is higher and the difference between enemy NPC hit and kill distances is larger in the pattern, suggesting lower tension. Given the low threat from the enemy NPCs, this might result from players not feeling particularly challenged, rather than paralyzed due to high levels of stress.

Players were hit by enemy NPCs less frequently, took less damage on average, and were hit at closer range. This is consistent with the goal of reducing challenge.

Table 17: Expected v. Observed Changes in SniperLocation-3

Trait	Expected	Observed
Pace	Increase	Indeterminate
Tension	Decrease	Decrease
Challenge	Decrease	Decrease

As mentioned above, the indeterminate effect on pace is more likely a secondary effect of the reduced challenge - players were not under any particular threat so had no incentive to move or engage in combat quickly.

2.1.4 SNIPERLOCATION-4

SniperLocation-4 is the only enemy NPC advantage sniper location in the user test. It's low, has good cover, easy access, and is the first encounter in the level. The two combine soldiers are equipped with AR2s, while the player only has the pistol and crowbar. The intended gameplay is that the player will work their way up to the sniper location by moving from cover to cover until they are in position to engage the enemy NPCs. The pace should be low while the tension and challenge should be high.

Table 18: Key Metrics in SniperLocation-4

Metric	Overall	Pattern	p-Value
Movement Distance	71.9	76.6	0.3
Movement Percentage	24.4%	25.1%	0.8
Enemy Hit Distance	553.2	680.3	0.02
Enemy Killed Distance	543.9	503.8	0.5
Player Fired Frequency	0.9	1.8	0.01
Enemy Hit Frequency	2.1	3.2	0.08
Enemy Killed Frequency	10.1	28.9	0.01
Player Deaths	20	0	n/a
Player Damage	3.5	3.1	0.0001
Player Hit Distance	500.7	720.2	0.0002
Player Hit Frequency	3.8	4.7	0.6
Accuracy (all weapons)	29.6%	56.5%	4.0×10^{-16}
Item Collection Frequency	17.1	19.7	0.4

Weapon Collection Frequency	15.7	28.7	0.0004
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The differences in move distance and frequency are not significant. Player fired, enemy killed, and weapon collection frequencies, however, are significantly lower, suggesting an overall decrease in pace.

Players exhibited a tendency to close on the enemy NPCs in this pattern, indicating a decrease in tension. Also accuracy was significantly increased, resulting in an overall decrease in tension for this pattern.

Though this was the most difficult level, there were no player deaths in this pattern. Players were generally hit from a greater distance, but damage was roughly the same and hit frequency was slightly lower, making it difficult to say conclusively how challenge was affected.

Table 19: Expected v. Observed Changes in SniperLocation-4

Trait	Expected	Observed
Pace	Decrease	Decrease
Tension	Increase	Decrease
Challenge	Increase	Indeterminate

The failure to create the intended effect for tension suggests that the pattern did not create the stressful situation that the designer intended. Due to the easy access and low number of enemy NPCs, players were able to rush into the engagement, diffusing the tension and obviating the intended challenge.

2.1.5 SNIPERLOCATION-5

SniperLocation-5 is a player advantage sniper location that has good cover and no access. It is off the main path through the level, so players could bypass it entirely if they are not exploring. The crossbow is available to be picked up in the sniper location. The intended gameplay effect is to give the player an opportunity to engage and eliminate enemy NPCs from a protected location, thus reducing the resistance they will encounter on their future advancement through the level. Due to the lack of threats, the pattern is expected to reduce pace, tension, and challenge.

Table 20: Key Metrics in SniperLocation-5

Metric	Overall	Pattern	p-Value
Movement Distance	71.9	32.0	1.1×10^{-11}
Movement Percentage	24.4%	5.8%	3.0×10^{-11}

Enemy Hit Distance	553.2	776.8	0.0003
Enemy Killed Distance	543.9	772.7	0.0002
Player Fired Frequency	0.9	3.8	0.003
Enemy Hit Frequency	2.1	5.4	0.01
Enemy Killed Frequency	10.1	10.6	0.8
Player Deaths	20	1	n/a
Player Damage	3.5	2.3	0.01
Player Hit Distance	500.7	514.3	0.9
Player Hit Frequency	3.8	16.9	0.2
Accuracy (all weapons)	29.6%	57.0%	0.0005
Pistol Preference	17.8%	5.1%	5.0×10^{-6}
Pistol Accuracy	54.3%	9.4%	7.6×10^{-14}
SMG Preference	21.3%	10.4%	0.0005
SMG Accuracy	16.2%	4.2%	1.6×10^{-10}
AR2 Preference	18.7%	3.5%	1.5×10^{-11}

AR2 Accuracy	41.1%	11.6%	1.8×10^{-8}
.357 Preference	19.2%	24.3%	0.2
.357 Accuracy	69.5%	54.8%	0.1
Crossbow Preference	5.5%	52.8%	7.2×10^{-9}
Crossbow Accuracy	62.7%	74.7%	0.2
Item Collection Frequency	17.1	2.5	2.0×10^{-16}
Weapon Collection Frequency	15.7	33.1	0.3

The smaller movement distance and frequency are consistent with decreased pace. Engagement frequencies are also generally lower than in the level overall. In terms of weapon selection, preference for the high rate of fire weapons, the pistol, SMG, and AR2, were all reduced.

The effect on tension is less clear. Movement percentage was reduced and the difference between enemy hits and kills was unaffected. Overall accuracy was increase, as was preference for the crossbow. Preference for other high rate of fire weapons, the .357 and AR2, were reduced or were not significantly affected.

The reduction in challenge seems to have been achieved. While this was the most difficult level, there was only one player death in this pattern. There was minimal change to damage, and hit frequency was lower. While some high powered weapons, like the .357 and crossbow, were preferred, this can be attributed more to their suitability for sniper behavior than the difficulty of the pattern.

Table 21: Expected v. Observed Changes in SniperLocation-5

Trait	Expected	Observed
Pace	Decrease	Decrease
Tension	Decrease	Indeterminate
Challenge	Decrease	Decrease

The indeterminate change in tension might be attributable to the small size of the sniper location and availability of cover. The reduced movement and accuracy could be a result of players feeling well protected, rather than experiencing high amounts of stress.

2.2 ARENA

Arenas are another common pattern. Many areas in levels that allow for large scale combat could be considered arenas, and both choke points and strongholds could be

considered specialized types of arenas. The three pure arenas that appear in the test levels and their intended effects are listed in Table 22.

Table 22: Intended Gameplay Effects, Arenas

Pattern	Pace	Tension	Challenge
Arena-1	Decrease	Increase	Increase
Arena-2	Increase	Increase	Increase
Arena-3	Increase	Decrease	Decrease

2.2.1 ARENA-1

Arena-1 is a medium sized arena with good cover and medium resistance. Enemy NPCs include two metro police and two waves of 4 combine soldiers. The intent is low pace, due to the small size of the arena, but high tension and challenge due to the number of enemy NPCs.

Table 23: Key Metrics in Arena-1

Metric	Overall	Pattern	p-Value
Movement Distance	61.8	54.5	0.009
Movement Percentage	18.2%	14.1%	0.007
Enemy Hit Distance	556.3	499.4	0.03

Enemy Killed Distance	616.9	551.9	0.03
Player Fired Frequency	0.9	0.8	0.7
Enemy Hit Frequency	2.1	1.8	0.2
Enemy Killed Frequency	8.5	7.1	0.03
Player Deaths	4	1	n/a
Player Damage	4.0	3.1	0.0002
Player Hit Distance	541.3	448.1	0.009
Player Hit Frequency	7.3	4.9	0.005
Accuracy (all weapons)	22.6%	24.6%	0.4
Pistol Preference	9.2%	9.9%	0.8
Pistol Accuracy	33.5%	33.1%	1.0
SMG Preference	46.1%	44.4%	0.6
SMG Accuracy	17.9%	17.6%	0.8
.357 Preference	30.1%	40.5%	0.003
.357 Accuracy	75.9%	77.5%	0.7

Item Collection Frequency	8.5	7.0	0.06
Weapon Collection Frequency	15.4	11.8	0.07

The smaller movement distance and frequency is consistent with lower pace. Engagement frequencies are higher, but the difference is not significant. There is a higher preference for the slow firing .357 weapon, and item and weapon collection times are faster, though not significant. Overall the effect on pace is unclear.

Smaller move frequency is consistent with higher tension, as is the retreating behavior shown by the difference between enemy hit and kill distances, though this is smaller than in the level overall. Accuracy was not affected by a significant amount.

In terms of challenge, there were fewer deaths, lower player damage, and lower player hit distance. Players did move less frequently, suggesting more use of cover, and players were hit more frequently. The high powered .357 was more preferred in this pattern, but so was the pistol, one of the lowest-powered weapons.

Table 24: Expected v. Observed Changes in Arena-1

Trait	Expected	Observed
Pace	Decrease	Indeterminate
Tension	Increase	Increase
Challenge	Increase	Indeterminate

It seems the large number of low-powered enemy NPCs prevented the pattern from having the intended effect. Multiple enemies meant faster combat action than expected, and the segmentation of the waves of attackers prevented the combat from ever being too challenging.

2.2.2 ARENA-2

Arena-2 is a small arena containing tight, narrow corridors and small rooms. There is heavy resistance, three waves of combine soldiers. There is good cover as players can duck around corners or in and out of rooms. The intent is to create a high paced, tense, challenging combat encounter.

Table 25: Key Metrics in Arena-2

Metric	Overall	Pattern	p-Value
Movement Distance	46.5	41.0	0.01
Movement Percentage	10.8%	7.5%	0.008
Enemy Hit Distance	427.7	324.4	2.4×10^{-7}
Enemy Killed Distance	520.2	345.4	1.4×10^{-10}
Player Fired Frequency	0.9	1.1	0.2
Enemy Hit Frequency	1.9	1.9	0.9
Enemy Killed Frequency	9.1	9.0	0.9
Player Deaths	19	6	n/a
Player Damage	3.7	3.3	0.03
Player Hit Distance	404.0	241.8	2.2×10^{-13}
Player Hit Frequency	3.9	5.4	0.2
Accuracy (all weapons)	26.0%	33.8%	0.007
Pistol Preference	12.3%	11.0%	0.5

Pistol Accuracy	59.8%	35.3%	0.0002
SMG Preference	36.3%	48.5%	0.002
SMG Accuracy	19.3%	20.7%	0.3
.357 Preference	21.7%	35.8%	0.0009
.357 Accuracy	68.5%	70.2%	0.8
Item Collection Frequency	12.6	13.9	0.3
Weapon Collection Frequency	12.8	9.9	0.01

In the pattern players moved less often and for shorter distances. They also engaged enemies less frequently, but only by small amounts. The high rate of fire SMG weapon was more preferred, but so was the slow rate of fire .357. Items were collected more frequently, but weapons slightly less, making the overall effect on pace unclear.

Players moved less frequently in this pattern, and while they generally retreated in combat, the difference is less than in the level overall. Accuracy was slightly increased, and preference for the long range .357 was greater. Again the overall effect is unclear.

In terms of challenge, movement distance was decreased slightly, consistent with increased challenge, but most of the other metrics suggest an overall decrease. Player deaths, player damage, player hit frequency, and player hit distance were all lower. Preference for the .357 was higher, but so were the preferences for the pistol and SMG.

Table 26: Expected v. Observed Changes in Arena-2

Trait	Expected	Observed
Pace	Increase	Indeterminate
Tension	Increase	Indeterminate
Challenge	Increase	Indeterminate

It seems that the tightness and narrowness of this pattern and the large number of enemy NPCs worked contrary to the intended increase in pace. Players were forced to use cover and engage opportunistically, rather than engage in the run and gun style gameplay envisioned by the designer. Similarly, the intended effects on tension and challenge are unclear. While players did experience enough stress to affect their movement, they were still able to make considered decisions regarding weapon

choice and aiming. In spite of the large numbers of enemy NPCs, they were not so difficult to overcome that the pattern posed a considerable challenge for the player.

2.2.3 ARENA-3

Arena-3 is a large, open, multi-level arena with minimal cover and light resistance. Given the large space to cover and the low number of enemy NPCs, the intended gameplay is for the player to move quickly and dispatch enemies with little difficulty. The pace should increase, while the tension and challenge should be low.

Table 27: Key Metrics in Arena-3

Metric	Overall	Pattern	p-Value
Movement Distance	61.1	76.7	6.0×10^{-7}
Movement Percentage	21.0%	32.2%	3.8×10^{-6}
Enemy Hit Distance	645.3	602.7	0.5
Enemy Killed Distance	581.5	582.3	1.0
Player Fired Frequency	1.3	2.0	0.2
Enemy Hit Frequency	2.8	2.8	1.0
Enemy Killed Frequency	11.1	6.6	2.4×10^{-5}

Player Deaths	3	0	n/a
Player Damage	3.8	6.0	0.002
Player Hit Distance	670.0	484.5	0.0006
Player Hit Frequency	7.1	4.3	0.05
Accuracy (all weapons)	37.9%	46.8%	0.08
SMG Preference	16.6%	22.7%	0.1
SMG Accuracy	13.8%	12.6%	0.6
.357 Preference	28.8%	40.8%	0.02
.357 Accuracy	57.7%	56.8%	0.9
Shotgun Preference	10.3%	22.9%	3.7×10^{-5}
Shotgun Accuracy	25.1%	20.4%	0.5
Item Collection Frequency	16.3	13.1	0.1
Weapon Collection Frequency	15.6	6.7	2.9×10^{-7}

The effect on pace appears to be supported, as both movement distance and frequency were increased. Enemy killed frequency is higher, though the other combat

frequencies were unaffected. The preference for the high rate of fire SMG was higher, though not significant. Weapon and item collection frequencies were higher.

The effect on tension does not appear to be supported. While movement percentage was greater, and players were generally closing in the pattern, it was at less of a difference than in the level overall. Overall accuracy was higher, though not significant. Preference for the long range .357 was greater. These metrics suggest that tension was increased overall.

In terms of challenge, players moved further, died less, were hit less frequently and at closer distance. However, damage was higher and preference for high powered weapons like the .357 and shotgun were increased, making the overall effect unclear.

Table 28: Expected v. Observed Changes in Arena-3

Trait	Expected	Observed
Pace	Increase	Increase
Tension	Decrease	Increase
Challenge	Decrease	Indeterminate

The large, open spaces of this pattern clearly had the effect of increasing pace, but contained too many high powered enemy NPCs to cause the intended decrease in

tension and challenge. While players were able to move quickly into and out of combat encounters, the combination of many combine soldiers and shotgun soldiers proved too difficult to defeat without taking hits and relying on high powered weapons, thus creating a more stressful experience for the player than intended.

2.3 CHOKE POINT

A choke point is another means of giving one side an advantage in a combat encounter. As one side is funneled through a narrow corridor, they are easier targets for the opposing side. Generally enemy NPC advantage choke points are meant to increase pace and challenge for the player, as they must move quickly and eliminate the threat. Player advantage choke points should reduce the pace, as players will reduce movement while taking advantage of their position and reduce challenge as they can more easily engage enemy NPCs trapped in the choke point. Widening the choke point will reduce this advantage.

Table 29: Intended Gameplay Effects, Choke Points

Pattern	Pace	Tension	Challenge
ChokePoint-1	Increase	Increase	Increase
ChokePoint-2	Increase	Decrease	Decrease
ChokePoint-3	Decrease	Increase	Increase

2.3.1 CHOKEPOINT-1

ChokePoint-1 is a wide, enemy advantage choke point with heavy resistance and no cover. There are two elite soldiers and two combine soldiers, all armed with SMGs and grenades. While the corridor is wide enough that the player could run past, the number of enemies present make it unlikely that this could succeed without taking considerable damage. The intended gameplay is to increase pace, tension, and challenge, as the player will have to move quickly to eliminate the sudden charge of high powered enemy NPCs.

Table 30: Key Metrics in ChokePoint-1

Metric	Overall	Pattern	p-Value
Movement Distance	61.8	80.7	1.3×10^{-7}
Movement Percentage	18.2%	26.6%	0.002
Enemy Hit Distance	556.3	469.1	0.0004
Enemy Killed Distance	616.9	452.0	2.7×10^{-7}
Player Fired Frequency	0.9	0.9	0.9
Enemy Hit Frequency	2.1	1.6	0.2
Enemy Killed Frequency	8.5	5.9	0.03

Player Deaths	4	2	n/a
Player Damage	4.0	3.3	0.1
Player Hit Distance	541.3	390.0	0.001
Player Hit Frequency	7.3	3.0	1.4×10^{-5}
Accuracy (all weapons)	22.6%	28.9%	0.05
SMG Preference	46.1%	66.1%	0.0005
SMG Accuracy	17.9%	19.2%	0.4
.357 Preference	30.1%	23.7%	0.2
.357 Accuracy	75.9%	33.4%	3.9×10^{-7}
Item Collection Frequency	8.5	7.9	0.6
Weapon Collection Frequency	15.4	4.2	8.5×10^{-9}

Most metrics indicate an increase in pace. Player movement distance and frequency are increased. Enemy kill frequency is higher, though player firing and enemy hit frequencies are not significantly affected. Preference for the high rate of fire SMG is increased. Weapon collection is faster.

The effect on tension is less clear. Movement percentage is higher. The difference between the enemy hit and kill distances is small, suggesting players are neither charging nor retreating. Players were generally retreating in the level overall, so the change suggests that tension is lower in this pattern. Also, accuracy is higher and preference for the long range .357 is lower.

Half of all player deaths in this level occurred in this pattern, and players were hit more frequently. However, damage was slightly lower and players were hit at closer distance. Also, preference for the high powered .357 was decreased and movement distance was increased, making the overall effect on challenge unclear.

Table 31: Expected v. Observed Changes in ChokePoint-1

Trait	Expected	Observed
Pace	Increase	Increase
Tension	Increase	Decrease
Challenge	Increase	Indeterminate

While the pattern had the expected effect on pace by creating a fast combat encounter, it did not create the level of difficulty or stress that was intended with the use of the tougher elite soldier NPCs. Players were challenged, but not to the

expected degree, and the encounter wasn't so high pressure as to cause players to flee or make excessive use of cover.

2.3.2 CHOKEPOINT-2

ChokePoint-2 is a long, narrow corridor with good cover. It serves as an enemy NPC advantage choke point. It has light resistance in the form of three metro police NPCs. With the low difficulty and readily available cover, the intent is to increase pace while decreasing tension and challenge.

Table 32: Key Metrics in ChokePoint-2

Metric	Overall	Pattern	p-Value
Movement Distance	61.1	48.7	2.4×10^{-7}
Movement Percentage	21.0%	11.6%	3.3×10^{-9}
Enemy Hit Distance	645.3	768.9	0.05
Enemy Killed Distance	581.5	632.7	0.4
Player Fired Frequency	1.3	1.1	0.09
Enemy Hit Frequency	2.8	2.0	0.01
Enemy Killed Frequency	11.1	8.0	0.009

Player Deaths	3	0	n/a
Player Damage	3.8	3.5	0.4
Player Hit Distance	670	710.6	0.6
Player Hit Frequency	7.1	7.6	0.8
Accuracy (all weapons)	37.9%	43.4%	0.1
SMG Preference	16.6%	18.9%	0.4
SMG Accuracy	13.8%	6.7%	0.001
Pistol Preference	34.2%	43.2%	0.006
Pistol Accuracy	54.8%	55.2%	0.9
Item Collection Frequency	16.3	4.1	7.1×10^{-9}
Weapon Collection Frequency	15.6	6.3	7.5×10^{-10}

While there was a decrease in the movement percentage, all other metrics indicate an increase in pace. Engagement frequencies are all faster and item and weapon collection are faster. Preference for the high rate of fire weapons, the pistol and SMG, were increased.

In terms of tension, players exhibited closing behavior with a larger difference than in the level overall. As there weren't any long range weapons available to the players in this part of the level, we cannot compare preferences.

The data is also consistent with a decrease in challenge. There were no player deaths in this pattern. Players generally took less damage, and at a slower frequency. Player hit distance was unchanged, and there were no high powered weapons available to the player.

Table 33: Expected v. Observed Changes in ChokePoint-2

Trait	Expected	Observed
Pace	Increase	Increase
Tension	Decrease	Decrease
Challenge	Decrease	Decrease

It's clear from the data that the designer's intent was enacted by this pattern. The small number of low-difficulty enemy NPCs succeeded in drawing the player forward without overpowering them. Players felt confident enough to engage at close distance.

2.3.3 CHOKEPOINT-3

ChokePoint-3 is a narrow player advantage choke point with no cover. It is the last pattern in the level. Shortly after dropping into the area, the player's position is assaulted by heavy resistance in the form of 6 combine soldiers. Given the number of enemy NPCs and the suddenness of the encounter, the intent is to increase tension and challenge. But since the area is small and the player has no room to maneuver, pace should be decreased.

Table 34: Key Metrics in ChokePoint-3

Metric	Overall	Pattern	p-Value
Movement Distance	71.9	61.2	8.6×10^{-5}
Movement Percentage	24.4%	11.4%	3.7×10^{-10}
Enemy Hit Distance	553.2	200.6	6.3×10^{-34}
Enemy Killed Distance	543.9	198.5	2.4×10^{-34}
Player Fired Frequency	0.9	0.9	0.9
Enemy Hit Frequency	2.1	1.4	0.08
Enemy Killed Frequency	10.1	5.3	0.009
Player Deaths	20	4	n/a

Player Damage	3.5	3.3	0.02
Player Hit Distance	500.7	170.7	2.8×10^{-29}
Player Hit Frequency	3.8	1.5	6.1×10^{-7}
Accuracy (all weapons)	29.6%	54.3%	4.7×10^{-10}
SMG Preference	21.3%	16.7%	0.3
SMG Accuracy	16.2%	7.3%	0.0002
.357 Preference	19.2%	9.0%	0.001
.357 Accuracy	69.5%	22.5%	1.7×10^{-7}
Shotgun Preference	14.4%	28.2%	0.01
Shotgun Accuracy	41.1%	34.9%	0.4
AR2 Preference	18.7%	37.1%	0.0005
AR2 Accuracy	41.1%	42.9%	0.7
Crossbow Preference	5.5%	0.1%	2.8×10^{-11}
Crossbow Accuracy	62.7%	n/a	n/a
Item Collection Frequency	17.1	9.6	0.06

Weapon Collection Frequency	15.7	11.2	0.6
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Movement percentage decreased and enemy kill frequency was reduced. Preference for the high rate of fire SMG was reduced, while the slow rate of fire shotgun was more preferred. Item collection times were slower. All these metrics indicate a reduction in pace.

The decrease in movement percentage also indicates increased tension. Other metrics that support this are the reduced preferences for long range weapons like the crossbow and .357. However, other metrics are more ambiguous. Accuracy was improved and there was little effect on the distance change between enemy hits and kills.

Almost a quarter of the player deaths in this level occurred in this pattern and player hits were more frequent, though player damage was lower. Preferences for high power weapons like the AR2 and shotgun were increased and players were hit at closer range. The overall effect of challenge is unclear

Table 35: Expected v. Observed Changes in ChokePoint-3

Trait	Expected	Observed
Pace	Decrease	Decrease
Tension	Increase	Indeterminate
Challenge	Increase	Indeterminate

While the confined space had the intended effect on pace, the effects on tension and challenge were not as strong. While there were many player deaths, the increased difficulty was not so much that players were experiencing great challenge or undue amounts of stress. Since this pattern provided only a short encounter it may not have been sufficient to have noticeable effects.

2.4 STRONGHOLD

A stronghold is a specialized type of arena where the player either assaults or defends a fixed location. Generally access is limited. A stronghold can either give an advantage to the player, by giving them a secure position to defend, or to the enemy NPCs by requiring the player to assault their position. Strongholds are often used to create a challenge for the player, or to create a high-pressure situation that increases tension.

Table 36: Intended Gameplay Effects, Strongholds

Pattern	Pace	Tension	Challenge
Stronghold-1	Decrease	Decrease	Increase
Stronghold-2	Decrease	Increase	Increase
Stronghold-3	Increase	Decrease	Increase

2.4.1 STRONGHOLD-1

Stronghold-1 is a small, enemy NPCs advantage stronghold. It is well defended, with four elite soldiers, two shotgun soldiers, and three combine soldiers. There is plenty of cover available for both the player and NPCs and there are multiple access points. The need to assault a protected position and the large number of defenders is meant to increase challenge, but the small space should decrease pace. The pattern is not designed to be stressful for the player, so tension should decrease.

Table 37: Key Metrics in Stronghold-1

Metric	Overall	Pattern	p-Value
Movement Distance	46.5	58.3	0.001
Movement Percentage	10.8%	18.2%	0.0002
Enemy Hit Distance	427.7	599.3	6.4×10^{-6}

Enemy Killed Distance	520.2	698.0	5.2×10^{-5}
Player Fired Frequency	0.9	1.3	0.08
Enemy Hit Frequency	1.9	3.2	0.01
Enemy Killed Frequency	9.1	11.4	0.08
Player Deaths	19	13	n/a
Player Damage	3.7	4.1	0.08
Player Hit Distance	404.0	642.1	9.5×10^{-11}
Player Hit Frequency	3.9	3.8	0.9
Accuracy (all weapons)	26.0%	28.6%	0.4
SMG Preference	36.3%	33.0%	0.3
SMG Accuracy	19.3%	11.9%	1.5×10^{-7}
.357 Preference	21.7%	12.4%	0.002
.357 Accuracy	68.5%	47.9%	0.03
Shotgun Preference	2.0%	5.6%	0.0004
Shotgun Accuracy	16.2%	16.2%	1.0

AR2 Preference	4.5%	11.8%	0.0001
AR2 Accuracy	22.1%	22.1%	1.0
Crossbow Preference	17.9%	31.1%	0.0001
Crossbow Accuracy	70.8%	66.2%	0.4
Item Collection Frequency	12.6	19.3	0.04
Weapon Collection Frequency	12.8	15.4	0.3

While movement distance and percentage were higher, engagement times were slower. Preference for the higher rate of fire AR2 was increased. Item collection times were slower, so the overall effect on pace is unclear.

Movement percentage was higher, and the difference between enemy hit and kill distances is similar to the level overall. Preference long range weapons like the crossbow and AR2 were increased.

13 of the 19 player deaths in the level occurred in this pattern. Player damage was higher, and players took hits at greater distance. Preference for high powered weapons like the AR2 and crossbow were higher.

Table 38: Expected v. Observed Changes in Stronghold-1

Trait	Expected	Observed
Pace	Decrease	Indeterminate
Tension	Decrease	Decrease
Challenge	Increase	Increase

While the intended effects on tension and challenge are supported by the data, the effect on pace is unclear. While the area is relatively small, players tended to move more than expected to probe different openings, resulting in some metrics indicating higher pace. However other metrics, like item collection frequency and weapon preferences are consistent with lower pace.

2.4.2 STRONGHOLD-2

Stronghold-2 is an enemy advantage stronghold. There is heavy resistance with four elite soldiers. There is good cover for both the player and enemy NPCs. The stronghold only has minimal access, with a door at either end. The expected gameplay is for the player to make use of the cover to avoid fire from the enemy NPCs. This is expected to increase tension while decreasing pace. Due to the number

of high powered enemy NPCs and the position as the final pattern in the level suggests that challenge will be increased.

Table 39: Key Metrics in Stronghold-2

Metric	Overall	Pattern	p-Value
Movement Distance	61.1	60.0	0.7
Movement Percentage	21.1%	19.6%	0.4
Enemy Hit Distance	645.3	746.8	0.04
Enemy Killed Distance	581.5	695.7	0.04
Player Fired Frequency	1.3	2.3	0.03
Enemy Hit Frequency	2.8	4.6	0.06
Enemy Killed Frequency	11.1	29.6	1.6×10^{-7}
Player Deaths	3	3	n/a
Player Damage	3.8	3.1	0.0009
Player Hit Distance	670.0	746.8	0.1
Player Hit Frequency	7.1	2.6	0.0005

Accuracy (all weapons)	37.9%	35.6%	0.5
SMG Preference	16.6%	21.7%	0.2
SMG Accuracy	13.8%	6.4%	0.0003
.357 Preference	28.8%	41.3%	0.009
.357 Accuracy	57.7%	48.7%	0.2
AR2 Preference	4.4%	14.0%	1.0×10^{-6}
AR2 Accuracy	3.4%	3.4%	1.0
Item Collection Frequency	16.3	3.4	2.9×10^{-13}
Weapon Collection Frequency	15.6	3.5	4.3×10^{-5}

Movement distance and movement percentage did not differ by significant amounts. Engagement times are slower, though item and weapon pickup times were faster. Preference for the high rate of fire AR2 was higher, making the overall effect on pace unclear.

Few of the metrics related to tension experience significant effects. Movement percentage was not affected, and players exhibited similar closing behavior to the overall level. Accuracy overall was not affected, but accuracy was lower with the

SMG. One metric that doesn't support increased tension is higher preference for the long range .357.

In terms of challenge, there appears to be some increase. All player deaths in the level occurred in this pattern. While was slightly lower, players took hits at a faster rate and at a further distance. Preference for high powered weapons like the .357 and AR2 were increased.

Table 40: Expected v. Observed Changes in Stronghold-2

Trait	Expected	Observed
Pace	Decrease	Indeterminate
Tension	Increase	Indeterminate
Challenge	Increase	Increase

Gameplay largely matched designer intent in this pattern, except the effects on pace were unclear. In terms of many metrics, pace was reduced as players were compelled to use cover, engage more slowly, and not pick up items. But when players did move they moved further, and when engaging were more likely to use high rate of fire weapons. This may have been more of an effect of what weapons were available to the player than anything.

2.4.3 STRONGHOLD-3

Stronghold-3 is a large, enemy advantage stronghold with limited access. It contains heavy enemy resistance, with 15 NPCs of different types. Given the large area to cover, player pace is expected to increase, and the large number of enemy NPCs is intended to increase challenge. However, there is lots of cover available for the player, and they never have to engage more than a few enemies at a time, so tension is not intended to increase.

Table 41: Key Metrics in Stronghold-3

Metric	Overall	Pattern	p-Value
Movement Distance	71.9	85.9	1.6×10^{-7}
Movement Percentage	24.4%	32.7%	0.0001
Enemy Hit Distance	553.2	625.3	0.0009
Enemy Killed Distance	543.9	609.4	0.01
Player Fired Frequency	0.9	1.1	0.2
Enemy Hit Frequency	2.1	3.0	0.03
Enemy Killed Frequency	10.1	12.5	0.03
Player Deaths	20	13	n/a

Player Damage	3.5	3.8	0.01
Player Hit Distance	500.7	604.2	5.2×10^{-5}
Player Hit Frequency	3.8	4.0	0.6
Accuracy (all weapons)	29.6%	23.2%	0.0005
SMG Preference	21.3%	28.4%	0.04
SMG Accuracy	16.2%	13.6%	0.06
.357 Preference	19.2%	23.1%	0.2
.357 Accuracy	69.5%	56.6%	0.03
Shotgun Preference	14.4%	22.6%	0.01
Shotgun Accuracy	41.1%	26.4%	0.02
AR2 Preference	18.7%	15.6%	0.2
AR2 Accuracy	41.1%	27.4%	0.001
Crossbow Preference	5.5%	2.1%	0.0003
Crossbow Accuracy	62.7%	25.7%	0.0002
Item Collection Frequency	17.1	17.5	0.8

Weapon Collection Frequency	15.7	09.8	0.07
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Movement distance and percentage were increased, as was preference for the high rate of fire SMG. However, engagement times were slower, as were item and weapon collection times (though not by a significant amount), making the overall effect on pace unclear.

In terms of tension, players exhibited more closing behavior in the pattern than the in the level overall. Movement percentage was higher, and preference for long range weapons was reduced except for the .357. One metric that doesn't correspond to reduced tension is the reduction in accuracy.

The effect on challenge appears to be as intended. 13 of the 20 deaths in this level occurred in this pattern. Damage was higher, and players took hits from a greater distance. Preference for the high powered weapon .357 was higher.

Table 42: Expected v. Observed Changes in Stronghold-3

Trait	Expected	Observed
Pace	Increase	Indeterminate
Tension	Decrease	Decrease
Challenge	Increase	Increase

Like the other strongholds, the effect on pace is the most difficult to assess. In this pattern, players had to move a lot to cover the entire area, but engagement times were lower due to the delay between encounters.

CHAPTER 7

DISCUSSION

Design patterns describe common game design idioms, expressing cause-effect relationships between these elements and gameplay. This research develops the science of level design by identifying and describing patterns in single player FPS level design, combat NPCs, and weapons. There are undoubtedly other, unidentified, patterns in these domains and others. Some additional pattern collections are introduced in Appendix A.

Unlike existing work on level design, these level design patterns provide concrete cause-effect explanations that designers can use to organize their thinking, communicate their ideas, and explore design alternatives. Additionally, these design patterns provide a useful, tangible way to teach level design. We anticipate these design patterns will lead to greater understanding of level design in FPS games, and through this, greater innovation in the genre.

To further explore these patterns and their effects, this research includes a user study that gathers data on player behavior in FPS levels. Through analysis of this data, we were able to explore the actual effects of these patterns on gameplay, leading to improvements in the pattern collection.

1 RESEARCH QUESTIONS

The goal of this research is to use data analysis to gain a deeper understanding of FPS level design and how it creates gameplay. This section revisits the research questions presented in Chapter 1 to examine how they have been addressed by the research.

- **RQ1: Are level design patterns useful for developing levels, communicating ideas, and teaching about level design?**

Level design patterns, as with the game design patterns previously explored by Björk, can support designers in four ways: idea generation, development of game concepts, problem solving, and communication [13]. In our process of exploration of design patterns and application to the user test levels, this research has shown their effectiveness in all four facets.

In our creation of levels for the user tests, the level designers generated new ideas by thinking about levels as a series of design patterns. This process is described in Chapter 5. To have good coverage of the patterns to be tested and their affordances, the designers tried combining patterns in previously unexpected ways. By focusing on patterns, the designers were able to consider issues like the overall tension arc of a level while filling in narrative as needed.

This development process proved to be more structured, as the designers initially blocked out sections in terms of patterns and filled in details later. Starting with the

high level description, each designer was able to fill in details during the level construction process to suit more immediate concerns, such as space, narrative consistency, and aesthetics. If a pattern instance proved to be unworkable, the designer could excise it and begin anew without major impact on other sections of the level.

During the development process, the designers were able to use patterns to address problems in the levels. In some cases, sections of levels proved to be problematic, and adjustment of the patterns or their affordances were an effective means of solving them. If, for example, high paced gameplay, was intended, but was not being created, the pattern collection provided guidance on how to adjust the affordances or what patterns to add, remove, or replace.

Most importantly, the pattern collection provided a language for discussing the level design ideas throughout the process. From the initial brainstorming to the final play balancing, the pattern-focused design facilitated clear communication. The level designers were able to suggest improvements in terms of the patterns and their affordances. Suggestions such as lowering a sniper location to increase tension or narrowing a choke point to decrease pace were made throughout the process, making use of the language set out.

This research has identified design patterns in FPS games, particularly in level design, to create a language for describing levels. The application of design patterns to FPS

levels and the patterns themselves are described in Chapter 3. These descriptions provide insight into the designer's intent and the gameplay that will result. Chapter 3 also provides examples from an existing level described extensively in terms of design patterns. To validate the effects of the patterns, this research includes a user study. The results have helped close the loop and improve the descriptions of the patterns and their gameplay effects. The end result of the study is a set of patterns that has been shown to create specific behavior in the player.

This research has contributed to the game design research and teaching community at large by bringing attention to the practice of design pattern analysis. The patterns described herein have been used in the teaching of classes on level design at multiple institutions. Interest in design patterns in games has led to the formation of a focused research community. The first Workshop on Design Patterns in Games was held in 2012 and portions of this research were presented there.

- **RQ2: Can we use data analysis to understand player behavior in FPS levels?**

This research tests the cause-effect relationship of the patterns and their affordances on gameplay by examining player behavior. To do this, we had to identify what metrics corresponded to various facets of gameplay. This is explained in detail in Chapter 5 and Chapter 6. Data on participant's in-game actions were collected and analyzed to discern overall trends and how those trends were affected by the patterns.

This was compared with the intended effects to see where the actual gameplay differed, allowing adjustment to the pattern collection.

This research is the first major scientific analysis of level design. We have shown that the data-driven approach described was effective at understanding player behavior and how it can vary under different conditions.

- **RQ3: Do the design patterns and their variants create the intended gameplay effects?**

The major contribution of this research is to define the science of level design by creating a process for data-driven analysis of player behavior resulting from design patterns in levels. This process starts with identifying the design patterns and their affordances through study of existing games and interviews with designers. To analyze the data, it is necessary to categorize the facets of gameplay and what metrics are tied to those facets. Finally, by comparing the observed results to the intended effects, a researcher can make claims about the effects of level design on player behavior.

The patterns and their affordances described in this research were used to create user test levels with specific intended gameplay effects. For example, the choke point in level AY02-04 was intended to increase pace, tension, and challenge. When looking

at the data to understand player behavior, this research found that players did not appear to be experiencing a significant increase in stress or difficulty in the pattern.

When expected behavior occurs when a player encounters a design pattern instance in the levels, the theory is validated. When they differ, we can look more closely and adapt the pattern descriptions to match the observed results. Table 43 summarizes the observed effects, and the following section explores the differences.

Table 43: Intended v. Observed Gameplay Effects for all Levels

Level	Pattern	Pace	Tension	Challenge
AY02-04	Arena-1	Decrease	Increase	Increase
		Indeterminate	Increase	Indeterminate
	ChokePoint-1	Increase	Increase	Increase
		Increase	Decrease	Indeterminate
	SniperLocation-1	Decrease	Decrease	Decrease
		Decrease	Increase	Indeterminate
GR01-07	Arena-2	Increase	Increase	Increase
		Indeterminate	Indeterminate	Indeterminate
	SniperLocation-2	Increase	Increase	Decrease
		Decrease	Increase	Decrease
	Stronghold-1	Decrease	Decrease	Increase
		Decrease	Indeterminate	Indeterminate
GR03-03	SniperLocation-3	Increase	Decrease	Decrease
		Indeterminate	Decrease	Decrease

	ChokePoint-2	Increase	Decrease	Decrease
		Increase	Decrease	Decrease
	Arena-3	Increase	Decrease	Decrease
		Increase	Increase	Indeterminate
	Stronghold-2	Decrease	Increase	Decrease
		Indeterminate	Indeterminate	Increase
RG03-04	SniperLocation-4	Decrease	Increase	Increase
		Decrease	Decrease	Indeterminate
	SniperLocation-5	Decrease	Decrease	Decrease
		Decrease	Indeterminate	Decrease
	Stronghold-3	Increase	Decrease	Increase
		Indeterminate	Decrease	Increase
	ChokePoint-3	Decrease	Increase	Increase
		Decrease	Indeterminate	Indeterminate

2 DIFFERENCES BETWEEN OBSERVED AND INTENDED EFFECTS

This section details the differences between the designer's intent and the observed effects on gameplay for each pattern, and suggests updates to the pattern collection.

To review the affordances of all patterns, we recreate Table 10 here.

Table 44: Patterns in Full Study Levels

Level	Pattern	Affordances
AY02-04	Arena-1	Medium size, good cover, medium resistance
	ChokePoint-1	Enemy advantage, wide, heavy resistance, no cover
	SniperLocation-1	Player advantage, high, good cover, no access
GR01-07	Arena-2	Small size, good cover, heavy resistance
	SniperLocation-2	Player advantage, low, no cover, access
	Stronghold-1	Enemy advantage, small, good cover, access
GR03-03	SniperLocation-3	Player advantage, high, good cover, no access
	ChokePoint-2	Enemy advantage, narrow, light resistance, good cover
	Arena-3	Large, minimal cover, light resistance
	Stronghold-2	Enemy advantage, good cover, minimal access
RG03-04	SniperLocation-4	Enemy advantage, low, access
	SniperLocation-5	Player advantage, good cover, no access
	Stronghold-3	Enemy advantage, large, minimal cover
	ChokePoint-3	Player advantage, narrow, heavy resistance, no cover

2.1 SNIPER LOCATION

To study the effects of sniper locations on player behavior more closely, we summarize the intended and observed effect in Table 45.

Table 45: Intended v. Observed Gameplay Effects, Sniper Locations

Instance	Pace	Tension	Challenge
SniperLocation-1	Decrease	Decrease	Decrease
	Decrease	Increase	Indeterminate
SniperLocation-2	Increase	Increase	Decrease
	Decrease	Increase	Decrease
SniperLocation-3	Increase	Decrease	Decrease
	Indeterminate	Decrease	Decrease
SniperLocation-4	Decrease	Increase	Increase
	Decrease	Decrease	Indeterminate
SniperLocation-5	Decrease	Decrease	Decrease
	Decrease	Indeterminate	Decrease

The first thing to notice is that no sniper location instance increased pace, even when that was the designer's intent. Two sniper locations, SniperLocation-2 and SniperLocation-3 were intended to increase pace, but had observed effects of either decreasing or indeterminate. In both cases the intended gameplay of high paced combat was not realized due to players taking advantage of cover, not favoring high rate of fire weapons, and not collecting weapons and items. This suggests that the general effect of decreased pace for sniper locations strongly holds, even when designers attempt to subvert it.

Tension effects are less clear. Three of the five sniper location instances were intended to decrease tension, but only in SniperLocation-3 did the data clearly confirm this effect. This may be tied to the low difficulty of this pattern instance. Of the remaining pattern instances, three resulted in increased tension, while one had indeterminate effects. This is surprising since two of the metrics for decreased tension are higher accuracy and higher preference for long-range weapons. The results suggest that players are not experiencing the reduction in stress levels intended by providing an advantageous sniper location.

Similar to pace, decreases in challenge appear to be a consistent effect, though no instance of a player-advantage sniper location in the user test levels was designed to increase challenge. SniperLocation-4, the only enemy- advantage sniper location in the user test levels, was intended to increase challenge, but had an indeterminate effect as there was no significant increase in player deaths, player damage, or hit frequency. The lack of a clear effect in SniperLocation-1 suggests that a high sniper location without access does not necessarily decrease challenge.

2.2 ARENA

Table 46: Intended v. Observed Gameplay Effects, Arenas

Instance	Pace	Tension	Challenge
Arena-1	Decrease	Increase	Increase
	Indeterminate	Increase	Indeterminate
Arena-2	Increase	Increase	Increase
	Indeterminate	Indeterminate	Indeterminate
Arena-3	Increase	Decrease	Decrease
	Increase	Increase	Indeterminate

Since arenas provide a venue for large combat encounters, the general effect is intended to increase pace. However, only Arena-3 had a clear increase in pace. Contrasted with the other arena instances, this was a large area with light resistance and not much cover. This suggests that decreasing the size of an arena or increasing enemy resistance will have a decreasing effect on pace. Neither Arena-1 nor Arena-2 showed an increase, but the effect was unclear as players showed more preference for slow rate of fire weapons.

Two of the three arena instances exhibited an increase in tension, while the third was indeterminate. This suggests that rapid movement and accuracy are sacrificed in these large combat encounters as players are more likely to go on tilt to survive. Arena-2 has the least clear effect, and differs from the other two by being the smallest arena,

suggesting that the larger the arena, the stronger the increasing effect on tension will be.

None of the three arenas had a clear effect on challenge. In most cases there was no significant increase in the key metrics associated with challenge, player deaths, damage, and hit frequency. Even Arena-2, with its heavy resistance, had minimal effects on challenge, suggesting arenas are not good patterns for regulating the challenge of a level.

2.3 CHOKE POINT

Table 47: Intended v. Observed Gameplay Effects, Choke Points

Instance	Pace	Tension	Challenge
ChokePoint-1	Increase	Increase	Increase
	Increase	Decrease	Indeterminate
ChokePoint-2	Increase	Decrease	Decrease
	Increase	Decrease	Decrease
ChokePoint-3	Decrease	Increase	Increase
	Decrease	Indeterminate	Indeterminate

Choke points appear to be highly effective at creating intended effects on pace. The two enemy advantage choke points exhibited a clear increase in pace, as intended, while the one player advantage choke point exhibited the intended decrease. This is

consistent with the expected gameplay: in a player advantage choke point, the player must hold their ground and engage enemy NPCs as they pass through the choke point to experience the full benefit of the positional advantage.

Choke points also appear to have a decreasing effect on tension. Two of the instances - ChokePoint-1 and ChokePoint-3 were intended to increase tension but either decreased or had indeterminate effects. Both featured heavy enemy resistance and no cover, affordances thought to increase tension, but these effects were not shown by the data.

Attempts to use choke points to increase challenge led to indeterminate results in the user test levels. Neither ChokePoint-1 nor ChokePoint-3 showed a clear increase, again suggesting that heavy enemy resistance and lack of cover are not useful affordances for overcoming the general effect of choke points to reduce challenge.

2.4 STRONGHOLD

Table 48: Intended v. Observed Gameplay Effects, Strongholds

Instance	Pace	Tension	Challenge
Stronghold-1	Decrease	Decrease	Increase
	Decrease	Indeterminate	Indeterminate
Stronghold-2	Decrease	Increase	Decrease
	Indeterminate	Indeterminate	Increase
Stronghold-3	Increase	Decrease	Increase
	Indeterminate	Decrease	Increase

The general effect of strongholds to reduce pace seems to hold. While Stronghold-1 exhibited a clear decrease, Stronghold-2's effect was less clear. Stronghold-3 was intended to increase pace but also had unclear effects. The large size of Stronghold-3 was insufficient to result in increased pace.

There is no clear general effect on tension. Only Stronghold-3 had its intended effect shown to hold true in the data. The major differences in affordances were size and availability of cover. Stronghold-1 had unclear effects in spite of having similar affordances to Stronghold-2 with the exception of the latter having more access.

In terms of challenge, strongholds appear to create a general effect of increasing challenge, though Stronghold-1 had unclear effects. The major difference with Stronghold-2 is access, while Stronghold-3 had good access, it is also much larger. So

it is unclear what affordances of the stronghold pattern have a strong effect on challenge.

2.5 SUMMARY

Table 49: Summary of Gameplay Effects of Patterns and Major Affordances

Pattern	General Effect		Confounding Affordances
Sniper Location	Pace	Decrease	
	Tension	Indeterminate	
	Challenge	Decrease	Low height, access
Arena	Pace	Increase	Small size, higher resistance
	Tension	Increase	Small size
	Challenge	Indeterminate	
Choke Point	Pace	Increase	Player advantage
	Tension	Decrease	
	Challenge	Decrease	
Stronghold	Pace	Decrease	
	Tension	Indeterminate	
	Challenge	Increase	

3 THREATS TO VALIDITY

While this research accomplished its goal of creating a framework for the scientific study of level design, there are potential threats to the validity of this work that need to

be examined. The threats can be divided into two broad categories: threats to the applicability of the design patterns and threats to the validity of the study.

Design pattern approaches are necessarily reductionist. Real world systems are complex interactions of multiple elements; design patterns attempt to describe some of those elements in isolation for the purpose of understanding its use. In this research we argue that this approach is valid for level design because levels are constructed as series of set pieces intended to create specific gameplay effects. A higher or lower level perspective would not lead to useful analyses as the granularity would be too coarse or too fine.

Another criticism of the design pattern approach used in this research is that it is specific to the genre of FPS level design. The patterns would have no relevance to a wildly different genre, e.g., platformers or real-time strategy. While they are highly genre-dependent, we do claim that the basic patterns are generalizable to other 3d action games, such as open-world and adventure games. To show this we have begun pattern elicitation in open-world games, detailed in Appendix A.

In terms of the validity of the study, this work could be criticized as using a small, non-representative sample. Testing resources were limited, and we felt the most impact would be realized through limiting the participants to experienced FPS players. As such, we recruited participants largely from the population of UCSC undergrads involved in the game design program. While arguably limiting, it did have

the benefit of minimizing learning and familiarity effects. Future studies could be conducted using larger samples, and drawing from a wider pool of potential FPS game players.

4 FUTURE WORK

Besides the goal of creating a resource for level designers, there are many applications of this research and potential future research directions. The most immediate of these would be to expand the research to include other genres or aspects of FPS games besides single-player. Other 3d game genres like open-world or adventure games are similar enough in gameplay that general patterns could be found that apply to all. Exploration of how these patterns are implemented in different genres would lead to a more richly defined design space that could be explored to create new and interesting gameplay experiences. Additionally, the process of eliciting design patterns and testing to confirm effects could be repeated with any genre of games, including those that differ widely from FPS games.

Furthermore, additional studies could be done on different populations and different aspects of FPS games. For example, it would be useful to know if the patterns have similar effects on less experienced or novice players. Studies could be done to validate the effects of patterns in a multiplayer game environment. Studies could be done to determine if combinations or different sequences of patterns have different effects.

Another application of this research would be to use design patterns as a framework for level design systems. For example, design patterns could be an input to a procedural content generation (PCG) system. One could envision mixed-initiative tools that create frameworks for levels by combining patterns procedurally, which the designer can then customize to gain the desired results. Such a tool could ask designers to specify their desired arcs for pace, tension, and challenge, and select patterns and affordances for each segment that fit the desired arc.

APPENDIX A

ADDITIONAL DESIGN PATTERN COLLECTIONS

1 MULTIPLAYER FIRST-PERSON SHOOTER LEVELS

The work presented in this section is based on material originally developed in collaboration with Chris Ueda.

In our examination of multiplayer levels, we will be paying particular attention to their relationship to single-player levels and their associated patterns. Certain elements of multiplayer design patterns have parallels to their single-player counterparts. While these parallels suggest a large overlap in design principles for the design of levels in a (FPS) game, there is a difference in design goals between single and multiplayer levels.

The goal of the level designer is to provide a specific gameplay experience to the player. Experiences such as a distinct gameplay experience or narrative diegetic effect can be produced by designers through the use of level geometry, item placement, scripted events, and other level design elements. A single-player level is designed as a linear space, segmented into rooms separated by corridors. This allows the designer to create highs and lows in player tension, pacing the gameplay and giving the player opportunities to experience moments of intensity without tiring themselves out. For example, *Half-Life 2*, a single-player FPS, often makes extensive use of open spaces

in which the player is guided through the level while being given visual cues tying narrative and world space together. The level tells the story rather than large blocks of text or cutscenes, adding to a sense of immersion.

The difference in player count between single-player and multiplayer affects the way in which the designer needs to approach level design. When crafting a single-player level, the designer aims to tailor an experience to one player, but in designing multiplayer levels, the game state is now based on the inputs of other players, whose game-playing experiences the designer must all consider.

An example of the differences between single-player and multiplayer levels is apparent in spawning points for players versus spawning points for NPCs (non-player character). While they have similar purposes (introducing new entities into the level), in multiplayer levels additional players are spawned in place of NPCs. In a single-player level a NPC can be created whenever the designer chooses, but in a multiplayer level, the designer must equally consider all players when designing spawning points in a level. As the spawn points of each player affects the encounter rate, and therefore the pacing of the game. If too high, a player may get exhausted by constant action, or get bored between respawns if it's too low.

Level design patterns are employed by designers to explore design choices and craft the desired gameplay for a level. These patterns vary based on the requirements of the game. For example, FPS gameplay involves the use of space and resources in real-

time in a way that makes cover or item pickups useful. Therefore, patterns emerge that relate to the placement and frequency of these objects, and these patterns differ according to the unique features that distinguish multiplayer from single-player gameplay.

1.1 KEY CONCEPTS

1.1.1 CONFLICT POINTS

A conflict point is a location in a level which is designed to bring opposing forces into an encounter. These locations are key in managing rhythm and flow in multiplayer levels. By designing a level with conflict points in mind, the intensity and pacing that a given player experiences can be adjusted. To do this, designers can utilize elements of a conflict point such as chokepoints, strongholds, pickups, and objectives. Chokepoints and strongholds change the movement of players in and about a conflict point, while pickups and objectives provide players a focal point for encounters. A powerful weapon or a bunker may motivate players to prioritize combat in that area, increasing the overall intensity of the location over others. Examples include the flag's location in a CTF game of Halo: Combat Evolved, Control Points in Team Fortress 2, or the Farsight XR-20 (an extremely powerful weapon) in Perfect Dark. These are objectives that players can obtain to get an advantage, and naturally conflict will occur in their vicinity.

Use of conflict points is critical to many design patterns, as multiplayer FPS levels depend on them for creating player encounters. For example, bomb sites in Counter-Strike serve as the objective destination for the Terrorist forces. The objective of the Counter-Terrorist forces is to prevent the Terrorist demolition mission, and both teams are aware of the state of the bomb sites through in-game HUD cues. These areas are often camped, with one team lying in wait to ambush the other team. The expected combat in the conflict point reinforces player planning and coordination followed by a burst of high-intensity combat. To support this style of gameplay, these bomb sites often contain various types of cover and are connected to the rest of the level via small, easily ambushed entryways serving as chokepoints.

1.1.2 PLAYER RESPAWN

Respawning in multiplayer serves an important function not present in single-player levels – it modulates the effect of re-introducing players into the level. The desired rate of player respawn depends on the type of game and the game types supported by the game. Near-instant respawn times in fairly close proximity to the action are common in Deathmatch and King of the Hill, allowing for constant action and fast pacing. More strategic game types such as Capture the Flag utilize a longer respawn time, and place the player further from the main conflict points. This makes CTF a slower, more carefully played game type, as players are given more time between encounters, as well as a larger penalty for death.

Examples include the round-based respawn in Counter-Strike, where players respawn after the end of a round. CoD: MW2's instant respawn in Deathmatch modes quickly throw the player back into the action. In Team Fortress 2, a delayed respawn system is used, in which players respawn with other teammates waiting to spawn at set intervals. By spawning with teammates, players are better able to coordinate. This promotes the objective-based gameplay of TF2, where kills count for significantly less than capturing or defending as a team. A wave of attackers spawned together can overwhelm a heavily fortified control point, and a group of defenders can quickly set up a defensive perimeter without getting picked off.

1.1.3 LEVEL BALANCING

The focus of design in a single-player FPS level is to provide the player with an optimal gameplay experience, using the level geometry, item and resource placement, and NPC behavior scripting. However, in multiplayer, NPCs are replaced with other players. The gameplay experience of multiple players needs to be managed, as well as the additional challenge of handling unpredictable input from every player.

Multiplayer level balancing focuses on design decisions which give players an equal opportunity at successfully attaining the intended gameplay experience. Opportunities for success are balanced against rewarding successful play. Designers can create balance in a number of ways, such as providing counter-strategies or advantages that a losing player or team can utilize. For instance, a player defeated in a skirmish could

be given an advantage, like spawning near a pickup or a bunker. However, spawning the losing player nearby a rocket launcher would be an excessive advantage, and would dilute the reward of the winning player's conquest.

Examples include symmetry in level geometry, pickups, abilities, customization, changes in respawn time, and alternate routes. Many capture points in Team Fortress 2 have pickups near, but not directly on the capture point. For example, a losing team on a King of the Hill map may be able to utilize resources hidden behind cover near the control point to outlast the opponent and push them off the point. In Halo: Combat Evolved, all maps with vehicles have their spawning points set nearby. Players defeated in combat can utilize these vehicles to quickly return to battle, with a new-found advantage.

1.2 PATTERNS IN MULTIPLAYER GAME TYPES

Multiplayer FPS games require a different set of game rules and objectives from single-player. Sets of rules collectively known as game types are defined in order to provide specific gameplay experiences. These may include rules such as a priority object or location, or a score objective. Level designers apply key concepts of multiplayer level design in the context of a specific game type in order to create a playable level.

1.2.1 LOCATION-BASED CONTROL (CONTROL POINT, DOMINATION, KING OF THE HILL)

These game types have teams competing for control of one or more locations. The points are often important features of the map, notable for their ease or difficulty in defending. When capturing a control point, players either have to occupy the location for a fixed amount of time or perform an action, such as raising a flag. Locations such as sniper perches, tops of hills, and bunkers are often used, allowing for strong defenses. Strategic options are given to attacking teams as well, like alternate routes or siege resources like grenades. Control points are conflict points; players are aware of their locations, and receive updates on their states through visual or auditory cues. Some types of control include the standard Control Point, where teams push through defensive lines to capture points on the map, Domination, where time or points are accumulated for control of areas, and King of the Hill, in which a single control point is contested between forces.

Examples include CoD: MW2's Domination game type, and Team Fortress 2's Control Point maps such as Well, Granary, and Badlands.

In Left 4 Dead's Finale events the survivor team is given time to prepare for the oncoming assault by stocking up with items from weapon caches. When the Finale event starts, the team can utilize these resources to hold off the oncoming Infected force.

1.2.2 CAPTURE THE FLAG (CTF)

This game type has both teams simultaneously on offense and defense, trying to claim the other team's flag and bringing it back to their own base while protecting their own flag. The game type is similar to Control Point, especially when the flag is located at a team's base. The flag's starting location serves as a point of conflict, and is often a strongly fortified location, making defense easy and requiring coordinated offense to capture.

After claiming the flag, a player must bring the flag to their team's own base. The enemy team must prevent the flag from being delivered by attacking the carrier. Flag carriers are encouraged to use alternate paths and shortcuts in order to evade the opposing team. Levels are often symmetric to ensure balance. Respawn times are long, allowing a team to press their advantage after defeating opposing forces.

Examples include Unreal Tournament - Facing Worlds (symmetrical) and CTF4 in Quake 3 Arena. Blood Gulch in Halo: CE is a classic example, set in a wide, open canyon with rolling hills. On the two far ends, a single bunker houses each team's flag. Teleporters quickly move players from a base to the middle of the stage, but not the other way, allowing respawned players to return to the action.

Team Fortress 2's Payload maps are a variation of the CTF format. In this game type the offensive team moves a cart forward by standing besides it, while the defense sets up fortifications to prevent progress. The linear path of the cart and the respawn

system of TF2 distinguishes this game type as being closer to CTF rather than Delivery, described further below.



Figure 42: Team Fortress 2's Goldrush, a Payload map where the blue team moves the cart along to its destination

1.2.3 DEATHMATCH (ARENA, SLAYER)

Deathmatch is characterized by fast-paced, constant action. Players are pitted against one another, in team or free-for-all, in a race to score the most kills. Levels designed for deathmatch often feature large, open areas with sporadic cover to promote constant combat. Sniper locations may be provided to give a bird's eye view of the level, and afford players the opportunity to engage other players. These sniper locations may be unprotected so that opposing players can retaliate, making their use a risky proposition. Powerful pickups and weapons may be placed at key conflict points, rewarding players who survive for long periods of time, as respawning players

are forced into engagements against better-equipped players. Respawn times are short to keep the pace high.

CoD: MW2's Rust, a small level with a large crane structure in the center allows players to move about in an open circle. Movement along the perimeter or through the center structure impedes movement but provides cover.

1.2.4 DELIVERY (DEMOLITION)

This game type separates teams into offensive and defensive roles. One team has a package (e.g. a bomb) they must deliver (and detonate) to a set location near the opposing team's starting point. The package serves a similar role as the flag, in that it promotes conflict wherever it is, carried by a player or on the ground. Both teams depend on the package's state to determine victory, and as such it is defended carefully, and attacked often. Designers create the level to allow for strategic gameplay options; alternate routes leading to (most often) two or more delivery points is critical. Respawning may not be allowed, meaning player count can only decrease, ratcheting up the tension for the remaining players when nearing the conclusion of a round.

Examples include Counter-Strike's `de_dust2`, among many other Counter-Strike maps. CoD: MW2's maps allow for Demolition, and Team Fortress 2's Avanti has multiple sequential capture points. A standard Counter-Strike defensive strategy is to spread team members into two groups and identify which of the two bomb points the

opposing team is attempting to plant the bomb in. Several paths link both spawn locations to each of these points.



Figure 43: Counter-Strike, de_dust2. A counter-terrorist defuses a bomb

1.3 PATTERNS IN MULTIPLAYER LEVELS

Multiplayer level design strives to create a level playing field. To provide gameplay options while maintaining this balance, beneficial structures such as sniper locations and alternate routes need to be viable, while the opposing players are provided with a valid counterstrategy. In Halo: Combat Evolved single-player, a sniper location provided a significant advantage to the player. In the multiplayer game, players in sniper locations must also be wary of counter attack from the complementary sniper location on the other side of the level, or rely on their teammates to protect a poorly defensible position. Team strategy may be required to make the most of a given pattern's potential, often reflected in a strong offensive or defensive feature of a location.

1.3.1 ARENA

Description

Open areas with good sight ranges. Promotes encounters as a result of visibility or traffic – arenas are often conflict points

Affordances

- Can contain a Control Point.
- Pickups will increase traffic and conflict in the area.
- Can include features such as battlements and alternate paths to prevent over-congestion.

Consequences

If surrounding area is confusing or congested, adding arena features may improve traffic flow.

Has sporadic cover, providing good defense but not concealment.

Examples

de_aztec (Counter-strike)

The terrorist force cross an open, unprotected area and take cover behind the crates located at demolition point A. A ramp up from a lower floor and a hallway with clear view of the bomb point threaten the terrorist force's objective.

Hang em' High (Halo: Combat Evolved):

An extremely open map, with small blocks for cover, and ramps leading up to a second level which surrounds the map. Catwalks crisscrossing the level can be accessed from the second level. These lead to powerful weapons, but players are vulnerable to attacks from below.



Figure 44: Halo: Combat Evolved, Hang em' High: Many catwalks cross the length of the map

1.3.2 VEHICLES AND VEHICLE-ORIENTED GEOMETRY

Description

Vehicles allow rapid movement, and provide an advantage against players on foot.

Affordances

- Armaments such as turrets or cannons can be added to vehicles. These cause vehicles to function much like a pickup, and can be strategically placed to create conflict between players or teams for possession. The vehicle itself may become a conflict point.
- Can be aerial or on ground.

Consequences

When adding vehicles, designers must take countermeasures to preserve game balance. This may include rocket launchers or other weapons that can disable vehicles, or terrain types inaccessible to vehicles, as they often require flat, open ground, or open airspace in the case of aerial vehicles.

Vehicles can be strategically important in CTF, creating cover for players or for rapid movement with the flag.

Examples

Various levels (CoD: World at War)

A few maps in World at War contain tanks in multiplayer. In these levels, tanks have little room to maneuver, and drive through or next to areas only accessible on foot, such as abandoned houses and rubble. Players on foot can destroy the tank if equipped with C4 explosives.

Blood Gulch (Halo: Combat Evolved)

Wide, open map, with a bumpy path between two bases. Players can access a Warthog vehicle nearby their base, and drive it on the central path. This path is visible from any point on the map except for inside the base itself, including the cliffside paths inaccessible to vehicles. Banshees (aerial vehicles) can cover the distance between two bases quickly, but are even more visible and are subject to counterattack by the rocket launchers located at the center of the map.



Figure 45: Halo: Combat Evolved, Blood Gulch: Vehicles are accessible near each base, allowing quick transport across the wide map

1.3.3 ALTERNATE ROUTES

Description

Any navigation option that allows a player to avoid the main routes, or bypass a specific portion of it.

Affordances

- Can be narrower in size than the main route. Combat in these areas will be more restricted, as there is less room to maneuver and shorter sight ranges.
- May be a flanking route or provide access to other advantages, such as pickups.
- Shortcuts are a type of alternate route, providing quick access at the cost of safety. CTF levels make extensive use of these, especially one-way shortcuts.

Consequences

Prevents stalemates and overly concentrated activity by rewarding nonstandard behavior, and reduces traffic on main path or arena.

Should be rewarding and advantageous in terms of gameplay objectives, but designers must provide countermeasures.

A balance between the main route and the alternate route is required. An example is a roundabout path which takes longer, but avoids conflict points or gains an advantage over the main path when taken.

Examples

Badwater Basin (Team Fortress 2)

Near the second payload checkpoint, a path off the main track leads to a roof overlooking the payload's path. Control of this roof by the defensive team creates a strong defensive position. The offensive team must use the alternate routes leading behind the roof in order to eliminate resistance and continue pushing the payload.

cs_assault (Counter-Strike)

In this hostage rescue map, the main entries to a warehouse are through a front garage door or a small backroom door. They are both easily defended by the terrorist force inside, but counter-terrorists can climb onto the roof of the warehouse and enter the airducts, which are cramped and difficult to maneuver in, contrary to the rest of the level. However, exiting the airducts is difficult, and traveling the ducts makes a distinct metallic sound.

Valhalla (Halo 3)

Jump pads send players flying towards the center of the map at high velocity. They are a shortcut, as the player reaches the main conflict points much quicker. However, it leaves the player vulnerable to sniping by other players.

1.3.4 BATTLEMENTS AND COVER

Description

Provides a defensive measure against opposing offensive actions. A defensive object placed in-level which can be used strategically to assist in player objectives.

Affordances

- In appearance, can be barriers, crates, sandbags, trees, or shields to fit the level's aesthetic.
- Battlements and bunkers are characterized by their strong defensive attribute. They are useful for Control Points and for flag locations in CTF.
- Sniper locations are also included as they provide a defensive element providing the player with an opportunity to snipe enemies without fear of retaliation.

Consequences

Allows players to focus on offense while protected from most directions.

Examples

2fort (Team Fortress 2)

The battlements for each team's base allow players to fire down on opposing forces entering their base without being flanked. The location is used to defend the entrances to the base, causing opposing forces to employ countermeasures such as counter-sniping and firing rockets and grenades into the battlement.



Figure 46: Team Fortress 2's 2fort, battlements on each side defend against the opposing forces from entering and capturing the flag

Afghan (CoD: MW2)

The caves, located in the center, provide cover from the rest of the map, which is otherwise open and vulnerable especially to aerial strikes. Firing out of the cave is a common tactic, as it is difficult to see into the dark from the outside. However, the cave has several exits, and the back exits can be accessed by players through an

alternate route. Players in this area are also vulnerable to grenades, as there is little room to maneuver.

de_dust2 (Counter-Strike)

As the bomb point itself is located in cover, the crates and boxes are used to defend the location and ambush counter-terrorist players attempting to defuse the bomb. The counter-terrorist force can circumvent this by taking control of the point, a strategy aided by their respawn points being closer.

1.3.5 ITEMS AND PICKUPS

Description

A resource which can be collected and used by the player to achieve objectives.

Affordances

- Weapon type, may be useful where it is picked up or may be more effective in a different location of the map.
- Vehicles are a type of pickup, offering unique actions to the player.
- Can be a powerup, such as invisibility or shield. Health kits can vary greatly in effectiveness.

Consequences

Item placement creates sub-goals for the player to pursue.

Promote use of alternate routes or creates conflict points.

Examples

Ascension (Halo 2)

This level has an open central hub from which four covered areas link the upper and lower floor. On one of the branches, the top floor contains a sniper rifle. From the location the sniper rifle is located much of the level is visible, making the location a high-profile area, watched carefully from the rest of the map, and heavily contested at all times.

Farsight XR-20 (Perfect Dark)

The Farsight XR-20 is a sniper rifle which can see and shoot through walls. As such, competition for the weapon is high in multiplayer games. Players rush to the item location at the beginning of the game, and the spawn location becomes a conflict point.

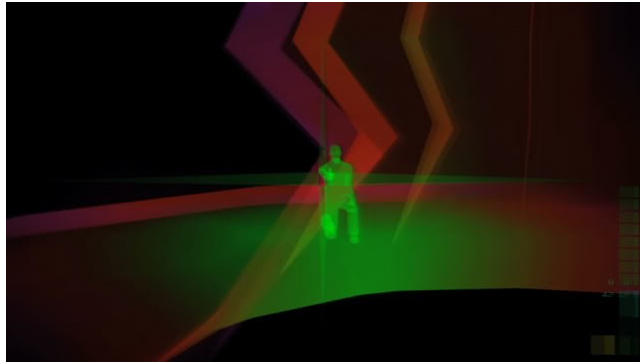


Figure 47: Perfect Dark. The Farsight XR-20 provides vision and shoots through walls.

Weapons in Team Fortress 2 are set on class loadout, but placements of ammunition and health are critical. Ammunition allows players in the Engineer class to collect metal in order to build structures, allowing defense of key points. Oftentimes, an Engineer will construct all structures nearby a large ammunition box, constantly supplying materials to build and repair with.

2 OPEN WORLD GAMES

The work presented in this section is based on material originally developed in collaboration with Stacey Johnson.

The patterns presented here use the following format:

Name – An identifier which exemplifies the key idea of the pattern.

Description – Describes the pattern in detail.

Affordances – Elements which may be varied by the designer depending on the kind of gameplay desired.

Consequences – How the pattern affects gameplay.

Relationships – How the pattern interacts with other patterns.

Examples – Uses of patterns in popular commercial open world games.

The pattern collection is divided into Mission State and Non-Mission State patterns.

2.1 MISSION STATE PATTERNS

2.1.1 CHASE/EVADE

Description

A mission where the player must chase or evade an NPC. This may occur along a path laid out in the game world or a separate area.

Affordance

- Designated path
- Obstacles
- Enemy NPCs
- Time Limit

Consequences

When this occurs through the main game world the player is not forced on any sort of path and it is harder for the designer to place challenges in the player's way. However, when the path is designated for the player this makes the mission more like a linear game and allows designers to set up specific challenges they would like the player to face. This pattern may also lead a player to a new or unexplored area.

Relationships

An Elimination mission can become a chase mission if the target tries to run from the player. An Escort mission can become an Evade mission if the player is forced to avoid attacking enemy NPCs.

Examples

In Saints Row 2, the mission Reclamation has the player go to the scene of a brawl and kill the three lieutenants there. After the player does this they are pursued by police officers and must escape without being caught or killed.

In Assassins Creed: Revelations, while retrieving one of the Masyaf keys the player must chase down and kill the Templars before they reach the door where the key is located. During this mission the player must traverse an obstacle course which

follows the path of the river which the Templar's boat is traveling, while at the same time avoiding their fire. (see Figure 48)



Figure 48: Chasing Templars in Assassins Creed: Revelations

2.1.2 ESCORT

Description

Mission where the player must lead a friendly NPC to a new location.

Affordances

- Being chased by enemy NPCs
- Avoid Detection by enemy NPCs

Consequences

The player must keep the friendly NPC from being harmed by enemy NPCs. This can be done by protecting them from attack or using stealth to avoid detection. The key difference is if the player eliminates the enemy NPCs in a stealth mission quietly then they will not attract a large number of enemies and put the friendly NPC in more danger.

Relationships

Can be combined with Chase/Evade if the player is frequently pursued by enemies when escorting a NPC.

Examples

In Just Cause 2, on the second part of the mission Casino Bust, the player is charged with protecting Karl Blaine and must escort him to a safe location while being chased by enemy NPCs.

In the Assassins Creed: Brotherhood mission Escape from Debt the player must escort senator Egidio and eliminate enemies while staying hidden. If the player is spotted then they lose full synchronization.

2.1.3 ACQUISITION

Description

The player must retrieve an object and bring it to a specified location.

Affordances

- Time limit
- Need to fight past enemy NPCs

Consequences

The player can acquire an item which may be very useful at some point later in the game.

Relationships

Can become a Chase/Evade mission if the object the player is trying to acquire is taken by an NPC or when an NPC tries to take it from the player.

Examples

In the Assassins Creed: Revelations mission The Wounded Eagle, the player must find the Templar Captain, kill him, and then retrieve Niccolò Polo's journal from him which has the location of the Masyaf keys in it.

In The Legend of Zelda: Ocarina of Time there is a mission to obtain Biggoron's Sword, a very powerful unbreakable sword. To accomplish this, the player must collect a series of items from different NPCs which ends with bringing the Big Goron eye drops at the top of Death Mountain Path. If you do all of these things you will then be given the Biggoron's Sword. (see Figure 49)



Figure 49: Turning in an item to get the Biggoron's Sword in The Legend of Zelda

2.1.4 ELIMINATION

Description

The player is directed to destroy a target.

Affordances

- What the target is: NPC, building, object, etc.
- Location of target known or unknown

Consequences

The elimination of a target may change what missions the player can access later.

Relationships

May cause the player to have to Evade pursuers after dispatching their target.

Examples

In the Saints Row 2 mission Homeland Security, the player is instructed to find and kill all members of the Los Carnales gang. The targets are shown on the mini map and the player must travel to each location and eliminate them.

2.1.5 FOLLOWING

Description

The player must follow an NPC without losing them.

Affordances

- Avoid detection if following enemy NPC

- Protect if following friendly NPC

Consequences

The NPC may lead the player to a new area or otherwise give information about locations that will be important later in the game.

Relationships

If the player must also protect the NPC then this becomes an Escort mission. This can also become an Acquisition mission if the player is following the NPC to ultimately acquire an object or can become an Elimination mission if the player must kill the NPC once the player has followed them to a new location.

Examples

In inFamous the player must follow enemy NPCs without being spotted or losing their target to obtain information which they leave behind.

In the Red Dead Redemption mission Political Realities the player must accompany the sheriff to follow Walton, a local gangster, back to his hideout and eliminate him once and for all. This mission then becomes an Elimination mission when the player catches up with Walton and needs to kill or capture him.

2.2 NON-MISSION STATE PATTERNS

In the non-mission state the player has access to all of the actions they are normally allowed and these patterns exist independently of the mission state patterns.

2.2.1 POPULATED AREAS

Description

Major areas where gameplay occurs. Contains many main missions and side objectives.

Affordances

- Size
- Density
- Kinds of missions in the area

Consequences

The player can find their main missions as well as many side objectives in this area.

Relationships

Main missions and Side missions located here.

Examples

In Assassins Creed 2 you can travel to several different cities such as Venice and Rome. All of these cities are Populated Areas and contain different kinds of missions for the player to do.

2.2.2 INTERSTITIAL AREAS

Description

Areas between the Populated Areas. Typically these are devoid of main missions but may have some side objectives for the player to do.

Affordances

- Size of area
- Can contain side missions or objective

Consequences

This can lend the player to a sense of realism by having to travel a long travel to reach new areas. Also gives the player another large area to explore that is different from the Populated Areas.

Relationships

Is the space between Populated Areas. May contain Side Missions and Collection.

Examples

In Red Dead Redemption there are large expanses of open areas between towns where the player can hunt or look for plants.

In Grand Theft Auto 4 there are freeways the player uses to travel between islands.

(see Figure 50)



Figure 50: Interstitial Area in Grand Theft Auto 4

2.2.3 SIDE OBJECTIVE

Description

A non-mission based activity the player can engage in which provides some non-essential rewards.

Affordances

- Kind of objective
- Access to player actions

Consequences

This encourages the player to explore the world to find these objectives and to complete them. Similarly to Mission state patterns the designer can also limit the actions the player can perform.

Relationships

Can be located in both Interstitial Areas and Populated Areas. Can be a type of Collection.

Examples

In Assassins Creed: Revelations the player can recruit assassins and send them on missions to improve their skills. These assassins can then help the player out during fights.

In inFamous there are different stunt challenges which the player can complete. When all of these stunts are completed they receive a trophy for their efforts which can be showed off online.

2.2.4 COLLECTION

Description

The player must collect items. These items exist in the game world at all times and do not appear only because the player is in a mission. They can be collected while in the mission state or the non-mission state.

Affordances

- Time limit
- Number of items to be collected
- Objects locations known or unknown
- Has a return destination
- Areas where the items are located

Consequences

Encourages the player to explore more of the game world and can lead the player to new areas. The locations where collectibles are found may become important later in the game. Can give the player powerups or new abilities.

Relationships

Is a type of Side Objective.

Examples

In The Legend of Zelda: Ocarina of Time the player can collect rupees or gold skulltula tokens which allow them to upgrade equipment and purchase items. These must be taken to special locations to receive rewards. Rupees can be taken to shops and exchanged for items while gold skulltula tokens must be taken to a certain house in Kakario village for a reward.

In inFamous there are blast shards which the player collects to increase their power level. If the player is close enough to the shards and they can get an indicator on their mini map. The more shards a player collects the more their power increases and once the player collects all of the shards they will have achieved their maximum amount of power. (see Figure 51)



Figure 51: Collecting in inFamous

2.2.5 MARKER

Description

A highly recognizable object or location that helps the player navigate within the game world. These may also help indicate important locations.

Affordances

- Can indicate an important place
- Can indicate a mission location

Consequences

The player is able to easily figure out where they are and navigate through the world without needing to look at a map.

Relationships

None

Examples

In Grand Theft Auto 4 there are many buildings which a player can easily recognize and many of them have signs which stand out from the background. This is particularly true for locations that the player can enter and interact with. (see Figure 52)



Figure 52: Marker in Grand Theft Auto 4

2.3 DISCUSSION

To show how design patterns are used in Open world games in a larger context we will use the Grand Theft Auto IV mission Three Leaf Clover to show how different patterns can be combined to create gameplay.

In this mission Niko, the player character, is helping Packie and his brothers rob a bank. The player must drive to the location of the robbery which is in a previously locked area. The player follows their mini-map to the location and identifies the Marker since it is a building which stands in contrast to those around it and has a large neon sign. After reaching the bank the player must Eliminate the security guard and Acquire the money from the vault. The player must then Follow the NPCs through the new area to Evade the police. Once the player reaches the street again they must travel the new Populated Area to lose their wanted level. They then return to the starting area which is indicated by Markers. In this example the main purpose of the mission is to introduce a new area to the player.

APPENDIX B

DATA ANALYSIS IN PROJECT GOTHAM RACING 4

We present an analysis of long-term play data from a commercially released game. For this case study, we looked at data from Project Gotham Racing 4 [62] (PGR4), an Xbox 360 game developed by Bizarre Creations and published by Microsoft Game Studios in 2007.

PGR4 is an auto racing game and is representative of many games in the genre. Players have the option to play either single or multiplayer races organized into various game modes and event types. Game modes include, for example, career mode, a single player mode where the player earns money by competing in races, which in turn allows them to unlock other races and vehicles, leading to continuous advancement. Other game modes are multiplayer quick races, arcade mode, and time attack challenges. There are ten of these in total. Event types are the 29 specific challenges a player may compete in within a mode. These include things like street race, cone challenges, and elimination races.

The game features 134 vehicles, both cars and motorcycles, organized into 7 classes, A–G. The primary division between classes is performance, with A-Class being the highest performance and G-class being the lowest. Races are conducted on one of 121 routes spread out over 9 in-game locations. Locations are generally virtual

representations of cities, such as Macau or Shanghai, while the routes are specific tracks laid out over the location.

In the time since its release, PGR4 has been played extensively by its audience. Telemetry data was collected from players who opted in whenever they played while connected to the Xbox Live service, regardless of whether they were playing in multi- or single player races.

1 DATASET

Several datasets were collected from PGR4. The primary one analyzed was the Start of Race dataset. This contained approximately 3.1 million entries, one for each time a player started a race, including both multi- and single player races. Data about both the race and the player were logged, including:

- Type of event
- Route selected
- Vehicle selected
- Number of vehicles in race
- Player's career rating
- Number of previous events completed by player
- Total kudos earned by player

1.1 FEATURES

For our analysis we looked at usage patterns for five game features of interest to the development team:

- Game modes
- Event types
- Routes
- Vehicles
- Vehicle classes

As these are the main options available to the player, patterns in their usage present a picture of how players are playing the game and what is most important to them.

1.2 SUBDIVISIONS

We felt it would be beneficial to separately examine players grouped according to their level of engagement with the game. To this end we subdivided the data into four groups based on the total number of races for that player in the entire dataset. The four groups were:

- Regular: > 200 races
- Mid 2: $> 85 \ \& \ \leq 200$
- Mid 1: $> 13 \ \& \ \leq 85$
- Infrequent: ≤ 13 races

For most analyses, we specifically compared the two most extreme groups: the regular and the infrequent players. This allowed us to make statements about how the behavior of the most enthusiastic players compared to the least engaged.

1.3 SUBSETS

In addition to studying the entire dataset, we examined three subsets for additional insight. We looked at multiplayer and single player races separately, and looked at the first ten races for each unique player. The motivation behind looking at the first ten races was to understand how a player's initial experience affects their subsequent engagement by the game. Differences that exist between infrequent and regular players in their first ten races may contribute to the likelihood that a new player will ultimately fall into one group or the other.

2 ANALYSIS AND RESULTS

We drew five conclusions from our examination of the Start of Race dataset:

- Regular players play more multiplayer races
- Regular players play more in career mode
- Many options (game modes, event types, routes, and vehicles) are underused
- A- & F-Class vehicles are most popular classes of vehicles
- C-Class vehicles equally or more popular than B-Class, especially among regular players

2.1 REGULAR PLAYERS PLAY MORE MULTIPLAYER

Within both the entire Start of Race dataset and the first ten races, regular players showed a clear preference for multiplayer game modes and event types.

For regular players, NETWORK_PLAYTIME was the 2nd most popular mode, used in 27.6% of races overall (see Figure 53). In contrast, for infrequent players, NETWORK_PLAYTIME is 3rd, at 16.1%, behind 2 single player modes (OFFLINE_CAREER at 47.0% and PGR_ARCADE at 19.6%) (see Figure 54).

In terms of event types, the most popular for regular players in the entire dataset was NET_STREET_RACE at 26.6%. For infrequent players, it was second at 10.5%, significantly less than the single player event type of STREET_RACE at 54.8%.

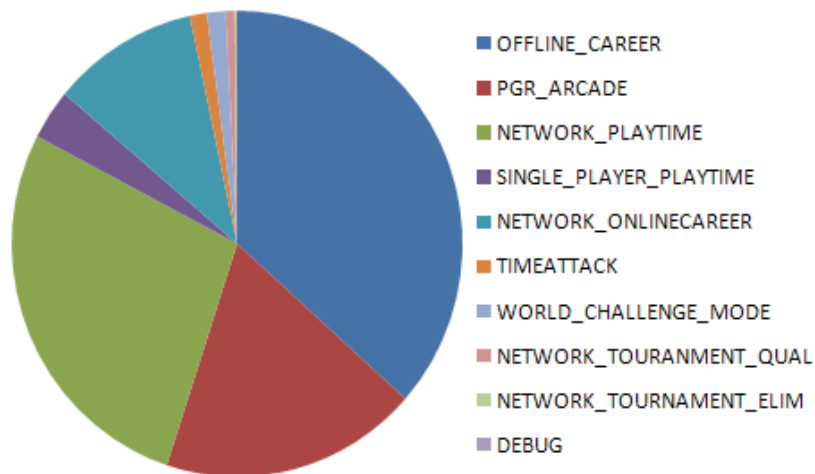


Figure 53: Game Modes, Regular Players

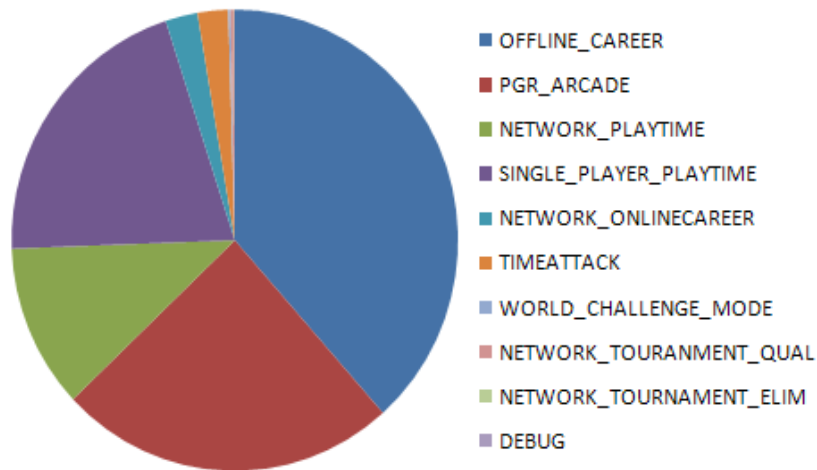


Figure 54: Game Modes, Infrequent Players

We see a similar pattern when looking at the first ten races only. 48% of races for regular player were in multiplayer game modes, compared to 20.8% for infrequent players. The most common multiplayer game mode, NETWORK_PLAYTIME, was significantly more preferred by regular players, 35.5% versus 7.6% for infrequent players.

For regular players NET_STREET_RACE was the most popular event type by an overwhelming margin: 39% of races, with single player STREET_RACE a distant second at 15.5%. For infrequent players, the single player event types of STREET_RACE and TIMEATTACK were vastly more preferred (24.9% and 20.8% respectively) over NET_STREET_RACE (3rd at 9.4%).

- Regular players used the NETWORK_PLAYTIME game mode more than infrequent players
- Regular players used the NET_STREET_RACE event type more than infrequent players
- In their first 10 races, regular players used the NETWORK_PLAYTIME game mode more than infrequent players by a large margin
- In their first 10 races, regular players used the NET_STREET_RACE event type more than infrequent players by a large margin

2.2 REGULAR PLAYERS PLAY MORE CAREER MODE

When regular players do play single player races, they are more likely to do so in career mode than infrequent players.

In the entire dataset, OFFLINE_CAREER was the most popular game mode overall for regular players: 36.6%, followed by the aforementioned multiplayer mode NETWORK_PLAYTIME at 27.6% (see Figure 53). In contrast, the non-career modes of SINGLE_PLAYER_PLAYTIME and PGR_ARCADE were more preferred by infrequent players (20.6% v. 3.5% and 24.5% v. 18.46% respectively) (see Figure 54).

When looking at data from the single player races only, OFFLINE_CAREER was the most popular for both regular and infrequent players. 59.9% of single player races for regular players were in OFFLINE_CAREER and 47.5% for infrequent players. This may not seem like a large difference, but when we look at the primary non-career mode, SINGLE_PLAYER_PLAYTIME, the difference becomes more apparent.

Regular players used SINGLE_PLAYER_PLAYTIME in only 5.8% of single player races, while infrequent players used it in 24.2%

We see a difference in the first ten races as well. Regular players prefer OFFLINE_CAREER career more than infrequent players (36.5% v. 22.2%). By contrast, infrequent players were more likely than regular players to play non-career modes TIMEATTACK (20.1% v. 0.5%) and PGR_ARCADE (26.4% v. 6.5%).

- OFFLINE_CAREER was the most popular game mode among regular players
- SINGLE_PLAYER_PLAYTIME was used more by infrequent players overall and in their first ten races
- Regular players used OFFLINE_CAREER more in their first ten races

2.3 MANY OPTIONS WERE UNDERUSED

Our analysis showed that large amounts of the options available in the game were used in so few instances that they could have been removed from the game entirely. In four of the features we examined, 20% to over 70% of available options were used in less than 1% of races. This suggests that savings in development times and costs could be realized in future games by offering fewer options without negatively affecting the players' overall experience. When looking at the entire dataset,

- 22% (2 of 9) game modes,
- 41% (12 of 29) event types,
- 67% (81 of 121) routes,

- and 78% (104 of 134) vehicles

were used in less than 1% of races each.

2.3.1 GAME MODES

As shown in Table 50, OFFLINE_CAREER (a single player mode) was the most commonly used game mode by far, with NETWORK_TOURANMENT_QUAL and NETWORK_TOURNAMENT_ELIM being used in less than 0.5% of races. In fact, the 7 least used modes account for only 15% of races overall.

Table 50: Game Modes

Game Mode	Races	% of Total
OFFLINE_CAREER	1479586	47.63%
PGR_ARCADE	566705	18.24%
NETWORK_PLAYTIME	584201	18.81%
NETWORK_ONLINECAREER	193091	6.22%
SINGLE_PLAYER_PLAYTIME	185415	5.97%
TIMEATTACK	43942	1.41%
WORLD_CHALLENGE_MODE	36581	1.18%
NETWORK_TOURANMENT_QUAL	13847	0.45%
NETWORK_TOURNAMENT_ELIM	2713	0.09%

When we look at just multiplayer game modes we see an even larger disparity: the top two modes account for 98% of all multiplayer races.

2.3.2 EVENT TYPES

When looking at event types, we again see a rapid drop off in popularity with the least popular types receiving only trivial usage. A reduced version of this data is shown in Table 51.

Table 51: Event Types (Reduced)

Group	Races	% of Total
STREET_RACE	795334	25.60%
NET_STREET_RACE	543491	17.50%
ELIMINATION	216042	6.95%
HOTLAP	195949	6.31%
...		
TESTTRACK_TIME	7484	0.24%
NET_CAT_AND_MOUSE_FREE_ROAM	3989	0.13%
CAT_AND_MOUSE	53	0.00%

Single player street races were the most popular event type, followed by multiplayer street races and elimination races (knock out stages in tournaments), whereas 12 of the 29 event types were used in less than 1% of races. The underutilization of event

types is even more pronounced when looking at multiplayer races only (7 of 16 event types used in less than 0.1% of races).

2.3.3 ROUTES

While 67% of the available routes were used in less than 1% of races each, collectively they account for 36% of races. i.e., two-thirds of races occur on one-third of the routes. Developers would likely not support a proposal to eliminate such a large portion of potential gameplay, so we looked at even smaller percentages of use and found that

- 47 (39%) were used in less than 0.5%,
- 19 (16%) were used in less than 0.25%,
- and 8 (7%) were used in less than 0.1%

of total races.

The 47 routes used in less than 0.5% of races account for 13% of overall usage, a much more palatable percentage to consider removing, while still leaving 70+ routes available for players.

2.3.4 VEHICLES

Similarly with routes, a wide variety of vehicles adds to depth of gameplay even if a significant portion is rarely used. Furthermore, the number of available vehicles in a driving game can be an important point in the marketing strategy.

The 104 of the 134 vehicles that are used in less than 1% of races each collectively represent 38% of usage. Furthermore,

- 72 (54%) were used in less than 0.5%;
- 50 (37%) were used in less than 0.25%,
- and 12 (9%) were used in less than 0.1% of total races.

The 50 vehicles used in less than 0.25% of races each represent less than 7% of the total races.

2.3.5 VEHICLE CLASSES

We can also look at vehicles in terms of their classes. The vehicles in the game are grouped into 7 classes based on performance. As seen in Table 52, A-Class vehicles were used nearly twice as often as the next most popular class, while Classes B through F were close in popularity, ranging from 10-15% of all races.

Table 52: Vehicle Class

Vehicle Class	Races	% of Total
A_Class	908581	29.25%
F_Class	478944	15.42%
C_Class	465889	15.00%
B_Class	454594	14.63%
D_Class	386862	12.45%

E_Class	338938	10.91%
G_Class	69625	2.24%

Also, G-Class was considerably less popular, being used in about 2% of races overall.

This suggests that the number of classes can be reduced. Players have little interest in the low-performance G-Class, and perceive little difference between the other classes except A-Class.

2.4 A- & F-CLASS VEHICLES MOST POPULAR

As seen in Table 52, A-Class vehicles were the most popular by a considerable margin. They were also the most preferred in multiplayer (53.6%) and in the first ten races (32.5%). These are the highest performance vehicles, so we would expect them to be most preferred by regular players, and they were (36.2% v. 20.2% for infrequent players). However, they were still used significantly by infrequent players, being the second most popular in the first ten races (33%) and overall (20.2%) and most popular in multiplayer races (54.5%).

While in the overall dataset F-Class doesn't appear significantly more popular than B-through E-Classes, when we look at subsets of the data we see certain trends. Amongst infrequent players, F-Class was by far the most popular, 55.4% overall (see Figure 55) and 47% in single player races only. This seems like an obvious result as F-Class vehicles are the only ones initially available in career mode at the start of the game, but as shown above, infrequent players are less likely to play in career mode.

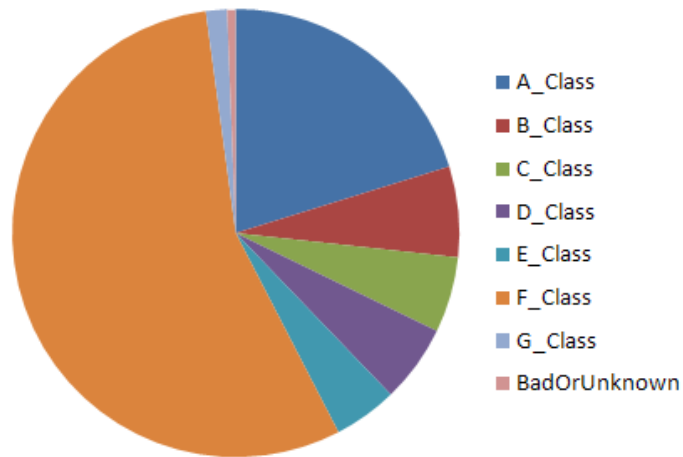


Figure 55: Vehicle Class, Infrequent Players

- A-Class vehicles were the most often used overall, in multiplayer, and in players' first ten races
- A-Class vehicle were the second most often used by infrequent players overall and in their first ten races
- F-Class vehicles were the most often by infrequent players

2.5 C-CLASS & B-CLASS EQUALLY POPULAR

As seen in Table 52, C-Class was slightly more popular than B-Class overall. This may not seem significant, but when we look at the data for the first ten races, we see that C-Class was the second most popular class among regular players at 26% v. 13% for B-Class. This suggests that C-Class cars have characteristics that make them more appealing to players than the higher-performance B-Class vehicles.

- In their first 10 races, regular players used C-Class vehicles twice as often as B-Class vehicles

3 RECOMMENDATIONS

The five conclusions we reached after examining the Start of Race dataset led to four recommendations for future development that would be applicable to many different games in the racing game genre, and could possibly be generalized to other games:

- New players should be encouraged to play in career mode
- New players should be encouraged to use F-Class vehicles in multiplayer
- Development time and costs could be reduced by having fewer available options
- Reduce the number of vehicle classes from 7 to 5

3.1 NEW PLAYERS SHOULD BE ENCOURAGED TO PLAY CAREER MODE

As discussed above, regular players are more likely to play in career mode, both overall and in the first ten races. This suggests that playing in career mode increases the likelihood that a player will continue playing the game for a much longer time. Players enjoy progression, and being presented with a series of increasing challenges and rewards, such as advancing through the stages in career mode, will cause them to be engaged and keep playing.

The data suggests that many new players come into the game, experiment with various game modes and event types in their first few races, and then stop playing. If they could be drawn into the challenge/reward structure of career mode they would be more likely to continue playing. The early career races are designed to be easy, so most players will start winning early, unlocking more cars and routes that they are then eager to try out.

3.2 NEW PLAYERS SHOULD BE ENCOURAGED TO USE F-CLASS VEHICLES IN MULTIPLAYER

While infrequent players were shown to prefer F-Class vehicles in single player races, they had as high a preference for A-Class vehicles in multiplayer as regular players. Given that the learning curve for A-Class vehicles is quite steep; this may be a factor in infrequent players losing interest in the game. If, in one of their earliest experiences with the game, a player joins a multiplayer race with experienced players on a track they are unfamiliar with, picks one of the fastest cars available, and then crashes in the first turn, they are likely to become frustrated and stop playing.

Alternatively, new players could, by default, be sent to multiplayer races only with other new players, specifically on tracks that are available early in the single player game. The only vehicles available would be the F-Class vehicles, so they wouldn't feel compelled to select an A-Class vehicle merely to be competitive with other players. These initial experiences in multiplayer would be gentler, on tracks and using vehicles they are familiar with, and against other players of similar skill levels.

3.3 DEVELOPMENT TIME AND COSTS COULD BE REDUCED BY HAVING FEWER AVAILABLE OPTIONS

Our analysis showed that 20-70% of the available options were used in less than 1% of races each. As asset creation is a major expense in game development, reducing little-used options could significantly reduce costs and development time while having little impact on players' experience. Each vehicle in the game, for example, represents a significant investment: a 3d artist must model it, a texture artist must decorate it, a designer must to tweak its performance values, and testers must rigorously use it in a variety of conditions to make sure there are no problems. Creating new routes requires artists, designers, and testers, while new event types require engineering effort.

That being said, there are benefits to having little used content available in the game. It can extend the life of a game for players; they can explore rarely-used options when they grow tired of the game. A wide variety of options can lead to emergent play as players find uses for content that developers never anticipated. The amount of content can be useful in the marketing of a game; being able to say that your game has more vehicles or event types than your competitors can drive sales.

While excessively pruning available content in future games might not be preferred, a reduction of 20% across the board could reduce costs and development times significantly while the back of the box could still boast that the game contains more than 100 vehicles.

3.3.1 REDUCE NUMBER OF VEHICLE CLASSES FROM 7 TO 5

In addition to reducing the sheer amount of content, removing complexity from the game can reduce cognitive overhead for the player. In particular, the seven vehicle classes are an unnecessary element that does not enhance the game experience for the player.

The analysis showed that G-Class vehicles were used in about 2% of races overall. These are mostly low-performance specialty and historic vehicles that are not generally of much use to players throughout the game. Any that developers feel are important enough to keep could be moved into other classes.

The analysis also showed little difference in preference for Classes B–E. While having stages of progression is important to the learning curve, fewer steps would achieve the same effect. In particular, C-Class is preferred over B-Class in some instances, suggesting there's little difference and the two could be combined.

The resulting five classes should offer sufficient ramp-up in difficulty for the player to progress through the game without any sudden increases.

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