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A Phenomenological Approach to Emergent Game Properties

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A PHENOMENOLOGICAL APPROACH TO EMERGENT GAME PROPERTIES

A thesis submitted in partial satisfaction
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ABSTRACT

A PHENOMENOLOGICAL APPROACH TO EMERGENT GAME PROPERTIES

SAMUEL M. SHIELDS

Video Games are a media platform that cannot be ignored - yet when we ask what methods can we use to make a successful video game, the answers are blurry. Players seem to care about the emergent properties of games that science traditionally struggles with: fun, balance, feel, and so on. These terms tend to be stigmatized in a research community - yet they also seem to be some of the strongest indicators of a game’s success.

This thesis presents two papers that offer a framework to understand how we might start getting good design recommendations for emergent properties through a deep analysis of the conscious experience of players. In the first, we present an automated game design system (AGD) that aims to generate “balanced” games. In the second, we provide a theoretical discussion on why we might need to take unconventional routes of analysis to produce impactful games. Together, these papers present a picture not only of how to think about design strategies of emergent properties in games, but also a case-study of developing such a system and deploying it amongst users.

DEDICATION

To Sasha, who made me whole.

To Eddie, who gave me a shot.

ACKNOWLEDGMENTS

The text of this dissertation [or thesis] includes reprint[s] of the following previously published material and material pending review: Text layout has been modified to match the formatting of this document, but no other content changes have occurred. The publication(s) are

Shields, S., Mawhorter, R., Melcer, E., & Mateas, M. (2022). *Searching for Balanced 2D Brawler Games: Successes and Failures of Automated Evaluation.* Proceedings of the AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment, 18(1), 189-198. https://doi.org/10.1609/aiide.v18i1.21963.

1. INTRODUCTION

Video games, as a media artifact, are wildly influential yet poorly understood in terms of why they are so influential. Designers produce artifacts that capture millions of players, create communities between them, and even creates economies between those players. At the same time, the industry is vicious to its designers and developers. So why is it that researchers and designers have a tough time consistently reproducing, understanding, or innovating how games are made in an appreciable way?

This thesis seeks to show that our base impulses as researchers and designers to use metrics and existing frameworks to understand games may be lacking when it comes to designing new games of importance. We first present a case study that shows an attempt to create a system that designs for emergent properties, and then a theory-driven approach that aims to advance the lessons from the previous case study into a usable design framework.

2. SEARCHING FOR BALANCED 2D BRAWLER GAMES: SUCCESS AND FAILURES OF AUTOMATED EVALUATION

Samuel Shields, Ross Mawhorter, Edward Melcer, Michael Mateas

University of California, Santa Cruz

Association for the Advancement of Artificial Intelligence, 2022

2.1. ABSTRACT

Automated game design (AGD) research focuses on creating systems that can design entirely new games. This is often done by a genetic algorithm, with a fitness function that is used to find individual games that satisfy certain design criteria. However, it is difficult to tell if generated games actually have the desired emergent properties (such as balance), since the fitness function might not align well with human aesthetic judgments about such properties. This is particularly problematic when trying to automatically design balanced, fair, yet asymmetrical games for multiple players. In this paper we present an early system for automatically designing brawler games, and present findings from a preliminary user study involving the same games. We show that while the system successfully optimizes for our written fitness function during human play, we found that this optimization did not correctly translate to our hypothesized human experience of the game.

2.2. INTRODUCTION

Procedural content generation has solidified as a commonly used technique in video games, leading to a wide body of research covering many techniques for creating video game content automatically. More recently, researchers have begun to focus on automated game design (AGD) (e.g. (Browne and Maire 2010; Cook, Colton, and Gow 2016a)). Here, the generation

systems are responsible for more than a single static artifact that will be used as part of a wider
game. Instead, they generate interactive parts of the game world including narrative, game mechanics, and other game elements like sound effects. Because these systems generate multiple parts of the game, they usually strive to make coherent choices, so that each part makes sense in the context of the other part, a framework called orchestration (Liapis et al. 2018). In addition to designing entirely new games, this framework can also be used to discover new mechanics that integrate well with the fixed design of an existing game.

A primary challenge of AGD is evaluation: many AGD systems are evaluated by defining an objective function that intuitively corresponds to desirable properties of the game, and show that generated examples score well on this metric (Cook, Colton, and Gow 2016a). Because of the complexity of games, the objective is often calculated using statistical data about play traces performed by an AI. However, even if the objective function is well-calibrated towards desirable gameplay, there is no guarantee that this AI behaves in a human-like way, and thus no way to tell whether the outputs of the system are games that achieve their aesthetic goals.

This is problematic when it comes to balance in multiplayer games. While there exists literature on automated balancing in multiplayer games, studies often stop short of performing user studies to determine if proposed methodologies produced artifacts that end-users perceived as balanced. In a study on Real-Time Strategy balancing, for example, human judgments are wisely included in an iterative system that aims to tune a set of parameters to achieve balance. (Preuss et al. 2018) However, evaluations of this system consist of case studies and evaluations using an internal fitness function, leaving the reader with little understanding if a broader or uninformed audience might actually judge produced artifacts as balanced. If we computationally model aesthetically-driven judgments in a game balancing system (this character feels overpowered, this unit is under game tempo, etc.), we should also strive to show in user studies that these aesthetically-driven properties are perceived without priming or bias.

In this paper we describe a system that automatically generates games in the brawler genre, and evaluate its performance with a user study (screenshots from gameplay shown in Figure 1). We show that the system's evolutionary algorithm successfully controls many facets of actual human play, but with a weaker effect on human perception of those facets. These results from real gameplay provide insight into the circumstances under which automated evaluation is correlated with human evaluation.

2.3. BACKGROUND

Brawler games (a.k.a. Platform Fighting Games) are a subgenre of fighting games where players each control a single character and attack each other with various moves. In contrast to the Street Fighter (Capcom Co. Ltd. 1987) style of game where players have a health bar, brawler games require players to knock their opponent off the screen. Knockback inflicted to a player is scaled with the total damage that that player has - the higher their damage, the farther they fly when hit. Some examples of brawlers are the popular Super Smash Bros games, as well as games inspired by these like Rivals of Aether and Nickelodeon All-Star Brawl (Nintendo
Co. Ltd. 1999; Dan Fornance 2017; Ludosity, Fair Play Labs 2021). Brawlers are popular and often host large and competitive eSports communities.

Brawler games are noted for the emergent complexity in their competitive environments in spite of their ease to learn (Codsi and Vetta 2021). Balance and fairness are common concerns of expert players and novice players alike: experts want fairness in tournaments, and novice players want a fighting shot in any given match. Deciding what object properties in a brawling game (damage of a move, layouts of levels, physics characteristics of characters) allows for an interactive, balanced game environment is a complex problem and is the subject of many "balance patches" that publishers apply after initial release.

Our system generates simple brawler games consisting of two characters with one move each and a single level. This simplified game allows us to parameterize the core elements of a brawler game. A full list of system parameters is in Table 1. Simple changes to parameters have dramatic impacts on emergent game feel. An example: The numerical value of a character's jump force has a large effect on how powerful they are overall. Level design also has a great impact on game balance: levels might have platform spacing that is difficult for one character but not the other.

Gameplay differences driven by parameter changes provides an opportunities for a parameter-tuning system to produce asymmetrical yet balanced characters. An ideal system should be able to produce games that feel fair with significantly different characters, not only characters that are mirror copies or are so poorly constructed that they cannot functionally interact. We acknowledge that our system does not cover the full space of brawler games (more players, more moves) - the complexity described above scales dramatically with every new mechanic introduced. Due to the paucity of existing work on brawler optimization, this study serves as a starting point to investigate the generation of emergent properties in this specific gaming environment.

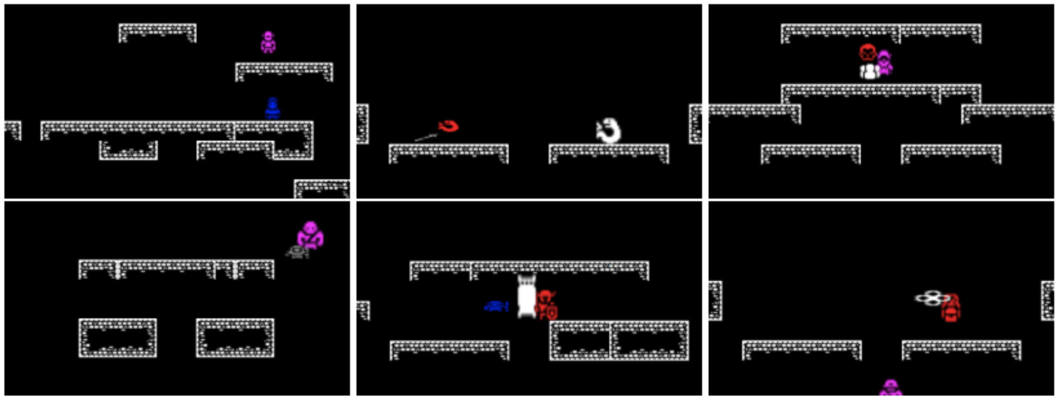

Figure 1: Six screenshots from example games. The games' labels from top left to bottom right respectively are: Game A (Evolved), Game B (Random), Game C (Evolved), Game D (Random), Game E (Evolved), Game F (Random).

2.4. RELATED WORK

Many existing Automated Game Design systems generate high volumes of candidate games and use automated evaluation to choose a subset that are judged to be the most enjoyable for human players (Togelius and Shaker 2016). Among these, it is common to use data from AI play traces to inform the objective function (e.g. (Togelius and Schmidhuber 2008; Liu et al. 2017; Browne and Maire 2010; Cook, Colton, and Gow 2016a)). This approach has also been used extensively for game balancing, where the game is mostly fixed except for optimizable parameters (Beau and Bakkes 2016; Volz, Rudolph, and Naujoks 2016; Preuss et al. 2018). Another approach involves leveraging learning techniques that strive for optimal gameplay strategy as in (Yu and Sturtevant 2019), though these methods are likely too computationally costly to have in an AGD evaluation function.

A wide variety of desired characteristics have been considered and used in fitness functions for automated game design. In addition to simple fairness, the existence of multiple competing strategies (Preuss et al. 2018), learnability (Togelius and Schmidhuber 2008; Liu et al. 2017), and the uncertainty of the outcome (Browne and Maire 2010) are a few examples. Some systems, like ANGELINA, evolve multiple parts of the game at the same time, evaluating each part individually, as well as the interplay between the pieces(Cook, Colton, and Gow 2016a,b). Our work lies somewhere between balancing and game generation: while the base game mechanics are not subject to change, the level geometry is evolved alongside the characters, and the parameter space for the characters is large.

While automatically evolving games is common, it is less common to empirically evaluate the fitness function. The success of the generated games does not necessarily mean that the fitness function actually optimized for the desired qualities. Some prior work solves this problem directly by using player preferences in the fitness function (Colton and Browne 2009; Hastings, Guha, and Stanley 2009). This solves the problem that the fitness function may be misaligned with player judgment, but it requires users to manually play and evaluate many games. Some notable prior work does take an extra step to validate their evolutionary strategy. In (Browne and Maire 2010), Browne and Maire validate their fitness function with a user study that ranked the games, showing how well each criterion in the fitness function correlated with human enjoyment of the games. In (Isaksen, Gopstein, and Nealen 2015), Isaksen et. al. optimize directly for a target difficulty of a one-button single-player game.

They performed a user study to validate their results, showing that human judgment broadly aligns with AI judgment in terms of the difficulty of the games. However, the AI in question was a player model that makes human-like mistakes and it might be infeasible to create an accurate model of human play for more complex games. Without such a model, it is still possible to use more rudimentary AI techniques to playtest a candidate game. However these playtests may be very different from actual human play in crucial ways, and understanding these differences is necessary to designing effective AI playtesters.

2.5. BRAWLER GENERATION

We used the Unity game engine to implement a brawler game generator BrawlerAGD[1]. We used free assets from Kenney licensed under CC0 1.0[2]. All games are playable with either a keyboard or Microsoft XBox controllers.

Entity	Parameter	Description	Range
Character	Ground Acceleration	Acceleration of players on the ground	0-1
	Air Acceleration	Acceleration of players in the air	0-1
	Max Ground Speed	Maximum self-applied speed on the ground	2-10
	Max Air Speed	Maximum self-applied speed in the air	2-10
	Ground Jump Force	Force applied from jump on the ground	1-15
	Air Jump Force	Force applied from jump in the air	1-15
	Mass	Impacts momentum and knockback	0.5-2.5
	Drag	Impacts air control	1-6
	Width	Scales width of player hitbox	0.7-1.5
	Height	Scales height of player hitbox	0.5-2.5
	Gravity	Scales how gravity impacts player	0.3-1.3
	Hitstun	Scales how a character responds to hitstun	0.1-0.3
Move	Distance	Distance between move and character center	0.8-1.5
	Angle	Angle Made between character and move	0-2*PI
	Width	Scales width of move hitbox	0.5-1.5
	Height	Scales height of move hitbox	0.5-1.5
	Warm-Up	Duration of move warm-up	0.1-0.6
	Execution	Duration of move execution	0.1-0.4
	Cool-Down	Duration of move cool-down	0.1-0.4
	Damage	Scalar for damage applied on hit	0-10
	Knockback	Scalar for knockback applied on hit	1-16
	Knockback Direction	Direction knockback applies on hit	(0-1, -1-1)
	Hitstun Duration	Determines base hitstun applied by move on hit	0-1
Platform	Location	Position of the platform (top left)	-
	Size	Size of platform in width and height	-

Table 1: A List of parameters used for game generation including ranges for parameter generation. Platform width and location are dependent on the game's bounds.

2.5.1. BASE GAME MECHANICS

Each generated game consists of two characters, a move that each character uses, and a stage that the characters play on. During gameplay, each character has 3 stocks (or lives), and

[1] Code for this project is available at https://github.com/smshields/BrawlerAGD. All trial games
used are playable in the repository, and the full evolutionary process is available for interested readers to generate their own new games. An example screenshot is shown in Figure 1.
[2] https://www.kenney.nl/assets/bit-pack

there is a static “blast zone” rectangle which causes characters to lose a life when they leave it. The loss condition is static: a player that loses all of their stocks loses the game.

The characters are parameterized by statistics used by other brawler games. Each character can jump twice, but the height of each jump is controlled by the generator, along with other physical attributes like the character’s size, movement speed, falling speed, and weight. The sprite is chosen randomly and scaled according to the generator. To create nuanced attacks, the generator controls the timings of the attacks, the placement of the attack relative to the character, and the knockback direction and damage of the attack. Finally, the stage is a list of platforms that each character can stand on, and block the characters from moving through them. The space of characters is large, with each character-move pair consisting of 24 independent parameters (Table 1) each of which has a predefined range of valid values. Stage designs can consist of up to 10 separate platforms.

2.5.2. GAME FITNESS

We perform evolutionary search over the space of candidate games. Stages are initially designed with an algorithm that creates a symmetrical stage where platforms are placed in accordance with player jump height. Players are generated initially by generating each parameter according to a uniform distribution on the valid set of parameter values.

We evaluate each game using the results of an automated playtest. The playtest is performed by a decision-tree AI. The AI continually tries to move towards a position that would put its opponent within the hitbox of its attack. Randomness is added to character movement (e.g. changing directions unexpectedly) to ensure that separate trials of the same game are not identical and so that characters do not get “stuck” when separated by platforms. If its character is off-stage, the AI switches to a recovery behavior tree, where it tries to get back onto the stage. This AI is capable of playing interesting matches, but the games it plays are visually distinct from human play. For this implementation, we determined that this simple agent would suffice in eliminating most extreme edge cases of generated characters: overpowered characters show imbalances in damage distribution between players, and underpowered characters lose all lives or inflict no damage to their opponent.

After the automated playtest, the objective function is calculated from a variety of information. From the playtest, we obtain ℓ the game length in seconds, d_1, d_2, the total amount of damage dealt by player 1 and player 2, s_1, s_2, the number of remaining stocks for each player after the game has ended, and h_1, h_2, the total number of hits taken by each player. From this, we calculate many fitness variables, each intended to influence a specific aspect of the candidate games. These variable are normalized to ensure that we do not overtune for any given property. The overall fitness function is the sum of the fitness variables.

We want games to last an appropriate amount of time and remove games that are unplayable. To keep the game "fast" paced and to keep our genetic algorithm efficient, we set a desired time and punished games that were too short or too long. We terminated overtime games, adding a constant score punishment (-35) if games lasted longer than a minute. The time fitness for a game is

$$f_{time} = ||\ell - \ell_{target}|| - 35 * g$$

Where ℓ_{target} is the target game length: 45s, and g is an indicator variable for whether the game ended in a draw due to running out of time after 1 minute of gameplay.

We encourage games where more damage is dealt, and more total player interactions take place:

$$f_{damage} = (d_1 + d_2)/10$$

$$f_{hits} = h_1 + h_2$$

We want each life for each player to end at an appropriate time and ensure that the system cannot blindly optimize for f_d by creating a game where players are stuck in a corner hitting each other. We set the desired damage per stock to 100, and if the total damage exceeds that, we add a linearly scaling penalty variable $f_{stocklength}$.

We also want each game to be fair. We apply a fitness penalty to games where the total damage dealt by each player is different, or where the stocks remaining are different:

$$f_{damage\ fair} = ||p_1 - p_2|| * 10$$

$$f_{stock\ fair} = ||s_1 - s_2||$$

With the overall fitness function being:

$$f = f_{time} + f_{damage} + f_{hits} + f_{stock\ length} + f_{damage\ fair} + f_{stock\ fair}$$

2.5.3. EVOLUTIONARY SEARCH

We evolve candidate games with a population size of 100, a mutation rate of 0.4, and a dropout rate of 0.5. Characters and moves are crossed-over by treating them as a list of parameters and applying single-point crossover. We leverage crossover as our character and level parameter lists are not organized according to emergent gameplay output, meaning we effectively randomize the design space between games by selecting a random point in the list and combining. Stage designs are crossed-over by treating them as a list of platforms with single-point crossover. To mutate a player or move, we re-generate 5 randomly chosen parameters using the ranges of parameters used in initial generation. To mutate a list of platforms, the entire stage is re-generated. Table 2 lists pilot study games' specific fitness scores as well as the average fitness scores of the generations that those games were selected from.

2.6. USER STUDY

We conducted a user study to understand how the genetic search of BrawlerAGD influences emergent properties of the games when played by human players. In particular, we focused on game fairness, i.e., the equal chance for each player to achieve a win given equal skill. We had users play both (1) randomly generated games and (2) games with high fitness chosen after genetic search. This study examines how players rate games from each of these groups across the following traits: ease to learn, balance, enjoyability, understandability, immersion, quality of design, and ease of control. We also examine differences in gameplay data by recording the total number of hits, the amount of damage, winners, and the game length. Players were asked to describe every game in 3 words and identify their favorite game. If we can show that evolved games have perceivably higher qualities than our randomly generated games, we can say our system is successful in designing “balanced” brawler games.

We ran 12 total trials with 24 participants. Two instances of participant data (from trials 11 and 12) were excluded due to an incomplete survey. On average, our players were moderately familiar with brawlers, with one player indicating they were not at all familiar with brawlers and five indicating that they were extremely familiar with them.

2.6.1. GAME SELECTION

To compare the random and evolved games, we used 6 sample games. Games were tested by having players play a survival match against each other, with each player having four stocks per game. To choose the random games, we generated and evaluated a set of 100 games, with a mean fitness score of -10.22. We randomly selected 3 games with fitness −10±5 to use in the study. These randomly generated games were named B, D, and F.

Game	Number of Generations	Agent Fitness	Human Fitness	Generation Top Fitness	Generation Average Fitness	Generation Average Holdover Fitness
A	315	109.32	88.26	128.27	50.12	83.14
C	98	129.47	146.29	138.47	63.56	96.93
E	224	122.23	64.53	109.52	48.67	84.44
B	0	-12.08	11.84	41.16	-10.44	2.12
D	0	-9.98	21.37	41.16	-10.44	2.12
F	0	-10.00	13.44	41.16	-10.44	2.12

Table 2: A table highlighting data from the generations of game samples used in the study. Note that randomly generated came from the same batch of 100 games. Average fitness denotes the average fitness of all games in a generation, and average holdover fitness shows the average fitness of all games that were kept for the subsequent generation.

Each run of the evolutionary search plateaued with a mean fitness score of 80-100 after 12 hours of computation. Fitness runs were taken consecutively. To select evolved games, we ran the evolutionary search to completion three times (average fitness above 80 for 20 generations). Within the final generation of each run, we grouped all games with fitness 100 or higher and randomly selected a game for use in the trial. Evolved games A, C, and E were generated from this process. The shortest evolved game was generated in generation 98, while the longest was created in generation 315.

2.6.2. MEASUREMENTS

Users started the study by playing a tutorial level where they learned the basic mechanics of games generated by BrawlerAGD using human-defined characters. Users were asked to verbally confirm that they understand game controls and goals before leaving the tutorial. Users then played each game in a random order, answering questions after each game is completed.

During trials, we collected the same gameplay data used to evaluate the fitness function. This included the total amount of hits and damage to each player, the game length, and the number of stocks remaining for each player. We leverage this data to get an understanding of how human gameplay corresponded to our written heuristic. We dropped ftime and fstocklength terms because humans play slower than our AI and occasionally took time to joke, ask questions, or experiment with characters.

2.7. RESULTS

We outline the general trends across the various games, both as observed by human players, and as seen through the statistical data about their matches.

2.7.1. USER PERCEPTION

To understand if the evolved games had better perceived characteristics, we first had to understand if the evolved games scores were statistically different from the random game user survey results. We used a t-test between the two groups (evolved and random, 3 games each) to examine the perceived differences between evolved and random games. Only one factor had a statistically significant ($p < 0.017$) difference: ease of control. Evolved games were on average slightly easier to control as perceived by users. To understand which of the games were specifically impacting that result, we performed a one-way analysis of variance (ANOVA) on all six games.

In our ANOVA comparison between all six individual games, we found that both balance and ($p < 0.001$) ease of control ($p < 0.013$) had significant differences. In particular, game C (an evolved game) was perceived to be more balanced and easy to control than the other games. Game F (a random game) was also perceived to be balanced, but was extremely difficult to control.

One simple observation comes from our post-trial survey: 63% of users listed an evolved game as their favorite game. None of the randomly generated games had a higher share of votes than the lowest evolved game.

2.7.2. GAME STATISTICS

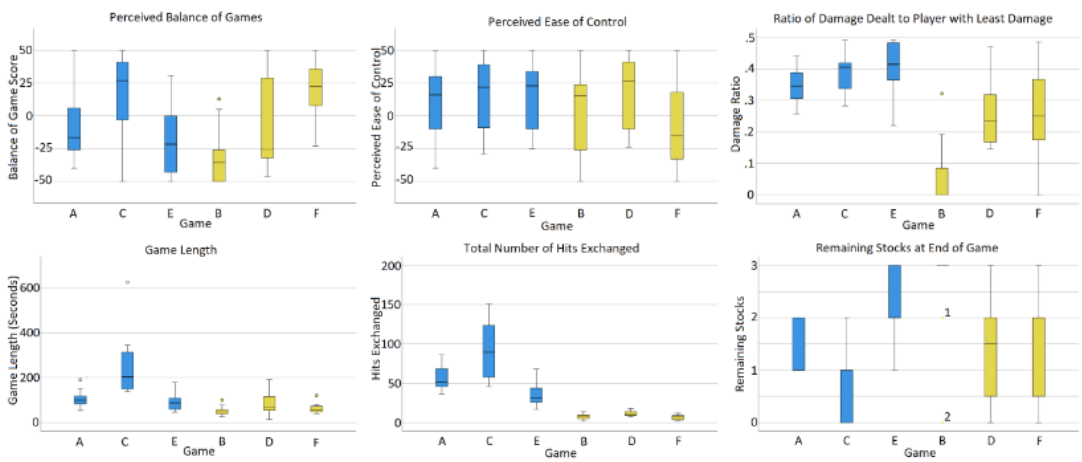

Figure 2: Distribution of user scores across a variety of measurement for evolved games (blue) and random games (yellow).

We also examined how human gameplay in the evolved games differed from gameplay in the random games, using t-tests on the quantitative data gathered from the user study. We recorded damage dealt to each player, the number of hits received by each player, the game length, and the game loser. Every one of these metrics, aside from game loser, showed statistically significant differences when comparing evolved games to random games ($p < 0.001$). Some examples of these trends: Evolved games tended to have higher amounts of damage and hits to each player. Each evolved game lasted, on average, more than twice as long as the randomly-generated games. These differences indicate that players had more interactions for a greater amount of time when playing evolved games compared to random games. Figure 2 summarizes these trends.

2.8. DISCUSSION

Here we discuss qualitative observations collected throughout trials and game evolution. These trends help provide explanations for our survey and gameplay data.

2.8.1. GAME QUALITY

Two of the games stood out both qualitatively and statistically - Game C, an evolved game, and Game F, a randomly generated game. C consisted of one short and one tall character, both with moves that pointed downward. In order for characters to land hits in C, they had to jump a single time, position themselves over the opponent, and trigger their attack. In F, both characters are roughly equal size but jump very high and move very quickly, making them challenging to control and land attacks on opponents. Attacks in F were high-powered and often killed in one or two hits.

Both of these games were evaluated as “balanced” by our players by a similar margin (and these results are also borne out by the empirical gameplay data). Game C (Evolved) scored the highest on most survey questions, while also producing games with the greatest length and damage/number of hits. Game F (Random) scored high on balance but scored poorly in control. In descriptions of the game, 3 players called the game “slippery” while others commented that the controls felt “touchy” and characters felt “floaty”. That the generator produced multiple examples of balance with human-perceived differences in game-feel indicates that the system is capable of producing balanced games that are not homogeneous or trivial in their gameplay.

C and F are just one example of a general trend in the differences between random and evolved games. While the system can randomly create games with some desirable characteristics, it is unlikely to find games that combine multiple desirable characteristics without some kind of search. This explains the lack of statistical significance in the individual categories, despite the preference for evolved games in aggregate.

2.8.2. AUTOMATED PLAYTESTER ALIGNMENT

Players often developed gameplay patterns similar to behaviors performed by the AI during evolution. Game C scored highly during evolution as AI characters would jump over one another inside of a corridor, attacking one another with their downward-facing attacks (as shown in Figure 1). This caused the automated testers to keep trading hits until one was flung outside of the corridor. During trials, most participants followed an extremely similar behavior pattern, which in turn led to similar damage and hit outcomes.

This effect backfired when users did not follow or understand the evolved game's key quirk. When users diverged from the most common AI behaviors, evolved gameplay started to become very unpredictable and unbalanced. I.e., the automated playtesting did not cover a broad enough set of gameplay styles to stand in for human play. Some stages forced or enticed users to play in a similar way as the automated tester, and these scored numerically higher on fitness when played by humans. The design of each game influenced how well the automated playtester was aligned with human play. While the system is far from perfect in covering all gameplay possibilities, the ability for the system to even infrequently create such intricate behaviors in players by tuning parameters indicates that this style of search can create distinct, meaningful, emergent playstyles while designing games.

2.8.3. TRENDS IN EVOLVED GAMES

There were some general trends in game design that we observed in the evolved games. Most of the evolved games tended to have characters with move hitboxes that would directly put the character in range of their opponent's hitbox. Evolved games also often had characters with attacks that could only be performed in some specific character state: for example, the downward attack in game C required players to jump first. These patterns meant that every attack would put player at risk, which encouraged interaction between the characters. If a player missed an attack, it can be immediately punished by their opponent. Another quirk of

high-fitness games is that many attacks had knockback directions that pointed diagonally backwards towards the attacking character (for example, game E). Most human players found this knockback confusing or disorienting. Players would line up what they thought was a fatal hit, only to have the resulting knockback push themselves off of the stage. This is an example of how a fitness function designed to increase the number of player interactions can create game elements that are incomprehensible to humans.

2.8.4. LIMITATIONS

While we had modestly positive results towards evolved games in user perception, we did not show that users consistently perceived evolved games as more balanced than randomly generated ones, even if their created heuristics would have indicated to us that they should have. We attribute this in part to the complexity of the term “balance” and making judgments about it. While balance may be intuitive to most people, that intuitiveness does not translate to agreement on what is balance between users or games. Narrowing definitions of the emergent properties we desire in these systems or grouping users into persona categories could help in future evaluations of emergent properties in AGDs.

Players also played the games against each other. When playing random games with clear mechanical imbalances (see Game B, where one player had their move behind and below their sprite), the winner would often feel very positive about their win. They might gloat, and on one occasion, one said “that was the most balanced game we’ve played yet”.

Furthermore, a player with a long history of brawler fighting games matched against a newcomer might make both feel that every game was not balanced. It should be noted that while this was qualitatively observed, the data does not clearly bear this out - winners and losers did not have statistically significant differences in balance judgments in games.

2.9. CONCLUSION

We created an automatic game designer that generates brawler-fighting games. We optimized these games for simple metrics that measure desirable properties about the games like balance, ease of control, and interactions between players. By evaluating the generated games with a user study, we learned about the ways in which our fitness function influenced human gameplay. Broadly, evolved games exhibited higher fitness when played by humans, indicating that automated playtesting (even with a very simple AI) can help optimize human play for given gameplay properties. The qualitative and quantitative matching of simple AI performances and human play indicate that our designer can also discover interaction patterns and mechanics that humans might enjoy.

These statistical differences did not necessarily translate well to human perception of the games, a problem also described in (Isaksen, Gopstein, and Nealen 2015). Ultimately, the goal of evolving games towards a fitness function is to improve and shape the user experience of the person who eventually plays those generated games. Towards that end, it is important to consider how the fitness function might be misaligned with how users will experience the game. A “high-fitness” game might not actually have the properties it was optimized for when played by humans. It is also important to tune the evaluation agent to better match human behavior. A future study might look to evaluate what factors might be critical in creating a balanced game for a future heuristic, or what types of agents create the most accurate representation of human play.

This means that data from human players should be more central when it comes to the design of automated evaluation. One path forward is more advanced automated playtesting that incorporates user data to play the game in a human-like way. This would extend research on player modeling in PCG such as (Shaker, Yannakakis, and Togelius 2010). Another method would be to change the generative techniques themselves to incorporate user data (for example, (Sorochan et al. 2021) does this for a single-player game). A novel approach might be to use techniques from Human-Computer Interaction, such as “Design Personas” - user profiles that guide design of an artifact (Salminen et al. 2022). Finally, by correlating design variables with human perception of the resulting game, a system could guess the perception of a novel game, allowing it to automatically adjust the fitness function in response to user feedback.

3. TOWARDS QUALIA-DRIVEN GAME DESIGN

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3.1. ABSTRACT

Video games act as engines that communicate aspects of experience through player interaction. We argue that this communication of first-person experience (qualia) is unique in its ability to interact with a player's mind-body in a potent and observable way. Unfortunately for designers and researchers, many of the desirable traits of video games are not inherently measurable via traditional, quantitative means - they are emergent properties dependent on the perspectives with which they are observed.

This position paper investigates the work of video game designers as it relates to phenomenology and embodied cognition and lays out a path for future researchers and designers to leverage phenomenology as a foundation for video game creation. We suggest that the intersection between embodied cognition, game design, and phenomenology suggests a path from descriptions of conscious experiences (qualia) to real, distributable design recommendations in video game design and study.

3.2. INTRODUCTION

3.2.1. VIDEO GAME ADOPTION

Video game design, as a discipline, is under a century old yet rapidly maturing. Video games dominate the entertainment market from an economic perspective, producing $180.3 Billion in revenue in 2021 [Wijman, 2021]. The academy rapidly integrates game design across disciplines, leveraging games as teaching tools or frameworks to run experiments. Games are increasingly used and presented as a new media of art that gives designers an even closer metaphorical seat to their audience by managing their interaction space.

The monetary, intellectual, and artistic success in games-as-a-media has led designers and researchers to search for techniques to consistently incorporate reliable, reproducible features that guarantee a creator's desired outcome. These outcomes are imagined and arguably evaluated against player perceptions emergent from their experience with the game. The creator hopes the players find their game experience fun, scary, and so on. Unfortunately, implementation techniques and strategies often need to catch up when consistently trying to reproduce these emergent properties from games. A readily identifiable example of this is balance - many studios place substantial effort into balancing a game so that a player feels the game is appropriately fair throughout play. Even with this investment, games are released yearly with balance problems requiring forced internet updates to fix [Švelch, 2019].

3.2.2. GAMES HAVE AN IMPACT

The race for developing consistent game development strategies is not only motivated by expression, money, or reputation - we are also rapidly discovering that games can have potent sensory effects on players over time. Research suggests that games can be effective education tools [Martinez et al., 2022]. Games have been used in medical interventions and prescribed as medication [Evans et al., 2021]. Game communities form modding circles, co-creating content to express themselves and deepen their relationship with a game world [Poretski, 2017].

A short illustration - In his seminal work on game design, "Game Feel," Steve Swink describes a phenomenon where players experience illusory tactile and kinesthetic sensations when playing a video game [Swink, 2009]. A typical example of this might be observing someone who leans into turns while playing racing video games, emulating leaning against the force of a turn in a real car. This behavior likely will not occur when watching a movie about racing or reading a book about racing. Game Feel is one of many other observed effects (e.g., the proteus effect) that stem from the quality of experience produced between a player and a video game. Swink understands this and frequently uses first-person examples and onomatopoeias to emphasize the role of the user's experience in game feel implementation.

3.2.3. METRICS-DRIVEN DEVELOPMENT

Contrary to Swink's approach, many professional and academic disciplines have oriented around metrics-driven quantifiable approaches emphasizing a reportable, reproducible design framework. This approach is attractive for these audiences because it enables one to convincingly show metrics that indicate if a study is successful in some specific regard [Christ, 2014]. This indication should reduce the risk that a project will not produce desired returns in a design environment where multi-year development times are the norm. Examples of this might be a high enough volume of players or the recorded sentiment after a game. Fuzzy-yet-intuitive concepts are tied to these gameplay metrics: did the player find the game fun, immersive, balanced, educational, and so on. However, if we look too closely at these concepts, simple definitions tend to fall apart. How do we get from attempting to create "fun" to some quantitative metric? While there are approaches to mitigate this problem, the space between our attempts to create emergent properties in games and developing metrics to measure them is a daunting gulf.

While we can reason about the value of creating and using such metrics, the lack of consistency in definitions makes it challenging to reuse metrics across use cases. In addition, metrics do little to tell designers how to make a game - aiming for a specific metric still leaves the designer to (at least implicitly) build out assumptions underneath the metric. When discussing the outcomes of games, metrics give us a language to use but are insufficient as a design or research strategy to get the embodied outcomes we described before.

3.2.4. QUALIA IN VIDEO GAME DESIGN

A practice named "Phenomenology" can provide a useful design toolbox in addition to quantitative-driven development. This discipline sought to restore the importance of a first-person, experiential viewpoint in the face of increasing suggestions of metrics requirements to make scientific claims [Smith, 2018]. An outcome of this discipline's interaction with cognitive sciences was the concept of qualia - instances of experienced phenomena. A simple way of thinking of this might be thinking through the experience of a person seeing a red balloon. There is an observer (person) and an object (red balloon), and the total experience the observer has of the object (person experiencing the red balloon). While primarily used in a theoretical context, we can repurpose qualia as a design tool and evaluation subject in video games. We can design to attempt to evoke specific qualia or interrogate an individual about their qualia to discover critical elements triggering the qualia. Using qualia as a tool is not only the way designers might intuitively do their work but also provide better access to the substantial impacts that games can provide when played.

3.2.5. SIGNPOSTING

Our first section will briefly introduce phenomenology and its current relationship to video games. Next, we will review embodied cognition, its connection to video games, and a list of behavioral effects that have started to pop up in the literature. We then present a synthesis of phenomenology and its relationship to game design. The paper's final section will present a case study on the video game property "balance."

3.3. BACKGROUND

3.3.1. PHENOMENOLOGY OVERVIEW

Phenomenology is concerned with understanding the "...conscious experience as experienced from the subjective or first person..." of an individual [Smith, 2018]. Phenomenology was initially formally introduced as an academic discipline in the early 20th century by Edmund Husserl, who was frustrated that intellectual analysis was increasingly being performed in theoretical terms abstracted from human experience. Husserl opens the field by distinguishing objects of perception and the act of perception as separate, allowing future philosophers to explore the space between experienced objects and their mental representations.

Husserl had a cadre of acolytes that provided critical dimensions to phenomenology. Heidegger zooms out from perception and includes being, maintaining that perception and representation are cognitive elements of a more encompassing state of being. Schutz incorporated social structures into phenomenology, discussing how experience is informed and reformed by compounding social observations and performances. Heidegger and Schutz are important examples to reference in design as they couch the cognitive, environmental, and social elements of experience as inextricably tied together. For the HCI community, perhaps the most relevant classical phenomenologist is Maurice Merleau-Ponty, who incorporated a naturalistic understanding of the human body into their analysis of experience [Smith, 2018].

[Dourish, 2001] provided a modern approach to phenomenology and technology, viewing embodiment and phenomenology as critical to interactive design practices. Embodiment is not physical awareness, and phenomenology is more than first-person reporting - both are deeply involved with analyzing the totality of being. Dourish's work forms a foundation for including phenomenological perspectives in digital design, establishing guidance for developing a practice oriented around embodiment and meaningful actions.

3.3.2. VIDEO GAME DESIGN PHENOMENOLOGY

The private industry has successfully incorporated phenomenology into product development. Good design is now popularly argued to stem from a detailed and diverse understanding of possible user experiences. Dan Norman's bible on Human-Centered Design is a hallmark of this pivot: we design for people, not for requirements [Norman, 2013]. Norman points out that objects with observed affordances (properties of things that indicate how they will be used) drive "good" design. The spread of Human-Centered Design into communities, such as Human-Computer Interaction, has produced diverse approaches to incorporate phenomenology into practical product development practices.

For example, "Persona" analysis has been a tool in software development to capture a diversity of viewpoints when designing products. This type of analysis requires a research period where the practitioner must create some profile that reflects a semantically meaningful category of users. Personas then become design and evaluation tools - how will this platonic persona use the designed system? This approach generally involves a range of interviews, reading firsthand accounts, and collecting important contextual information about a critical customer segment to create a summarized representation of their goals and capabilities. [Salminen et al., 2020]

In general, phenomenological design practices involve a conversation between a designer and an audience, informed by the usage (or imagined usage) of the designed product by an individual and that individual reporting on it. This reporting can be quantified and used in further software development, automating phenomenologically-defined quantitative profiles in advertising targeting, recommending systems, and the like.

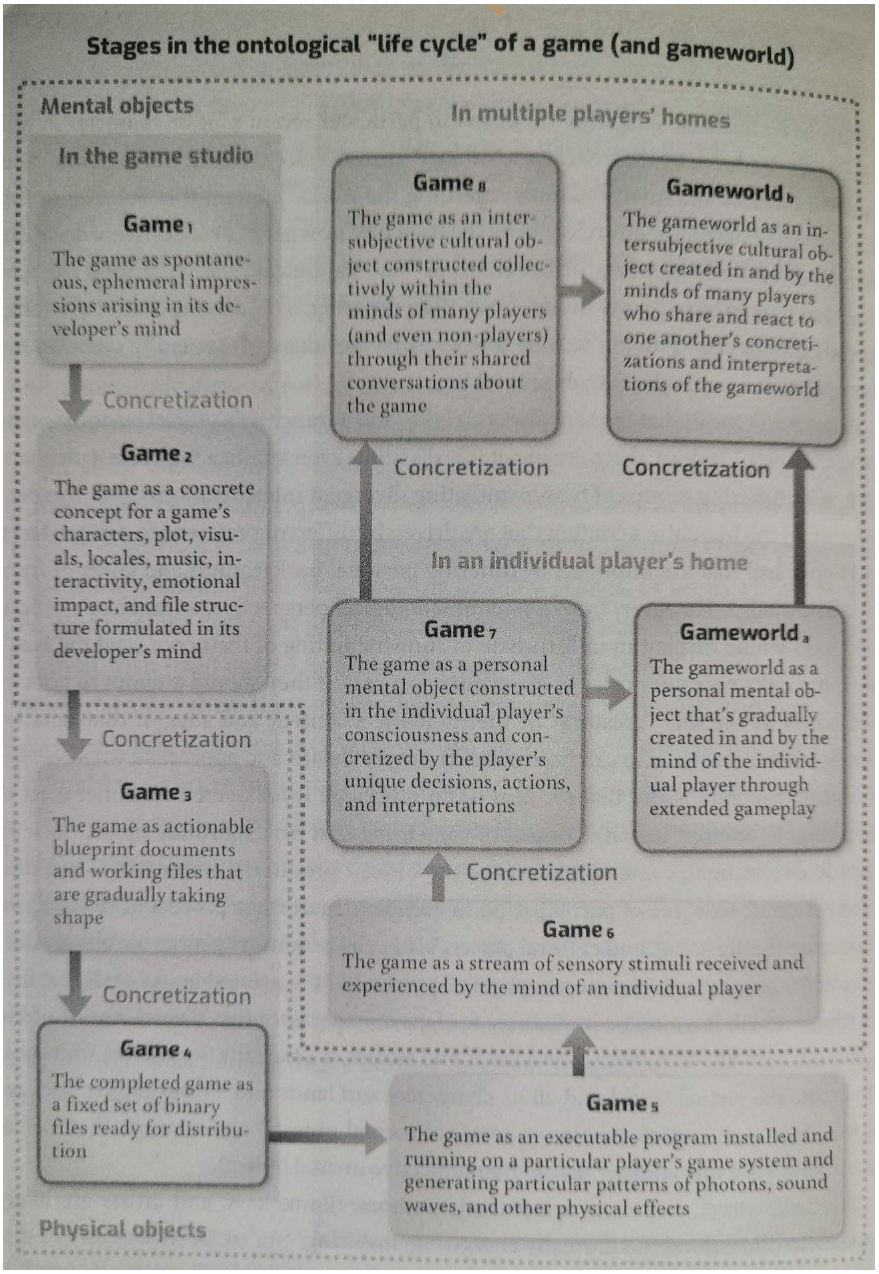

Figure 1: A diagram demonstrating Matthew E. Gladden's categorization of different ontologies produced by games over their total lifecycle. This lifecycle demonstrates how the perceived world of a game artifact can vary greatly depending on the use

case and perspective of the end user. [Gladden, 2019]

3.3.3. DEFINING EMBODIED COGNITION

Embodied cognition states that the mind is not abstracted from the body but necessarily embedded in our body. Embodied cognition, like phenomenology, is less of a specific field and more of a research program oriented at centering understanding through the lens of a mind-body. The similarity between embodied cognition and phenomenology is no accident - the work of Husserl's entourage influenced the foundations of the field. Embodied cognition exists in opposition to the idea that the mind/brain controls the body from a privileged position, separate from the body. This grounding in bodily responses has made embodied cognition approaches portable to areas such as sports psychology or psychiatry [Leitan et al., 2014].

3.3.4. CONNECTING EMBODIED COGNITION TO VIDEO GAME PERCEPTION AND DESIGN

In Video Game Design, gameplay experience has frequently been claimed to be embodied or deeply seated in the mind-body. [Gee, 2008] uses a model that views the mind as a simulation of embodied experience. Gee views the mind as an engine to simulate, predict, and prepare the body for upcoming embodied experiences. Similarly, [Isbister, 2018] points to "grounded cognition" as a wellspring for cognitive reactions in video games. Grounded cognition seeks to explain behavioral responses in the context of the individual's prior "grounded" experiences. In other words, how we react to situations, actual or simulated in a video game, will still be tied to our mind-body reactions in our past experiences. Our brains root for new mental experiences as reconfigurations and transformations of previous experiences.

This conclusion has been reflected in some empirical respects as well. For example, character-based video games have been found to evoke embodied feelings of extension [Lankowski, 2016]. We see a character with a familiar form, and we feel what happens to that form through an embodied lens. Core game design elements - managing player challenge and enabling player agency - directly overlap with cognitive science concepts of flow and personal agency [Isbister, 2018]. Uncertainty is used as a way to trigger and influence player engagement in similar ways that behavioral schedules might be articulated [Costikyan, 2013]. The use of virtual reality for neurorehabilitation proves to be promising, prompting a flurry of research that leverages the embodied properties of the format as a therapeutic tool [Perez-Marcos, 2018]. [Melcer, 2021] articulates how embodiment as a concept lacks a singular coherent definition, instead having applications across many domains such as design and the brain sciences. In the same paper, Melcer notes the potential for embodied interfaces to specifically promote increased benefits in learning games and simulations, providing a design taxonomy to fulfill such goals. Melcer's exploration transitions nicely into our next section, where we explore the potential mental and physical benefits of embodied-cognition strategies along with observed behavioral and sociological effects attributed to video games.

3.3.5. EMBODIED COGNITION AS AN EXPLANATION FOR OBSERVED VIDEO GAME EFFECTS

While it might be easy to dismiss embodied cognition as a specific paradigm of phenomenology, embodied cognition has produced testable benefits in understanding how learning with the body can accelerate learning or relieve various conditions. For example, embodied cognition has contributed to a movement in trauma therapy treatment that leans heavily on re-establishing the mind-body connection as an avenue for treatment. This treatment style has proven markedly successful, competing in efficacy with previously established treatments. Mindfulness practices, trauma-sensitive yoga, and eye-motion desensitization response (EMDR) are all interventions that lean on the embodiment of the mind to operate to great success [van der Kolk, 2015]. The success of these campaigns, and their connections to embodiment, provide a template for understanding why video games have the potential to cause strong cognitive reactions in players.

Suppose embodiment is critical to certain psychiatric interventions and can be produced by video games. In that case, it should follow that we can trigger relevant psychological interventions if we can figure out how video games produce embodiment. While the literature is young, there are multiple peer-reviewed publications detailing the creation of serious games targeted at specific neurological ailments. Some examples include using Virtual Reality environments and games to provide stroke rehabilitation [Charles et al., 2020] and a tablet-based game to teach children with ADHD emotional regulation skills [Evans et al., 2021]. Potential is beginning to be shown for video games managing Autism-Spectrum disorders. [Jiménez-Muñoz et al., 2022] Experiments connecting a video-game interface to a pain-management minigame successfully produced changes in patient perception of said pain [Huang et al., 2022]. As referenced in work from Melcer and Isbister, incorporating movement into activities increases the educational potency of those activities.

These are examples pulled to emphasize connections to existing literature concerning mental illness, education, and brain science - but the observed phenomena around video games show that there is still significant uncharted territory regarding the type of cognitive effects we can evoke with games. The following section will explore two effects, each driven by an individual's experience of a digital interactive system.

3.4. EXAMPLES OF VIDEO GAME EFFECTS RELATED TO EMBODIED COGNITION AND PHENOMENOLOGY

3.4.1. THE PROTEUS EFFECT

The Proteus Effect shows that a player's "occupation" of a virtual avatar leads to real-world differences in player behavior. First described by [Yee et al., 2007], the effect is significant because it demonstrates how the aesthetics of a game's avatar alone can trigger substantial personality changes, both with and without the knowledge that said changes are happening. A hypothetical example of this might be a player acting uncharacteristically intimate when assigned an attractive avatar to occupy [Yee, 2014]. A notable trend in the literature surrounding the proteus effect is that it only tends to happen when the player experiences a high level of embodiment. Further, it tends to only happen on character traits that the player views as positive - negative traits are avoided for personal incorporation and even act as a literal obstacle for embodiment during a game experience [Praetorius et al., 2020].

From a design perspective, one can already see how one might leverage this effect to evoke specific behavior patterns from players. One can lean on cultural tropes to encourage players to act along them implicitly or design avatars to help players feel confident enough to enter an intimidating area. Outside of pure entertainment, one can imagine creating characters that help players occupy personality traits they wish to embody - sociability, confidence, and so on.

3.4.2. GAME FEEL

Game Feel is the illusory tactile and kinesthetic feelings players perceive during gameplay [Swink, 2008]. Game feel might be the sense of movement one feels when racing around a racetrack in game or the shock and jump of receiving a high-impact hit in a fighting game. Game feel requires experiential consideration because it relies on learned cues across various affordances to invoke the feeling of movement. It also helps to make movement predictable and consistent between a game experience and an authentic experience [Pichlmair et al., 2021]. Returning to our racing example, we might observe players engaged in a tight race leaning into turns or jumping as they bump into obstacles. Playing a game with no pre-thought game feel elements might not evoke this reaction. Games like *Need For Speed* are blurring the edges of vision, adding screen shake to emulate the engine rumbling, jostling player hands with controller feedback, and applying the doppler effect to give experiential similarities to going very fast in a car. Implementing game feel is not possible along one dimension. One has to first consider the complete perceptual experience of the thing before including the appropriate list of signifying effects to evoke it in the audience [Hicks et al., 2018].

An abstracted example of game feel provided by Swink is the expectations players develop in response to Game Feel Aesthetics. If we drop a textureless, gray ball on a textureless, gray floor, we might not expect it to bounce, interpreting it as concrete falling on the floor. If we gave the ball a basketball texture, we might expect it to bounce. Similarly, the sound feedback from the ball hitting the ground would set our next expectation: "BOING" or "THUD"? Game Feel is vital for our analysis because it explicitly encapsulates a desirable outcome of games that is only observable at run time and evaluated through a first-person perspective. When combined with characters and audio-visual metaphors we can project onto or empathize with, game feel becomes an even more potent tool for driving player reactions [Carter, 2022].

3.5 QUALIA-DRIVEN DESIGN

3.5.1: LEVELING THE IVORY TOWER

The core premise of working with accounts of conscious experience as a critical foundation for video game development that is often minimized. This tendency is driven by the tension between 1.) video games being artifacts that require tremendous technical skill to implement and 2) experiential perspectives to execute in valuable and relevant ways to a potential player. Taking the approaches phenomenology has taken in understanding conscious experience, the mind-body can also be leveraged to understand and replicate the most surprising mental and physical outcomes in video games. By attempting to capture the qualia of an experience that we want to share with another, we can bracket off irrelevant information about those experiences until we end up with experiential attributes that we can reproduce in a digital game environment.

We have little interest in producing a framework that is only understandable through a sophisticated enough vernacular. Instead, we wish to provide concrete and replicable tasks and recommendations to benefit from experiential-driven design practice in video games. Our approach to video game design can be summarized as follows: use our intended player's conscious experience to build an interpretable and measurable framework for video game development rooted in embodied-cognition literature. The core benefit of this approach is that we create an implementable path between the nebulous yet attractive properties we observe in video games and the underlying design strategies that produce them.

We will use the rest of this section to suggest processes to capture relevant information from qualia and then use that information to build out relevant game-design information. We will also discuss approaches to create generalizable engineering recommendations in the design space as well as approaches to evaluate if a given interactive digital system is ethically viable or not. The following processes are not meant to be linear or exhaustive. Video game development is far too messy and chaotic to suggest a solely linear mode of collecting data is realistically implementable; these recommendations are more to build a "mode" of operation in readers while they tackle such issues.

3.5.2. THE QUALIA CONVERTER

An essential tension has not been addressed throughout this paper: the "capture" point of qualia is inevitably a quantification in and of itself that strips away the unique properties of the experience itself. This tension has also been hinted at when discussing existing metrics - it cannot be that they are all inherently bad, as the new wave of metrics we create from analyzing qualia would be just as susceptible to such criticism. There is an ineffable, uncrossable gulf between the perception of experience and the communication of that experience to others; this discussion asks when and where we should attempt the crossing. This paper's argument is not that all existing metrics and quantifications are bad, nor that a purely experiential-driven approach would be successful; rather, that critical design aspects are embedded in the holistic experience of an artifact that is not capturable by metrics alone. Thus, we must embed a phenomenological approach into a game design or research practice to increase the likelihood of building a game with desirable but complex emergent properties (e.g. balanced, fun, educational).

The traditional problem of this is the translation point. At some point in a qualia-driven development practice, we have to decide the relevant and meaningful features of a group of qualia and how we can affect them. Luckily for us, the last few decades in marketing, product design, and software development have provided us with numerous approaches to capture how end-users might interact with a given artifact and translate that into a relevant design strategy.

3.5.3. CAPTURING QUALIA

When we have discussed qualia, we have often switched between discussing it as a mental concept and as a literal thing that exists. This usage is not a mistake. While we acknowledge that qualia are inherently inaccessible to all but the observer due to structural mind-body and cultural differences, qualia have shared traits that can be productively used. Our first tasks in a qualia-driven design practice entail collecting and analyzing experiential accounts.

Another subtext that needs to be addressed is the multiplicity of phenomenological analysis generated by different academics over the years. We do not specifically suggest that a specific phenomenological framework is ideal for game development but that such a framework is *a priori* and essential. The diversity of game audiences' targeted qualia means it would be naive to think that we should get a unifying phenomenology that tells us how to design games. Instead, we should embrace that each desired experience engine develops a phenomenology in and of itself that depends on the interaction of its creators and users to form a language. Such inclinations of devices forming a specific literacy have been emphasized in works by Keogh in embodied literacies and Winograd and Flores in device-specific ontologies. These engine-specific phenomenologies can be empowered by tying them to mind-body concepts that produce mental or physical effects.

3.5.4. HUMAN (MIND-BODY) FACTORS ENGINEERING

A downside of phenomenological approaches is their relative need for anchoring to a generalizable framework. We might use phenomenological approaches that are wildly successful for our users, but we cannot port such techniques easily from one game experience to another. While phenomenology might be more successful in explaining or designing a causal experiential chain of events, connecting a purely consciousness-driven explanation to observable outcomes we want to see in a player is more complicated.

The cognitive sciences, specifically around the concept of the mind-body and embodiment, provide us with a solution. Designing for humans does not stop at an experiential consideration; we must also include a person's physical and mental anatomy considerations. Quirks of memory, attention, neurodiversity, and so on represent areas where we can be aided or burdened by our digital systems.

An approach we can borrow from engineering practices is that of "human factors engineering," or the practice of making technical specifications out of the various physiological limitations of human beings, behavioral and physical. The core of the idea is that better interfaces are designed and implemented when we incorporate some of the human mind's and body's natural dispositions [Lee, 2017]. While we do not have nearly a sophisticated enough understanding of these limitations in video game design, we can use HCI research as a foundation to continue building out recommendations for different mechanic implementations, recommendations that respect a biologically human end-user. Video games are a productive research platform for human-factors engineering.

A naturally beneficial side-effect of embedding embodied cognition concepts into a video game practice is that it provides us with a usable ethical scale to interpret different experiences. If we can point out how different mechanics are exploitive and then back it up with explicit research foundations, we might have better luck at getting ahead of concepts like “loot boxes.” Using a holistic view of the gameplay experience also provides us with a secondary avenue to investigate potential ethical transgressions of digital designers.

3.6. A CASE STUDY: BALANCE

3.6.1. A PHENOMENOLOGICAL CONCEPT

Many video game designers, researchers, and players assume balance is a narrow and quantitative measure. A commonly-adopted definition is that a balanced game has equally skilled players win roughly equally when playing matches against one another. When looking at fighting game communities, this definition seems obvious - if one character can statistically win disproportionately in a roster, it might indicate that the roster is unbalanced. This conceptualization of balance is a correct one that deserves to be included in the discussion of the concept. That said, one does not have to look far to find contradictory balancing models.

For example, Mario Kart includes balancing mechanisms that "dampen" positive feedback for the lead player. A player in first place will be punished with a limited amount of available items and an increase in the volume of offensive items that other players can use against them. On the other hand, players in last place receive outcome-changing items and have almost no offensive items used against them. Mario Kart, in other words, is balanced to help players in last place recover and hinder players in first place [Bogost, 2014]. This balancing style directly counters the equal skill-based definition - why would we want to punish the skilled player and reward the unskilled player? In reality, this balance style works for precisely the opposite reason - it makes players of most skill levels feel like they have a fair shot at winning. Which definition of balance is correct?

We can keep problematizing balance as a concept. In the above examples, we only cover multiplayer games. What about single-player games? Players also have intuitive conceptualizations of balance within the context of a single-player game: does the game favor one combat strategy over another, is the challenge consistent throughout the game, and so on. Game economies in single, multi-, and massively-multiplayer games require balance, and the ease with which they are broken is a recurring development hurdle and topic at game conferences [Moran, 2021]. All of these interpretations present a clear picture of a hazy concept - balance seems deeply related and connected to quantitative tuning and evaluation, but our global evaluation is anything but. One thing does run consistently across all of these definitions: all center on a given player's judgment of fairness within a given game context.

Balancing video games is notoriously hard to do. While detailing strategies for game balancing, veteran game designers Ian Schrieber and Brenda Romero designated it a "Game Design Dark Art," often escaping both definition and implementation as it has been applied in different genres and platforms [Romero et al., 2021]. Balance is a term that players "know when they see it" but might struggle to define what needs to be changed to improve balance. In their recent (800-page) comprehensive technical guide on balance concepts, Schrieber and Romero call out that some essential qualities of balance are that it is sensitive to context and highly interpretable. In other words, any instance of balance can be interpreted differently by different critics and changes based on the environment in which it is placed in addition to the traditional literal, quantitative properties of the balance itself. "Balance is a feeling" is what the authors conclude in their introduction, which is affected by a wide range of controllable and uncontrollable variables. Jeff Kaplan, lead designer at Blizzard (in)famously echoed this sentiment when he claimed that "the perception of balance is more powerful than the balance itself" [Chalk, 2017].

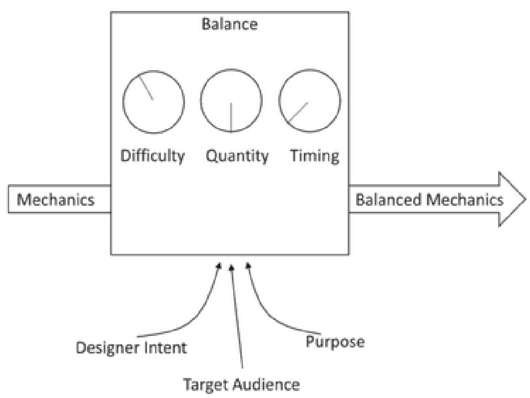

Figure 2: Romero and Schrieber describe balance as a pass-through filter for existing mechanics. It takes a tangible concept, evaluates audience, designer, and goal context, and adjusts the mechanics' difficulty, length, and timing to create a balanced experience [Romero, 2021].

This consolidation of game design professionals around a feeling/perceiving balance model helps signal how we should consider an emergent property such as video game balance in research or design. Balance is a phenomenological account of a player's experience of fairness while immersed in a video game; it is not a number or equation. The rest of this section will suggest ways to tie these designs into the cognitive-science literature, suggesting a path for starting from a phenomenological analysis and ending with real-world outcomes.

3.6.2. BALANCE DEFINITIONS IN THE LITERATURE

The academic literature does not have a single agreed-upon definition of balance. In multiplayer games, skill-based systems reign supreme. Automated systems like TrueSkill seek to quantify a user's abstracted skill level through gameplay performance, then use that information against a normal curve of skill levels to keep players within close skill ranges. However, approaches that purely leverage the skill and uncontextualized rankings often miss vital indicators of game outcome [Nikolakaki et al., 2020]. Authors suggest including information about play style, role experience, or differences in team composition in order to get more engaging matches. This perspective seems to be growing recently, with authors targeting "engagement" instead of skill as a critical determinant of establishing matches that players enjoy or view as balanced [Chen et al., 2022]. In local games or games with only two players, the commonly used definition is when two players have an equal chance of winning against players of the same skill level [Karavalos, 2017]. Fairness is similarly frequently defined in this way.

A skill-based challenge between players is not the only domain in which academic papers analyze balance - many conceptualize balance as a game's capability to keep the player in a "flow" state. As players know it, balance is best managed by adjusting the challenge they encounter between "too easy" and "too hard" obstacles. If one is in this Goldilocks zone of challenge, the player should experience an increased immersion in the game in the form of a flow state [Baumann, 2016]. If a game is too easy, it is unbalanced, and the player will lose interest. A player will get frustrated and give up if a game is too hard. The most significant benefit of this perspective is that it links us directly to psychology and cognitive science for keeping players in a 'flow' state, which many find desirable [Andrade et al., 2006]. A downside of this model is that it fails to capture games that are still engaging but too challenging for a novice player - as we will describe Soulslike in the next section.

A more modern approach that resolves some of these issues in the previous two examples is that of Adaptive or Dynamic Game Balancing. This form of game balancing assumes that satisfaction correlates closely to how challenging the game remains at any given time. This method requires an in-game measure of current difficulty, informing the game manager if the game should be more or less difficult for the player at any given time. The challenge function must shift over time to match how the player changes [Hendrix et al., 2019].

Overall, the academic literature on the balance begins with a relatively narrow conception of equally-skilled players having equal victories. As attitudes have changed over time, the inclusion of single-player game concepts and variety in game design goals shifted this goal to a concept of "challenge," where player flow and immersion become the best indicators of a successfully balanced game. While the literature has gradually started to acknowledge the semantic complexity of balance, this recent trend reflects the lack of a phenomenological perspective.

3.6.3. NOTABLE EXAMPLES OF BALANCE

A brief overview of video games generally perceived as balanced, along with some specific examples, will help us understand what phenomena of balance people care about when playing games. Specifically, we will review the Super Smash Bros. series, DOTA 2 and League of Legends, and the "Soulslike" genre of action/adventure games. These examples are picked due to their popularity and what principles they can illustrate in balance.

3.6.4: SUPER SMASH BROS. MELEE

The Super Smash Bros. Series is a fighting video game series in which two or more players play a character from the Nintendo pantheon of characters and attempt to knock one another off the screen. This game was designed with skilled and unskilled players in mind, providing players with match editing options that could make gameplay less random. [Taelman, 2015] Surprisingly to Nintendo, the game evolved into an intense competitive experience when skilled players pushed the games to their limits. [Elmezeny et al., 2015] Super Smash Bros Melee, the second game in the series, is still played competitively alongside its sequels because of the unique environment it provides. There are multiple attributions to this longevity and dedication to the game: nostalgia for familiar cultural properties, an ongoing community drama, and accessibility of the game after the turn of the century. However, there are some unique design considerations outside of those that influence the competitive attractiveness of the game space.

First, the game operates at a pace on the edge of human physical performance. This speed is a theme among competitive games, where executing physical tasks and planning tactical moves together are essential to success. Next, the game is a modified physics sandbox that allows players to discover emergent properties of that space. Players constantly find "Advanced Techniques" or ways to find edge cases in the game's engine to squeeze more performance (frames, damage, movement) out of their characters. A prominent example of this is "Wavedashing." Wavedashing is the practice of air-dodging into the ground, causing the character to slide or "dash" without a lengthy landing cooldown. Wavedashing allows players to deploy offensive moves with more mobility, turning the already lightning pace of the game even faster.

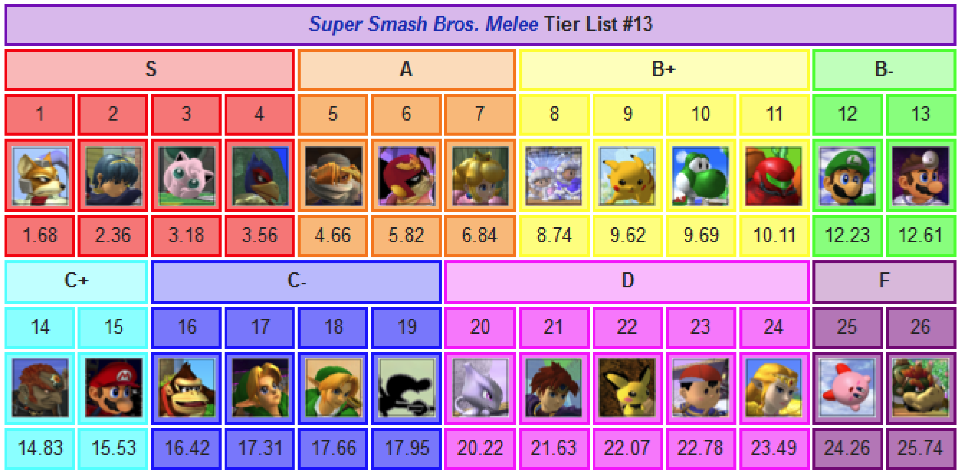

Figure 3: The most recent “tier list” from SSBM, published by ssbwiki.com and produced by PG Stats, based off of previous tournament rankings. “S” and “A” tier characters have significant advantages over “D” and “F” characters. [PG Stats, 2021].

Despite the game's overall longevity, only around 5-7 characters are popularly considered viable at the highest levels of competition. Even in this genre-defining example, we have substantial difficulty balancing characters. Once games in the series have been out long enough, balance patches stop, and the "tier-list" (a dynamic community interpretation of different character's match-ups) solidifies around a much smaller set of characters. Later games in the Smash Bros series had larger pools of competitively viable characters, though they remain finite.

3.6.5. SOULSLIKE

In the Smash Bros. example, balance was evaluated against a foil of letting players compete fairly. In single-player games, balance is often perceived as the "smoothness" of the challenge the player experiences throughout the game. In other words, single-player games that players say are balanced might say so because it lacks extreme spikes in difficulty and exploitable strategies to progress. However, this concept can be inverted to get different phenomenological feedback from players. For example, the "Soulslike" subgenre of action/adventure games focuses on extreme combat difficulty as the core gameplay and progression. Enemies are outrageously deadly and unpredictable compared to other titles, constantly undermining players' previous strategies. "Dark Souls," which featured a dark-fantasy world full of grotesque monsters and punishing world navigation, provides the template for the genre. By our prior definitions, the fact that the first few enemies in these games often trigger game-over screens for many players should indicate that the game is unbalanced. However, by creating this power imbalance where the player is at a major (but not impossible) disadvantage, the designers of this genre create an incredible feeling of fulfillment when you finally triumph as a player. From a first-person experience perspective, it feels like the player is the underdog - and they have just beaten the best team in the league [Ford, 2020].

Often in Soulslike games, the latter half of the game has the player become impossibly strong, transitioning this feeling of being the underdog into the feeling of becoming an untouchable champion. In both experiences, the designers do not try to create a perfectly "balanced" or approachable difficulty curve. Instead, they intentionally invert the difficulty curve to trigger specific emotions or experiences in the player. As we can see from these three cases, balance is less of an explicit term and more of a methodology for understanding fairness in a player's experience and how it applies to the perception of the game.

3.7: TAXONOMIES OF BALANCE

An approach we can use with hazy terms like balance is the creation of taxonomies, which allow us to group different use cases and produce usable concrete recommendations for complex, emergent traits. Schrieber and Romero, targeting game developers, choose to spread balance through different implementable systems. These two practitioners understood that balance could take wildly different forms based on context and have wildly different levers for accomplishing goals.

Balance Category	Description
Mathematical Balance	The quantitative form of balance - costs of items, hit points, and so on.
Balanced Difficulty	Does the balance stay at an intended level throughout the game over time? Note that this definition does not assume an optimal challenge to target - it is reliant on both designer and player intent.
Balanced Progression	Do players feel they are progressing through the game at an appropriate rate?
Balanced Initial Conditions	Are starting conditions symmetric or asymmetric?
Balance Between Initial Strategies	Do multiple strategies have relatively equal viability?
Balance Between Game Objects	Is a specific game entity balanced in context to the rest of the game?
Balance as Fairness	Players feel their summative experience was fair.

Table 1: A list of balance dimensions to consider in a taxonomy created by [Romero, 2022]

Some exciting concepts emerge from their praxis-oriented categorization. First, none of these categories provide prescriptive actions to provide balance. There is no singular correct progression that we can generalize across games - they must always be considered in context because the correct progression for one game could be game-breaking in another.

Also, the authors pick up on the experiential perspective of balance with point number 7, claiming:

"The use of the word "feel" here is not accidental. From the player's perspective and as noted earlier, balance is something that arises from perception. As different players may have different perceptions of a game, players can disagree over whether a game is balanced in the same way that they might disagree over other subjective interpretations such as whether the game is fun. Somewhere out there, there is someone who hates Half-Life 2."

Merging academic literature with practitioner and player accounts can provide us with a way to organize a higher-level taxonomy based on phenomenology. Such a taxonomy would provide designers and researchers with a template to understand what subtypes of balance should be considered in different contexts.

3.8: MIND-BODY CONCEPTIONS OF BALANCE AND FAIRNESS

In earlier sections, we noted that a central element of balance, from a phenomenological perspective, is the value judgment the user makes about a given qualia's fairness. As this is the uniting thread around balance, we can use this as a seed to investigate balance's cognitive and physiological implications in this domain.

Fairness has a neuronal basis and is related to empathy [Singer, 2007]. Fairness evaluations and reactions, as a process, can exist without language: young children and primates express jealousy and envy when put in unfair situations next to others [Brosnan, 2006]. Empathy is a critical component of our experience of fairness. Our brains have specialized neurons that seem to simulate and emulate what others do for our understanding [Gallese, 2006]. Empathy gives us additional tools to manipulate balance; it shows us how we might use opposing players or avatars to generate empathic responses related to fairness.

Another cognitive phenomenon mentioned with consistency is flow - keeping a user in a state of embodiment throughout gameplay. This connection allows us to bring theories about creating, maintaining, and breaking flow for experiential effect throughout gameplay [Isbister, 2017]. These are a rough canvas of how we can pull phenomenological game traits and connect them to cognitive processes that suggest tangible mind-body outcomes.

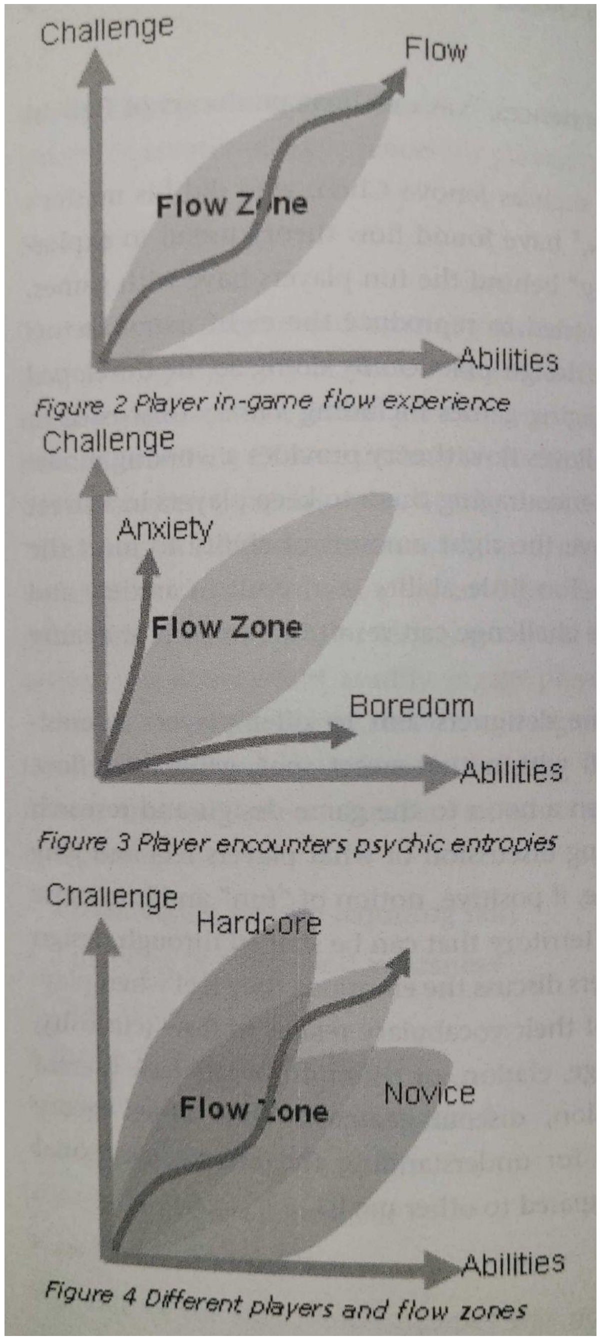

Figure 4: A figure detailing flow from How Games Move Us by [Isbister, 2017].

Flow can provide an explanation for how engaged players are in a given game and what happens when players lose said flow.

These are a rough canvas of how we can pull phenomenological game traits and connect them to cognitive processes that suggest real mind-body outcomes.

3.9. CONCLUSION

In this work, we have reviewed phenomenology and embodied cognition in the context of game design, establishing links between the unique experience of a video game and embodiment. We examine the video game concept of "balance," framing it as a phenomenological concept before a quantitative one. We show how this framing can be productive, explaining the everyday accounts of balance and providing methods to reintegrate quantitative approaches where the use case calls for it. We discuss balance as a perception of fairness in a given game environment, providing us avenues to analyze and tweak that perception using tools from the cognitive sciences.

We synthesize this knowledge by suggesting a framework for "qualia-driven design," which proposes a design strategy that prioritizes a phenomenological approach to firmly ground a game design in end-user experience. This framework suggests that games are engines to produce qualia in the audience's mind; thus, attention to qualia overall is critical to a design process. This framework implies that many supposed technical measurements of video game properties (balance, immersion, enjoyment, etc.) should never be taken at face value. These properties are highly sensitive to the context and use case of the engine in which they are embedded. Immersion in a horror video game looks very different from immersion in a puzzle video game - though some scales may attempt to compare the two. Such properties are not useless, pseudo-scientific labels - instead, they are situational measures that we must use consistently in the context of the first person's experience of a given game to understand fully. Over time, as it has already begun for video game balance, consensus-building on these properties and their relevant taxonomies may allow for such portability. As for now, the current literature suggests that one should start asking questions when they see concrete claims of emergent properties produced by video games. In future research, we want to emphasize the interaction between embodiment, phenomenology, and emergent properties of video games. As for designers, we hope to see these three areas leveraged as foundations for future "good" games.

4. CONCLUSION

In this paper, we've discussed the usage of an AGD to try and explore the creation and appreciation of emergent characteristics of games. We've also provided a design framework that can both explain and provide practical recommendations for how a studio, research lab, or otherwise might try and provide a better foundation for attaining strong cognitive results out of games in audiences. Overall, we hope that a game research and design strategy that emphasizes phenomenological understandings as a priori to making impactful, meaningful games.

5. APPENDIX I: SEARCHING FOR BALANCED 2D BRAWLER GAMES: SUCCESS AND FAILURES OF AUTOMATED EVALUATION

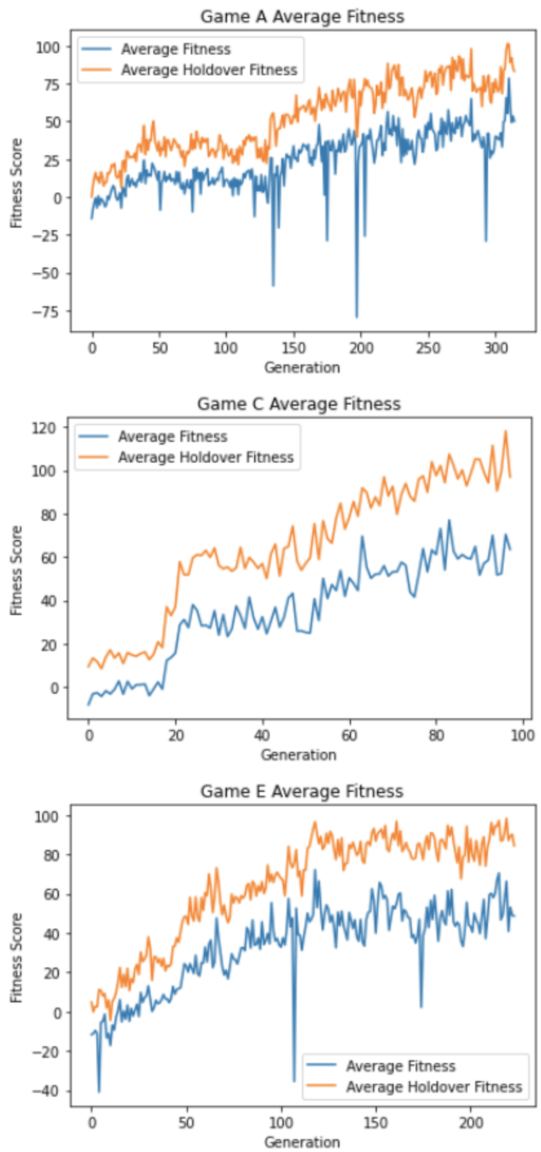

Figure 3: Fitness graphs for each of the evolved games from the user study. Each graph shows the fitness of the population that games A, C, and E were selected from, respectively.

Question Timing	Question	Response Format	Required
Pre-Trial	Please indicate your familiarity with "brawler" fighting games (examples include: Super Smash Bros, Playstation All Stars Battle Royale, Nickelodeon All Star Brawl)	Familiarity, 1-5	Yes
	Full Name	String	Yes
	Player Number	1 or 2	Yes
Post-Game	I found the game easy to learn	Slider, -50 to 50	Yes
	I found the game to be balanced between both characters.	Slider, -50 to 50	Yes
	I found the game to be enjoyable	Slider, -50 to 50	Yes
	I understood what was happening throughout the game.	Slider, -50 to 50	Yes
	I felt mentally immersed in the experience.	Slider, -50 to 50	Yes
	I found the game to be well designed.	Slider, -50 to 50	Yes
	I found the game easy to control.	Slider, -50 to 50	Yes
	Did you find your character substantially stronger or weaker than your opponent's character?	Stronger, Neither, Weaker	Yes
	Please indicate how you think this game was created.	Random, AI, Human	Yes
	In less than three words, describe the game.	Text	Yes
Post-Trial	Provide a description of allowed player actions (e.g. move right) and their corresponding control mapping.	Text	Yes
	Did you observe any characters that felt under- or over-powered? If so, please describe.	Text	No
	Were there any distinguishing designs that separated some games from others? For example, did a set of characters or level stand out to you? If so, please describe.	Text	No
	Indicate your favorite game played.	1, 2, 3, 4, 5, 6	Yes
	Please provide any other feedback you'd like about the game and/or survey.	Text	No
	Any additional Comments?	Text	No

Table 3: Full list of questions used in the user study survey. Specific slider values were derived from a slider that the users would move between Disagree/Agree.

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