RESEARCH ARTICLE

Action Games Evolution Analysis: A Case Study Using the God of War Series

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ABSTRACT Technology advancements allowed the development of action games that packed multifaceted play in a single game while requiring fast-paced movements. Since modern action game is composed of boss battles, evaluating them was scarcely investigated. In this study, the analysis of the boss battle was conducted based on the God of War (GoW) series, where the underlying entertainment aspects of the game were identified. The information progress of the boss battle of each of the considered GoW series was modeled using the game refinement (GR) theory and its extension, called motion in mind. The evolution of challenge, anticipation, and unpredictability between different GoW series was identified while the entertainment aspects of the game were investigated. The evolutionary trend of the sophistication and unpredictability of the GoW series games provided insights into the intended narrative design, harmonic balance between skill and chance, and provided learning comfort for player mastery of the game-playing.

INDEX TERMS Action game, game evolution, god of war series, game refinement.

I. INTRODUCTION

The defining characteristic of action games has depended substantially on their historical development. From many players’ perspectives, they are straightforward: controlling a single game character passing levels can be called an action game (i.e., Super Mario series). Sometimes, the game character may do a series of movements and passes several levels. In the view of the electronic video game, action games have no strict border. For example, fighting games can be seen as one branch of action games [1], [2]. However, fighting games focus on competition and are programmed by rounds. As such, a clear definition of an action game is a challenging question [3].

So what are action games? As the name implies, action games take “action” as the primary means of expression to be called action games. Such a situation is what exactly makes an action game’s definition complicated. Before 2005, simple action games became harder and more challenging to enter the gaming market [4]. The fast pace of technological invention has allowed electronic video games to have a vast capacity, so the elements a game contains can be unlimited. As a result, action games now may also include a good deal of different fighting-like game factors, shooting, and even puzzle-solving elements [5], [6]. In addition, multiplayer online battle arenas or real-time strategy games are also considered part of action games.

With the development of new graphic technology, action games also made many improvements. In addition to the typical action-based gameplay, they may sometimes contain a significant proportion of other fast-paced game factors throughout the whole game series, such as shooting (i.e., Uncharted series [7]), fighting (i.e., Assassin’s Creed series [8]), or both (i.e., God of War series [9]). These conditions increase the games’ tension and makes them more attractive. In essence, action games are challenging to define due to their multifaceted play packed into a single game, compared to simple and monotone action games a decade earlier. Furthermore, the choice and storytelling provided by the action games, which is movie-like, immerse players...
in a flow-like state due to having the freedom of making their “own story,” such as different endings, consequences of choices, and interconnected narratives. Action games are sorted into two types; one pays attention to beautiful, exaggerated movements, while the other is realistic. Some action games appeal to players with the gorgeous combos and the manipulation of players (i.e., fighting games [6]). Other action games combine exciting storytelling, background music, and optical effect incongruity while becoming the means to express themselves. In both instances, action games involve learning and gaining experience, where players must think to pass through specific challenges while enjoying the game. While an action game includes necessary physical factors to overcome challenges (such as precise aim and quick response times), other factors such as competitions, puzzle-solving, collecting objects, strategy, planning, and exploration challenges were also important. However, such factors were catered toward the pressure of time running out, which uniquely represents a challenge in action games [4].

As an electronic video game, action games generally represent one title or story [2]. It emphasizes the ability of players’ hand-eyes coordination and players’ reactions. Action games are typically played by game consoles, assisted by computing unit and graphic processing, and driven by compelling storytelling and narrative, forwarding the leading line of games while adding high tension in completing the whole game’s story. Players usually manipulate the protagonist or avatar, allowing the players to choose and immerse themselves in various game elements, such as leveling up, collecting objects (utility or generally), avoiding obstacles or enemies, and engaged in various actions (i.e., battle an enemy, find treasure, build items, etc.). At the end of a level or group of levels, the players always have to beat against a ‘boss enemy’ character, which becomes the biggest challenge for them [10].

Although boss battles were a significant part of any modern action game, studies on its evaluation metric and efficiency on such battle scenes or level(s) were scarcely investigated. To the best of our knowledge, the only study that focuses on the boss battle in an action-like game was the study by [11]. The study showed that specific game metrics could quantify critical insights into game entertainment. In this study, data from the God of War (GoW) series were collected, where analysis of these data was conducted to identify the underlying entertainment aspects of the game. In addition, the evolution of the GoW between the main series and additional releases, based on the changes, specifically on the boss battles, which influenced the entertainment of such titles, were investigated.

II. RELATED WORKS

As one of the fastest-growing entertainment industries, the video game industry has various platforms, genres, and cutting-edge technologies. In addition, video games have evolved with specific game mechanics making genres not definitive, while the genre itself is reshaped as the technology develops [12]. As video games become an immersive cultural medium with global implications, game metrics were essential to facilitate the development [12], [13], which balance narrative (immersive stories), graphics (attractiveness), and game experience (delivering user experiences) towards a game that engaging, educational, and entertaining.

A narrative analysis of the GoW series was conducted by [14] to identify the impression of the game’s fundamentals. The study found a significant discord between the advancements in the play mechanics, narrational, and puzzle-solving components of the game, implying that complex interactive elements existed that require a generalized measure or metrics. [13] argued that game metrics and analytical techniques would provide the foundation for evaluating and understanding game development via a data-driven framework, allowing for quantifiable and verifiable measures. As such, a generalized game metric could provide the operational measure of development growth and quality of the game itself before its launch or release.

[15] explored action game design to promote empathy between young adults and the elderly using two play interfaces: finger and foot. The study found that shared action during intergenerational play between individuals and pairing the young and the elderly affected the difficulty and training due to different learning and evaluation metrics paradigms between the generations. Meanwhile, [16] reviewed the possibility and impacts of action video games as a tool to drive attentional control and characterize play style or preferences. However, not all games have the same features to determine player characteristics, implying the need for a paradigm shift from rigid genre categorization but instead relies on a methodology that emphasizes play experience (or data-driven).

Also, [11] developed an ontology of boss battles in a two-dimensional run-and-gun action game (Cuphead, studio MDHR). The boss attack was clustered using a Gaussian mixture model and multinomial regression to predict the player experience. It was found that fine-grained details of the attack information, instead of an aggregated one, are crucial for better attack clustering and leading to stronger correlation.

Finally, [17] investigated the methods to improve agility in young boxers through action games. Attention should be paid to applying a more sophisticated variant of action games in the training of young boxers to improve the quality of the process to develop agility and unique agility qualities.

Action games also provided a monumental and highly effective training environment that could lead to improvement in vision [18], attention [16], [18], cognition [18], and agility [17], [18]. These situations showed that action games outside their original intentions were beneficial and would be invaluable in providing insights towards a better understanding of the player’s cognition and coordination. However, an action game’s “boss battle” is typically understudied, albeit being the key component in making or breaking an action game.
Bosses have been part of the video game formula, especially generating and understanding one. Among the previous works on video games, a programming model for describing bosses in 2D action games was developed by [19]. Such a programming model formed the foundational work proposed by [20] which generated the bosses via a program synthesis. Another study by [21] explored the history of bosses to determine enjoyable features of boss battles. In contrast, [22] finds metrics to predict qualitative human ratings on game levels in the domain of Super Mario Bros. Nevertheless, these studies do not strive to uncover the underlying entertainment aspect of the game, especially the one carried over from one series to another of the same game title, based on the boss battle.

To this end, the paper’s organization is as follows: Section III provides the overview of the model used to analyze the game, namely the game refinement model and its extension. In addition, the introduction of the God of War series and the model adoption for the boss battle of the God of War series were elaborated. Then, Section IV describes the details of the computational data and analysis of the results based on the attributes identified from the adopted model. Subsequently, Section V discusses the implications of the presented results from the game designer’s perspective and player experiences. Finally, Section VI concludes the paper.

III. ANALYSIS OF ACTION GAMES

A. GAME REFINEMENT MODEL AND ITS EXTENSION

Revisiting the game refinement (GR) theory, the original formulation of the outcome uncertainty from the game progress model is based on early work by [23]. It was applied to measure the design sophistication in domains of business [24] and education [25] while acting as a tool for exploring the evolution of popular board games [23], [26]. The GR values for most popular games were situated within a reasonable zone of $GR \in [0.07, 0.08]$.

Considering from the players’ viewpoint, the information on the game result is an increasing function of time (the number of moves in board games) $t$. Here, the information on the game result is defined as the amount of solved uncertainty (or information obtained) $x(t)$, as given by (1). The parameter $n$ (where $1 \leq n \in N$) is the number of feasible options and $x(0) = 0$ and $x(T) = 1$. $x(T)$ stands for the normalized amount of solved uncertainty. Note that $0 \leq t \leq T$, $0 \leq x(t) \leq 1$. (1) implies that the rate of increase in the solved information $x'(t)$ is proportional to $x(t)$ and inverse proportional to $t$. Solving (1), (2) is obtained.

$$x'(t) = \frac{n}{t} x(t) \quad (1)$$
$$x(t) = \left(\frac{t}{T}\right)^n \quad (2)$$

It is assumed that the solved information $x(t)$ is twice derivable at $t \in [0, T]$. The second derivative of (2) indicates the accelerated velocity of the solved uncertainty along with the game progress, which is given by (3).

$$x''(t) = \frac{n (n - 1) T^n}{t^{n+2}} \bigg|_{t=T} = \frac{n (n - 1)}{T^2} \quad (3)$$

is the difference in the rate at which information is gathered as the game progresses. Then (5) gives the acceleration or ‘free-fall’ motion (denoted as $a$). $a$ is estimated in the domain of board games as (4), where $B$ and $D$ denote the average number of possible moves and game length, respectively.

$$a = \frac{n (n - 1)}{T^2} \approx \frac{B}{D^2} \quad (4)$$

In the context of sports (or shooting games), the game information progress was created by the number of attempts ($T$) and the total number of goals ($G$); it can analyze different game-playing mechanisms revealed in each state; given by their velocity ($v$), acceleration ($a$), and jerk ($j$) during their game processes (see (5)). In physics, mass determines the difficulty of changing the state of motion when an object is stressed. Thus, mass is a physical quantity that describes the inertia of an object, which describes the “heaviness” and the difficulty of holding an object [27]. In games, the risk factor is the reason that determines the difficulty of progression; thus, the difficulty of obtaining scores. Therefore, assuming the mass as the risk rate, then the mass is given by $m = 1 - v$, where velocity ($v$) of information progress is the speed of getting goals, described by (6).

$$x(t) = \frac{G}{T} = \frac{1}{2} a t^2 = \frac{1}{6} j t^3 \quad (5)$$

$$v = \frac{G}{T} \quad (6)$$

Since the possible attempts or moves for one goal, ($N$) is defined as (7), which was based on the definition of variable reward schedule of reinforcement rewards. Solving (5), the solutions of acceleration and jerk are (8) and (9). Correspondingly, it is known that $GR$ and $AD$ values measure entertainment and quantify unpredictability by (10) and (11). It was found that both $GR$ and $AD$ measures played an important role in retaining players’ interest and enjoyment [28]. Table 1 shows the measures of game refinement for board games. For sophisticated board games such as Chess, Shogi, and Go, it is assumed that there exists a reasonable zone for the acceleration ($\sqrt{a} = GR$) and jerk ($\sqrt{j} = AD$), which is between $GR \in [0.07, 0.08]$, and $AD = [0.045, 0.06]$, respectively.

$$N = \frac{1}{v} = \frac{T}{G} \quad (7)$$

$$a = \frac{2G}{T^2} \quad (8)$$

$$j = \frac{3G}{T^3} \quad (9)$$

$$GR = \sqrt{a} \quad (10)$$

$$AD = \sqrt{j} \quad (11)$$

In motion in mind model, momentum in mind ($\vec{p}$) is among the analogy of physic measures that were adopted, given
by (12). Based on its first derivative, where $\ddot{p} = 1 - 2v = 0$, and $v = \frac{1}{2}$ and $\ddot{p} = \frac{1}{4}$, the peak of $\ddot{p}$ can be identified. At $v = \frac{1}{2}$, the probabilities of win and loss are halved, and so do the risk rate ($m = 1 - v = \frac{1}{2}$). In addition, $\ddot{p}$ is the difficulty to stop moving objects and the tendency of moving objects to keep moving. Also, $\ddot{p}$ is an instantaneous variable that measures the momentary trend based on the current velocity. Finally, concerning the game process, $\ddot{p}$ describes players’ tendency to maintain the game’s state and continue to focus on the game. In other words, when their success rate is constant, their tendency to keep playing the game is the highest. Hence, the $\ddot{p}$ measures the players’ tendency to keep playing the game in different velocity situations [30].

$$\ddot{p} = m \cdot v = (1 - v) \cdot v$$ (12)

Potential energy ($E_p$) is the energy stored at an initial position and related to the expectation of the specific state. For different winning rates, there are different energy and different expectations in our minds. $E_p$ given as (13), in the context of a game, is defined as the amount of the required game information a player needs in progressing the game [29] which implies the anticipation of the player in finishing the game. As a game progresses, the game’s potential energy reflects the anticipation the game may give the player (degree of winning comfort). More importantly, this helps the game designer determine the stability of a sophisticated game.

$$E_p = 2mv^2$$ (13)

The notion of energy conservation had provided a deeper knowledge of games’ engagement and addictive mechanisms by differentiating the perspective of objectivity and subjectivity [31]. The momentum ($\ddot{p}_1$) is regarded as half of a combination of potential energy in the mind ($E_p$), then based on the conservation of energy in mind, given by (16), the momentum in mind ($\ddot{p}_2$) can be derived, associated with the player’s engagement, given by (17). Applying (17) by assuming the formulation of $\ddot{p}_2 = mv_2$ where the subjective reward $v_2$ is given by (18).

$$\ddot{p}_1 = mv$$ (14)  
$$E_p = 2mv^2$$ (15)  
$$E_p = \ddot{p}_1 + \ddot{p}_2$$ (16)  
$$\ddot{p}_2 = E_p - \ddot{p}_1 = 2m^3 - 3m^2 + m$$ (17)  
$$v_2 = 2m^2 - 3m + 1 = (1 - 2m)(1 - m)$$ (18)

Then, the velocity ($v$ relabelled as $v_1$) and its subjective one ($v_2$) is established, where $v_0$ be the reward function over various masses of the perfect player. As such, the objectivity is given by (19). By generalization, $v_k(m)$ is the reward function over various $m$ for a player with ability parameter ($k$), given by (20). $k$ correspond to the strength of players in the competitive game context or error-tolerance in the social or non-competitive context (i.e., there is no error tolerance for the perfect player $v_0$).

$$v_0 = 1 - m, \text{ where } 0 \leq m \leq 1 \text{ and } 0 \leq v_0 \leq 1$$ (19)  
$$v_k = (1 - km)v_0, \text{ where } 0 \leq k \in \mathbb{R}$$ (20)

Generalizing the notion of reward frequency (denoted as $N$) and the concept of reinforcement schedule (denoted as VR($N$)). The objective reinforcement ($E_0$) refers to the potential energy in mind of the perfect player ($v_0$). Otherwise, the subjective reinforcement ($E_k$) refers to the potential energy in the minds of other players ($v_k$). A game would produce its potential energy in the field of play (hence, called potential energy of play) where players would experience engagement or “reinforcement” (Figure 1) relative to the enhancement of behavior in behavioral psychology. Such a term was used as a positive interpretation, where greater reinforcement gives people a greater interest in staying on the event under consideration.

The notion of reinforcement relies on the player’s ability in the game context, where the reward function ($v_k$) represents the model of the sense of the value of the players. When $k > 3$, $v_k < 0$ holds at $m = \frac{1}{4}$ where the objective reinforcement is maximized. This condition implied that most comfort point (peak of $E_0$) is not included in the learning context. Therefore, it is highly expected to have $k \leq 3$. Since Go game ($m = 0.42$) is still not yet solved, then it is expected that $2.38 < k$ holds. As mass ($m$) becomes larger at $0 \leq m \leq \frac{1}{4}$, $\Delta k$ increases (Figure 2). Meanwhile, $\Delta k$ decreases at $\frac{1}{5} \leq m \leq \frac{2}{5}$.

Additionally, subjective reinforcement ($E_k$; $m = \frac{1}{4k}$) was maximized at it peak in the non-competitive gaming context (such as puzzle solving or solving comfort). This condition implied that puzzle solving or solving comfort is highly

### TABLE 1. Measures of game refinement for popular board games, adopted from [29].

|   | $B$ | $D$ | $\sqrt{a} = GR$ | $\sqrt{J} = AD$ |
|---|-----|-----|-----------------|-----------------|
| Chess | 35  | 80  | 0.074           | 0.089           |
| Shogi | 80  | 115 | 0.078           | 0.054           |
| Go   | 250 | 208 | 0.076           | 0.044           |

![FIGURE 1. Objective and subjective reinforcement when $k = 3$.](image-url)
games. Situations that yield a significant benefit or advantage, typically found in fighting situations and the mobile phone. This condition showed that PlayStation 4), including the portable and console versions. The newest version of the God of War series, exemplified in March 2018, focusing on modern Norse mythology. However, the newer version was excluded due to significantly different game mechanics, play experience, and narrative design. The series consists of seven single-player-only games and one that includes multiplayer. God of War: Ascension is the first in the series to feature online-only multiplayer for competitive and cooperative play. GoW games featured a third-person, fixed cinematic camera (except for GoW: Betrayal, the only installment to feature a 2D side-scrolling view). Meanwhile, a first-person camera is featured in God of War III and GoW: Ascension. Throughout the series, the player controls the character Kratos in a combination of hack-and-slash combo-based combat, platforming, and puzzle elements to achieve goals and complete the game’s narrative.

The GoW series was primarily developed in most of the major PlayStation platforms (PlayStation 2, PlayStation 3, PlayStation 4), including the portable and console versions and the mobile phone. This condition showed that the GoW series was a versatile medium for various game mechanic experimentation (design of the quick time events, side-scroller play), control schemes (changes from the controller of the console into a portable version), and mode of interfaces (i.e., stereoscopic 3D of GoW: Origins collection). Furthermore, different marketing schemes (collections of high-definition remastered GoW releases) and business model development (downloadable contents) were also explored, which provided eudaimonic experiences and narrative engagement of the play [32]. Such situations were due to the well-blend mechanics’ support and key narrative themes provided by the series. In addition, the interface design was essential to drive significant impression [33], which was integrated into part of the series. On the one hand, it could enhance the immersion of the play (adapted control between different platforms), while on the other, it may break the game’s narrative flow (cutscenes not in 3-dimension while the gameplay does).

Action games were known for extended gameplay and sometimes complex narrative [34]. Naturally, this implies that players will spend more time on an action game. Such a condition is especially true when fighting against a boss, which can range from 10 minutes up to half an hour. Therefore, The GoW series was adopted as the representative of the action game because the crucial part of this study focuses on the fight against the boss. Although action games such as the GoW series were classified as action-adventure games [4], with the advancement of graphics from both hardware and software, this kind of game involves a lot of factors and decision-making while having continuous movement game. Such a concept emerged in the 70s, but fell short in design and innovation in the game-playing experience [35]. With decades of advancement in action games, the gameplay standards have soared and become more complex. Therefore, another aspect of our study is to analyze the historical differences between the GoW series.

In action games, boss battles were influential elements that were not well-studied. Game bosses can be generally defined as a significant computer-controlled enemy that must be defeated to reach a goal or ensure continued progression [36]. As battling a boss can be regarded as overcoming insurmountable odds, it depicts a universal conflict at the core of the human psyche, which drew the player, as the main protagonist, to participate actively [21]. While the developer meant the boss battle to be there, it also offers a new experience, or somewhat related to the emotional height, compressed into a single point or moment, which to some extent, breaks the established rules of the game and makes it exciting and engaging. As such, the boss battle remains highly popular in most developers’ retrospection and design philosophies. Therefore, such reasons motivate this study to explore in-depths, from the perspective of game informatics, the entertainment aspects that arise from the boss battles, specifically in the GoW series. Adopting GR theory relative to the considered GoW series, two types of information in each round of boss battle were recorded. The first one is engaged at the success rate of $v_k \left( \frac{1}{16} \right) = \frac{3}{4} - \frac{1}{16} \mid k=3 \mid= \frac{11}{16} = 0.6875$. Meanwhile, $\Delta_k$ is maximized at its peak at $m = \frac{5}{3}$ when $k = 3$, which implies the game under consideration is extremely engaged due to its high competition level (called competitive comfort).

Conjecture 1 (Learning and Competitive Comfort): $\Delta_k$ is maximized at its peak $m = \frac{1}{3}$ when $k = 3$ where learning comfort is optimized. Meanwhile, $\Delta_k$ is maximized at its peak $m = \frac{5}{3}$ when $k = 3$ where the game under consideration is extremely engaged due to its high competition level.

B. ANALYZING GOD OF WAR SERIES

Table 2 provided all the GoW series releases, based on Greek mythology, according to their time of release, including replicas and original versions. The newest version of the God of War series was released on the PlayStation 4 (PS4) platform in March 2018, focusing on modern Norse mythology. However, the newer version was excluded due to significantly different game mechanics, play experience, and narrative design. The series consists of seven single-player-only games and one that includes multiplayer. God of War: Ascension is the first in the series to feature online-only multiplayer for competitive and cooperative play. GoW games featured a third-person, fixed cinematic camera (except for GoW: Betrayal, the only installment to feature a 2D side-scrolling view). Meanwhile, a first-person camera is featured in God of War III and GoW: Ascension. Throughout the series, the player controls the character Kratos in a combination of hack-and-slash combo-based combat, platforming, and puzzle elements to achieve goals and complete the game’s narrative.
TABLE 2. History of God of War.

| Version       | Year | Platform | Publisher | Description (Added Feature)                                                                 |
|---------------|------|----------|-----------|-------------------------------------------------------------------------------------------|
| GoW           | 2005 | PS2      | SCE       | The first game (combo-based combat, puzzles, platforming, QTEs)                            |
| GoW II        | 2007 | PS2      | SCE       | The second game (enlarged puzzles and bosses)                                             |
| GoW: Betrayal | 2007 | M-Phone  | SPD       | A only mobile phones game with 2D side-scroller                                          |
| GoW: Chains of Olympus | 2008 | PSP      | SCE       | The first game for the PSP (reconfigured control scheme)                                  |
| GoW Collection| 2009 | PS3      | SCE, Capcom | A HD reissue of first and second games with remote play function                        |
| GoW III       | 2010 | PS3      | SCE       | The best game in the series (enhanced control system, enemies, DLC)                       |
| GoW: Ghost of Sparta | 2010 | PSP      | SCE       | The second game for the PSP (25% more content)                                            |
| GoW: Origins Collection | 2011 | PS3      | SCE       | A 2011 reissue of two PSP game with Stereoscopic 3D                                      |
| GoW: Ascension | 2012 | PS3      | SCE       | Reissue of five games in the series, except for GoW: Betrayal                             |
| GoW Collection | 2013 | PS3      | SCE       | The last game for this series (enhanced quick time events)                               |
| GoW Collection | 2014 | PSVA     | SCE, Capcom | A PlayStation Vita reissue of first and second games                                  |
| GoW III Remastered | 2015 | PS4      | SCE       | A 2015 HD reissue of God of War III (DLC)                                                  |

PS 2/3/4: PlayStation 2/3/4; PSVA: PlayStation Studios Visual Arts; PSP: PlayStation Portable; M-Phone: Mobile Phone; SCE: Sony Computer Entertainment; SPD: Sony Pictures Digital; Quick time events (QTEs): complete game controller actions in a timed sequence; Remote play: transmit video and audio output to another device; DLC: downloadable content; 2D: Two dimensional; HD: high-definition; Stereoscopic 3D: enhanced illusion of depth in image.

the sum of attack numbers completed by Kratos against the in-game boss battle, denoted as the game length \( T \). The second one is the sum of the successfully attacked adversary, also called successful attacks or instruction attempts, denoted as \( G \).

IV. COMPUTATIONAL DATA AND RESULT ANALYSIS

This study collected data on the GoW battles with the boss for six games of the GoW series. Excluding the replica, re-edition versions, and the one released in the mobile phone version, there are six productions in total in the GoW series. These six productions were analyzed in this research, focusing on the boss battle. In any modern action game, the battle with the boss is a crucial inflection point in the game narrative, influencing the overall game outcome and providing the means to natural progression [11], [21], [37].

As one of the most renowned action game series, there are many commentaries on the internet and many videos made for the GoW series, especially those which have completed the whole series. These videos facilitate the collection process by obtaining valuable data where only the recorded videos that passed all six chapters were observed to ensure quality and consistency. The data collection was conducted with five people with different levels of play experience in the GoW series.

The participants were five males of varying ages (between 20 to 40) and educational levels (between bachelor’s degrees or above, up to doctorate graduate levels). These players were considered to have some experience in action games (considered beginner players) to the ones that frequently played action games (considered expert players). They have explicitly agreed to participate in the data collection and were briefed on its purpose.

The statistics and average of the data collected were compared with a well-known Chinese game blogger (called Heigutongge)\(^2\). The typical time for each boss fight is about five minutes. According to the game refinement theory, two data in each round of the boss battle were recorded for the video. The first data is the sum of attack numbers completed by Kratos against the in-game boss battle, denoted as the game length \( T \). The second data is the sum of the successfully attacked adversary, also called successful attacks or instruction attempts, denoted as \( G \).

A. ANALYSIS OF GoW SERIES BASED ON SOPHISTICATION (GR) AND CHALLENGE (m)

The player controls the protagonist (Kratos) in this fighting game to attack the boss; some attacks are efficient while others are not. Meanwhile, every single attack is an attempt, whether successful or not. In addition, the main GoW series were also unique where it has all the characteristics of simple fighting games but also decides the winner and loser in one round, like board games. However, players must undergo two or three rounds to defeat a boss, and later accompanied by boss transformation. Such transformation changes the attacking style, game scenes, and interludes of cinematic storytelling. This situation makes the game experience fresh, adds amusement value, and allows the player to relax, calm their nerves, and concentrate on the boss battle.

The values of \( G \) and \( T \) of the six productions of the GoW series were recorded where the \( GR \) value was calculated (Table 6 to Table 11). It provides the results of the computed \( GR \) values and the associated motion in mind measures \((v, m, N, \vec{p}, \text{and } \vec{E}_p)\) of the boss battle scene, where each table corresponds to one game production of the GoW series. To visualize such findings, the trend of the \( GR \) and \( m \) of each GoW series, based on the sequence of bossess were plotted (Figure 3).

Based on Figure 3(a), Figure 3(b), and Figure 3(d), the main GoW series were different from one another in terms of the boss challenges relative to the game progression.

\(^2\)Example gameplay recording by the Heigutongge Youtube channel on GoW I: https://youtu.be/mlgjNpsZDj0
FIGURE 3. Tendencies of GR and \( m \) for (a) GoW I, (b) GoW II, (c) GoW: Chains of Olympus, (d) GoW III, (e) GoW: Ghost of Sparta, and (f) GoW: Ascension.

TABLE 3. The tendency of average motions in mind of different GoW series.

| Version                  | \( G \)  | \( T \)  | \( GR \) | \( AD \) | \( v \)  | \( m \)  | \( N \)  | \( \bar{g} \) | \( \bar{E}_p \) |
|--------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| GoW I                    | 104.111 | 132.444 | 0.081   | 0.056   | 0.786   | 0.214   | 1.283   | 0.164   | 0.252   |
| GoW II                   | 90.368  | 127.053 | 0.078   | 0.055   | 0.698   | 0.302   | 1.455   | 0.204   | 0.280   |
| GoW: Chains of Olympus   | 77.833  | 107.667 | 0.086   | 0.063   | 0.703   | 0.297   | 1.431   | 0.206   | 0.287   |
| GoW III                  | 76.067  | 101.667 | 0.089   | 0.064   | 0.740   | 0.260   | 1.366   | 0.187   | 0.273   |
| GoW: Ghost of Sparta     | 83.750  | 115.125 | 0.085   | 0.061   | 0.719   | 0.281   | 1.397   | 0.200   | 0.286   |
| GoW: Ascension           | 92.273  | 132.364 | 0.073   | 0.050   | 0.688   | 0.312   | 1.468   | 0.211   | 0.287   |

GoW I and GoW III shared a similar pattern where the challenge peaked (high \( m \), \( GR \) in the zone) around the final three boss battles. At the same time, GoW II was more inconsistent for the boss challenge (rapid change of \( m \)) but still attractive relative to GoW I and GoW III (approximately similar \( GR \) values for the three main GoW series).
Meanwhile, Figure 3(c), Figure 3(e), and Figure 3(f) showed that the peak of the challenge was roughly in the middle of the overall progression of the boss battle. However, this boss battle was more difficult since the \( GR \) value was higher than the sophistication zone \( (GR > 0.08) \).

From the data analysis of the average boss battle of each GoW series (Table 3), it can be observed that the \( GR \) and \( AD \) values were located within the sophisticated zone \( (GR \in [0.07, 0.08] \) and \( AD \in [0.05, 0.06]) \). This condition implied that these different GoW versions were sophisticated with enough complexity, making them popular and highly attractive. However, with the subsequent GoW series, the \( G \) value was reduced while maintaining roughly similar \( v \). Such a trend indicates that the game increases in difficulty and becomes more challenging to overcome by the players as the series progresses.

**B. ANALYSIS OF GoW SERIES BASED ON CHALLENGE \( (m) \) AND ANTICIPATION \( (E_p) \)**

The success of action games depended on the pace and plot of the stories behind the gameplay, emphasizing engagement and attractiveness in conjunction with the in-game actions.
Such settings were visible in the GoW series. Relative to the boss battles in the series of GoW, the battle scene is divided into two to three rounds before it can conclude the outcome. This condition is necessary for the action game that concluded within minutes to be prolonged into some number of hours, increasing satisfaction and fulfilling the game’s narrative.

Figure 4 depicted the measure of challenge (m) and anticipation (Ep) of the considered GoW series. Observing the trend and pattern of the figures, the specific bosses were divided further to highlight the pattern of each of the GoW series. GoW I (Figure 4(a)) and the rest of the non-main series of the GoW (Figure 4(c), Figure 4(e), and Figure 4(f)) shared approximately similar pattern of anticipation building up before the greatest challenge (Ep value being high just before the highest m). However, GoW I was a more typical ‘ground-up’ building than the other non-main GoW series, making anticipation higher after or in-between the greatest boss battle (highest m).

Meanwhile, the pattern observed for GoW II (Figure 4(b)) and GoW III (Figure 4(d)) were somewhat inconsistent with intermittent exchanges between anticipation level (high Ep compared to the m) right before the high level of challenge (highest m throughout the overall boss battles). Interestingly, the more minor bosses (such as Euryale, Kraken, and Clotho in GoW II; Hermes and Hercules in GoW III) in-between the greater bosses (such as Barbarian King and Perseus in GoW II; Hades and Helios in GoW III) provided the needed anticipation before reaching the most significant challenge (Zeus in GoW II and GoW III). Based on these results, it is clear that the GoW series experimented with different intervals of a boss battle and a different number of rounds allotted to each of the bosses to determine their impact on the entertainment of the battle itself.

Considering the ending or the last (strongest) boss of the GoW game, along the subsequent GoW series (Table 4), it can be observed that the average of the battle stages typically within the sophistication zone (GR ∈ [0.07, 0.08]), while m → 0.3 and Ep → 0.29. Such a condition implies that the final boss battle of the GoW game was designed to have sufficient complexity that could cater to expert and beginner players, requiring objective reinforcement to overcome the challenge of the battle, and the challenge itself induces learning comfort that warrants the player to learn the mastery of the battle.

Finally, observing the trend of m dynamics of the GoW series (Figure 4), there were positive trends visible for GoW I, GoW III, and GoW: Ascension. However, GoW III had more intense changes of m dynamics, implying that the latest version of the GoW series incorporates high unpredictability and makes the experience feel roller-coaster-like. Such a situation was also similar in GoW II, but the trend of the m dynamic was negatively inclined. This condition meant that the boss battle was less challenging towards the end. While similar situations were also observed for GoW: Chains of Olympus and GoW: Ghost of Sparta, the m dynamic was predictable with apparent seesaw turnover between decreasing (or increasing). As such, the m dynamic was an essential element emphasized by the GoW developers to balance the levels of anticipation and predictability, where players enjoyed the experience of playing or solving in the moments between the m changes.

### V. DISCUSSION

This study analyzed most of the GoW series, except the GoW IV, due to the differences in gameplay (failed combination of action and role-playing [38]) and unable to fit the same model to be discussed with other GoW series. However, it was found that there was a distinction between different boss battles throughout the GoW series. One of the distinctions was because of the game’s medium, where overall boss battles of the game released on a PSP were shorter (see Table 8 and Table 10) than those released on the PS console. Besides, the first GoW also showed that the number of rounds of boss battles was somewhat limited, making it less celebrated than the latter GoW series. Nevertheless, variations in the number of boss battle rounds make the game exciting and the play experience attractive to the players.

Such a situation can be observed in the first series of the GoW, where the only boss battle with a single round was the Medusa. The battle was designed to regain the power of the protagonist, Kratos, and had no impact on the main narrative and overall gameplay. The $GR = 0.107$ and $m = 0.181$, indicating that the battle was relatively straightforward and short since the number of successful attempts (G) needed was low. In contrast to the final boss, the second round was $GR = 0.061$ and $m = 0.269$, where the battle was the toughest, likely due to the need for fast-paced hand-eye coordination since the successful attempts (G) were higher compared to other boss battles. Therefore, the $GR$ value provides a viable

### TABLE 4. Challenge ($m$) and anticipation ($E_p$) of the final strongest boss of each GoW series.

| Boss Name                  | $GR$ | $m$  | $E_p$ |
|----------------------------|------|------|-------|
| GoW I-Ares1                | 0.088| 0.245| 0.279 |
| GoW I-Ares2                | 0.061| 0.269| 0.287 |
| GoW I-Ares3                | 0.089| 0.349| 0.296 |
| GoW II-Zeus1               | 0.095| 0.377| 0.293 |
| GoW II-Zeus2               | 0.061| 0.322| 0.296 |
| GoW II-Zeus3               | 0.061| 0.322| 0.296 |
| GoW III-Zeus1              | 0.067| 0.309| 0.295 |
| GoW III-Zeus2              | 0.087| 0.465| 0.266 |
| GoW III-Zeus3              | 0.071| 0.287| 0.292 |
| GoW III-Zeus4              | 0.129| 0.279| 0.290 |
| GoW: CO-Persephone1        | 0.082| 0.269| 0.287 |
| GoW: CO-Persephone2        | 0.073| 0.250| 0.284 |
| GoW III-Zeus1              | 0.063| 0.243| 0.279 |
| GoW: GoS-Thanatos1         | 0.112| 0.250| 0.281 |
| GoW: A-Alecto1             | 0.064| 0.239| 0.277 |
| GoW: A-Alecto2             | 0.069| 0.281| 0.291 |
| GoW: CO - GoW: Chains of Olympus |
| GoW: GoS - GoW: Ghost of Sparta |
| GoW: A - GoW: Ascension    |
TABLE 5. Summary of entertainment aspects identified from the GoW series boss battles and potential implications.

| Entertainment Aspect | m   | \( E_p \) | GR | AD  | Rounds/Intervals | Implication                  |
|----------------------|-----|-----------|----|-----|------------------|-----------------------------|
| Impactless obstacle  | <   | >         | >  | >   | Single           | No challenge                |
| Small “bumps”         | >   | < zone    | <  | zone| Little           | Practice/Training challenge  |
| Ground-up            | >   | zone      | >  | zone| Little → Medium  | Progressive challenge        |
| Erratic incline      | >   | zone      | >  | >   | Medium → Little  | Unstable challenge           |
| Erratic decline       | >   | zone      | >  | >   | Medium → Little  | Unstable challenge           |
| Hard obstacle        | >   | >         | >  | >   | Medium → Many    | Mastery challenge            |
| Risky obstacle        | >   | >         | >  | >   | Medium → Many    | Ultimate challenge           |

\[ m: \text{positive increase}; <: \text{negative increase}; \uparrow: \text{fluctuating}; \rightarrow: \text{up to}; >: \text{more than zone value}; <: \text{less than zone value}; ^1: \text{recommended estimation based on corresponding entertainment aspect}; \]

Little: 2–3; Medium: 3–4; Many: 4 or more;

measure of complexity and sophistication of the boss battle of the GoW game.

In GoW II, the number of boss battles was the highest compared to all other GoW series. Interestingly, the boss battle against the Sparta soldiers was entirely rendered as a two-dimensional fighting game. It was found that the final boss battle had \( GR = 0.061 \) and \( m = 0.322 \), implying that the battle requires some comfort in learning to outmaneuver the final boss while requiring a high number of successful attempts. It also explained why the GoW II was among the most complex and challenging throughout the GoW series. GoW III is the third main release of the series with enhanced graphics, exciting narratives based on Greek mythology, and supported in PS3 console, which makes it the most popular and attractive version in the GoW series. However, based on the GR value of its last boss battle (see Table 9), the complexity is less likely to be a challenge where it relaxes the player by making the battle more manageable and more accessible than in the previous GoW series. In addition, its sanguinary scenes were made deliberately at the end to make the experience movie-like and immersive.

Table 5 summarized the findings of this study, where the entertainment aspects of the GoW series were extracted and the potential implications. It includes six potential entertainment aspects, where the change in the \( m, E_p, GR, \) and \( AD \) impacted the level of challenge posed based on the rounds/intervals of the boss battle. Increasing (or decreasing) \( m \) provides the necessary obstacle for the player, but tied with fluctuation of \( E_p \) and \( AD \) zone makes it a good condition for the training/practice environment, given the rounds/intervals is small since it provides some unpredictability yet highly expected. However, when \( m \) fluctuates, the \( GR \) zone would provide challenges that can either be progressive or unstable given the state of \( E_p \) and \( AD \). Since \( E_p \) and \( AD \) influence expectation and unpredictability, it would be left to the developers’ imagination to experiment with a different configuration that best suits their intended design of the game flow and narrative—for instance, balancing more or fewer rounds/intervals relative to player expectation towards a more difficult boss (unstable challenge) or allowing for the play experience to be aligned with a more complex narrative (progressive challenge). Subsequently, higher \( GR \) and \( AD \), with fluctuating \( E_p \), could make the play experience very difficult or require some level of mastery, which typically requires more rounds/intervals to be engaging (or fair). At this point, the risk of character death is generally acceptable since the player would associate it with an obstacle that requires some overcompensation to overcome it.

Nevertheless, the reader should take the findings with a grain of salt as the study may be exposed to some threats to the validity of the findings. Firstly, the collected data may be exposed to human error as the data collection procedure involves intervention from multiple participants of different educational backgrounds and biases towards the action game. Secondly, the data collection procedure was conducted from a recording of gameplay posted on a public video-based website, in which the play experience may be lost or excluded from the video recording due to other external motivations. Nevertheless, future works can address such threat by collecting the data either via external programs (i.e., game-specific application programming interface or API), in-game metrics (i.e., scores, achievements, time spent), game telemetry (remote data monitoring, measurement, or recording), or psychophysiological means (i.e., heart rate and skin conductance), in which the considered GoW series lacks in the first place.

VI. CONCLUSION

This study analyzed the GoW series via the GR theory and its extension, called motion in mind, based on the actions of the boss battles available in each of the series of the GoW considered. From the analysis, the evolutionary trend of the GoW series was identified where not only the challenge increases, insights into the narrative design, levels of predictability, and balances the experience of play for beginner and advanced players.

From the findings (Figure 3 and Table 3), it can be concluded that the boss battle of the GoW series was designed with sufficient sophistication to be entertaining to diverse players (\( GR \in [0.07, 0.08] \)) while applying enough unpredictability and retain the interest of the player (\( AD \in [0.045, 0.06] \)) to allow the experience repeatable. Additional features identified include the learning comfort imposed by the developers, where the player is expected to learn and
master the battle when reaching the final boss for each GoW series. In addition, the dynamics of the game imply a roller-coaster-like gameplay experience, where the uncertainty makes it enjoyable to the player.

The study also found that the game’s platform indirectly related to different GoW series experiences. As different platform had different interfaces (diegetic or non-diegetic) [39] and new media technology [40], it could significantly influence the play experience. As the findings of this study showed, the GoW series had demonstrated parallel development of human-computer interfaces and measures of information delivery. The developer encouraged players to learn and adapt not only to in-game challenges but also to involve rapid reactions and excellent hand-eye coordination, thus, making the expected experience from the play much more holistic and enjoyable.

As action games are rich with other game-playing elements, future work may want to consider those other elements to enhance the analysis. For instance, the inclusion of puzzle-solving stages, building and/or crafting, character skill combination and/or balancing meta-gaming elements (user interface, mini-games, and in-game progression and/or
badging), and narrative structure. These elements also measured and determined their roles relative to the expected enjoyment and entertainment of the intended game-playing experience of the players by the developers. Finally, having a unified view of the game design (inclusive of the aforementioned elements) would provide insights that were beneficial to the developers and publishers of the games alike.

**APPENDIX A DETAILED DATA COLLECTED FOR EACH GOD OF WAR SERIES**

See Tables 6–11.

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