

Cause-Effect Relationships between Design Patterns and Designer Intent in FPS Levels

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ABSTRACT

When creating a game level, the designer has an idea of the gameplay they are trying to elicit from the player. One approach to understanding designer intent is through design pattern, recurring arrangements of design elements that exist across similar games. By identifying design patterns and the associated designer intent, we can provide tools to explore design space and teach about game and level design. But design patterns may not always create the intended gameplay; this paper looks at common design patterns in single-player first-person shooter (FPS) levels and presents some results from a study that explores these cause-effect relationships. Analysis of data from this study shows the player behavior that resulted, improving our understanding of the design patterns.

Keywords

level design, game design, design patterns, game metrics, data analysis

1. INTRODUCTION & RELATED WORKS

In some game genres, level design can be a critical aspect of what creates gameplay. The game mechanics define the verbs the player is able to perform while the level gives the player a space in which to enact them. In FPS games specifically, level designers create gameplay through the construction of geometry, placement and behavior of non-player characters (NPCs), and the availability of weapons and items. 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.

Previous work in this area has explored level design patterns for FPS games, providing cause-effect relationships between level design patterns and gameplay [4]. To help validate these relationships, we present results of data analysis from an extensive user study on FPS level design patterns. 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 is unique since it shows specific cause-effect relationships between the level design and player behavior. The goal is to provide 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.

Interest in game design pattern research is on the rise, recent publications have included explorations of patterns in RPG quests [10], motivational patterns in social games [7], FPS weapons [2] and NPCs [9], platformer games [1], and patterns to guide player movement [8]. Similarly, research in game data analysis has involved studies of long-term player data to understand player retention [14], game balance [6], and player engagement [5].

2. DESIGN PATTERNS

This work builds on existing exploration of single-player FPS level design patterns [4]. Details on all identified patterns can be found at the LDP website [11]. Space limitations require us to limit our presentation of results in this paper to a single pattern, the Sniper Location. For completeness we reproduce the description of the Sniper Location pattern here.

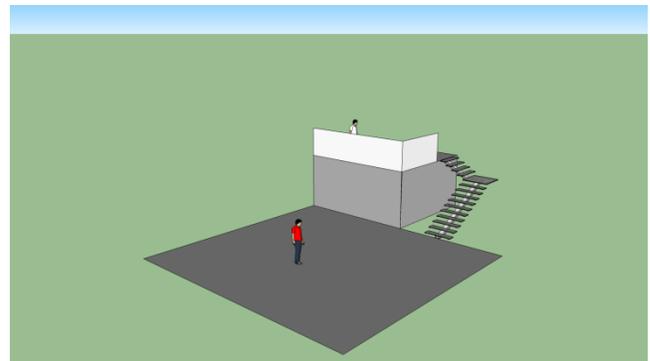


Figure 1: A Typical Sniper Location

Description. Sniper locations are one of the most common patterns. A character in a sniper location can engage 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.

Examples. In the level “Route Kanal” of *Half-Life 2* [12], the player encounters an enemy sniper location, shown in Figure 2. 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 2: Sniper location in *Half-Life 2*

There is a sniper location in the level “Corinth River” of *Killzone 2* [3]. 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.

3. USER TEST

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 using instances of the design patterns. The game engine used for this study, Valve’s Source SDK [13], has a built-in data logging system, but it needed to be modified for our purposes. Several new event types were added to capture important aspects of player behavior in the needed detail.

To track the participants’ progress through the level, we added an event was added to the telemetry system to report player state every ½ second. It captures 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 game, we needed 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 dummy triggers for the sole purpose of tracking when the player entered or exited a pattern instance, as well as a level end trigger so we could track when the player successfully completed a level.

Table 1: Logged Events

| Event Name | Activation | Data Logged |
|-------------------------|--------------------------|--|
| LevelInit | Level begins or restarts | Level name |
| Trigger | Player touches trigger | Trigger name (PatternEnter, PatternExit, LevelEnd) |
| PlayerStatusReport | Every ½ second | Player position (X, Y, Z), health, armor, weapon equipped |
| WeaponFired | Player fires weapon | Weapon type, player position |
| WeaponHitEntity | Player’s weapon hits NPC | Weapon type, damage, NPC type, distance, player position, NPC position |
| PlayerKilledOtherWeapon | Player eliminates NPC | Weapon type, NPC type, distance, player position, NPC position |
| PlayerDamage | Player takes damage | Damage, NPC type, distance NPC position, player position |
| PlayerDeath | Player dies | NPC type, distance, NPC position, player position |
| PlayerPickedUpItem | Player picks up item | Item type, player position |
| PlayerPickedUpWeapon | Player picks up weapon | Weapon type, player position |

Since the purpose of this study was to understand how FPS players respond to design patterns in the levels, we focused on recruiting experienced players that reflected the general demographic of FPS players. Prior to the study, each participant was asked a series of questions to gauge their experience with FPS games and digital games in general. The purpose of the survey was to justify excluding any participant with a low enough skill level to add noise their data, though all participants proved to be experienced FPS players. On average, they spent 10.4 hours per week playing games, and 47% of that time was spent playing shooter games.

4. METRICS

To show the effects of design patterns in FPS levels on gameplay, we built levels explicitly using patterns and analyzed the collected data to understand player behavior. For this study, we focused on pace, tension, and challenge as the primary facets of player behavior. To study how these facets are affected by level design, we first identified what metrics affect each facet, and how the effect increases or decreases the facet. Table 2, Table 3, and Table 4 show how the metrics are expected to change for each facet.

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 NPC actions are considered. Support metrics include the player's health and armor levels, the number of items and weapons collected 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 pattern being considered.

When looking at pace (Table 2), 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 eliminating 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 sub-machine gun (SMG) and AR2.

Table 2: 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 experiences while playing the game. 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 3: 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 are hit by NPCs, 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 4: 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 |

5. RESULTS

We analyzed the user test 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 [15]. 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.

For this paper, we present the results for one of the more common patterns in FPS levels, the Sniper Location. There were 5 different sniper locations in the 5 levels in the user test. Each was designed with different intended gameplay effects, as shown in Table 5.

Table 5: 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 |

5.1 SniperLocation-1

SniperLocation-1 (Figure 3) is a wide, high, well-covered, player-advantage position that overlooks a small area containing five mid-powered enemy NPCs. The enemy NPCs have no access to the sniper location and a long-range weapon (the crossbow) is available for pick up in an obvious location. This combination of affordances was intended 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 a 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.



Figure 3: SniperLocation-1

Table 6: 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 |
| NPC Hit Distance | 556.3 | 980.0 | 1.1×10^{-19} |
| NPC Killed Distance | 616.9 | 1003.9 | 2.6×10^{-17} |
| Player Fired Frequency | 0.9 | 2.3 | 4.1×10^{-4} |
| NPC Hit Frequency | 2.1 | 3.0 | 0.0068 |
| NPC 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} |
| Overall Accuracy | 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 preference for the long-range weapons is also inconsistent with the intended 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 7: 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.

5.2 SniperLocation-2

SniperLocation-2 (Figure 4) 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 NPCs 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 8: 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 |
| NPC Hit Distance | 427.7 | 513.8 | 0.17 |

| | | | |
|-----------------------------|-------|-------|-----------------------|
| NPC Killed Distance | 520.2 | 570.4 | 0.45 |
| Player Fired Frequency | 0.9 | 3.8 | 0.05 |
| NPC Hit Frequency | 1.9 | 8.8 | 0.1 |
| NPC 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 |
| Overall Accuracy | 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 |



Figure 4: SniperLocation-2

The lower movement distance and frequency in this pattern indicate a reduction in pace. Frequency of combat actions was lower, also suggesting a reduced 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 the level containing this pattern was the second most difficult level in terms of player deaths, there were no player deaths in SniperLocation-2. Players took hits from 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 9: 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 NPCs one by one, rather than creating the large combat situation as intended.

5.3 SniperLocation-3



Figure 5: SniperLocation-3

SniperLocation-3 (Figure 5) is a high, large, well-covered player advantage sniper location with no access. Players overlook a large area containing three low-powered NPCs, plus another NPC that starts in the sniper location. No long range weapons are provided; the player is only equipped with the low-powered, high rate of fire pistol. Given the advantage of the position, the relative weakness on the 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 10: 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} |
| NPC Hit Distance | 645.3 | 499.0 | 0.0003 |
| NPC Killed Distance | 581.5 | 404.4 | 0.0001 |
| Player Fired Frequency | 1.3 | 1.0 | 0.1 |
| NPC Hit Frequency | 2.8 | 1.7 | 0.004 |
| NPC 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 |
| Overall Accuracy | 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 11: Expected v. Observed Changes in SniperLocation-3

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

As mentioned, 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.

5.4 SniperLocation-4



Figure 6: SniperLocation-4

SniperLocation-4 (Figure 6) is the only enemy NPC advantage sniper location in the user test. It is low, has good cover, easy access, and is the first encounter in the level. The two mid-level NPCs are equipped with AR2s, while the player only has the low-powered, high rate of fire pistol. 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 12: 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 |
| NPC Hit Distance | 553.2 | 680.3 | 0.02 |
| NPC Killed Distance | 543.9 | 503.8 | 0.5 |
| Player Fired Frequency | 0.9 | 1.8 | 0.01 |

| | | | |
|-----------------------------|-------|-------|-----------------------|
| NPC Hit Frequency | 2.1 | 3.2 | 0.08 |
| NPC 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 |
| Overall Accuracy | 29.6% | 56.5% | 4.0x10 ⁻¹⁶ |
| Item Collection Frequency | 17.1 | 19.7 | 0.4 |
| Weapon Collection Frequency | 15.7 | 28.7 | 0.0004 |

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 13: 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.

5.5 SniperLocation-5



Figure 7: SniperLocation-5

SniperLocation-5 (Figure 7) 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 high-powered, long-range 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 14: 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} |
| NPC Hit Distance | 553.2 | 776.8 | 0.0003 |
| NPC Killed Distance | 543.9 | 772.7 | 0.0002 |
| Player Fired Frequency | 0.9 | 3.8 | 0.003 |
| NPC Hit Frequency | 2.1 | 5.4 | 0.01 |
| NPC 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 |
| Overall Accuracy | 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 15: Expected v. Observed Changes in SniperLocation-5

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

The indeterminate change in tension could be attributed 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.

5.6 Summary of Results

Table 16: 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 no clear effect. 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.

6. DISCUSSION

Design patterns describe common game design idioms, expressing cause-effect relationships between these elements and gameplay. The level design patterns considered in this paper 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, paper presents the results from a user study that explored these relationships in single player FPS level design by capturing data about how experienced players reacted to the patterns. Through analysis of this data, we were able to explore the actual effects of these patterns on gameplay and compare the results to the intended effects, leading to improvements in the pattern collection.

The major contribution of this research is to define the science of level design by illustrating 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. This process could be used to examine different types of pattern across a wide range of genres.

While this paper has only presented results from one type of design pattern, the user study included multiple patterns and reached conclusions about how those patterns, and variations of their affordances, can affect player behavior in FPS levels. Future publications will expand on these other patterns and their gameplay effects.

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