

# **Video Games Classification with Game Experience and Hierarchy of Needs**

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Master of Engineering

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# Chapter 1: Introduction

Why is a game divided into specific genres? Players raise this question when they have completely different game experiences of video games with a same genre. Although players are used to the convenience that genre brings to their cognition, such classifications are unreasonable and inaccurate for game researchers and experienced players in particular circumstances. Because of the rapid development of game design concept and development technology, this problem is becoming more and more severe.

The diversification of game design makes the new games contain numerous elements from classic games, which increases the complexity of its game experience and makes the classic genres unable to describe it well. This has led game researchers to continually expand the classic genre system with new genres or subgenres, which become prolix, complicated, and difficult to understand. Developers and platforms do not want potential players to abandon the game because they are unfamiliar with a new genre, so these newly designed genres or subgenres still have not replaced the classic genres.

Besides, the descriptions of game genres are not systematic, and the definition process is too subjective. This leads to the same game being defined in varied genres by different researchers. Therefore, a new game classification system needs to be developed, which can not only meet the expectations of game researchers to find similarities and differences in video games but also reduce the cognitive cost of the public.

In this research, we first combined a mainstream technique of measuring game experience with the modern edition of Maslow's hierarchy of needs to generate an original questionnaire. After conducting a survey of a representative sample of games among game researchers and developers, its factors and items were then validated by exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). Based on the results of the revised questionnaire and corresponding gameplay, we first attempt to compare and classify the games in groups. Machine learning algorithms were then introduced to cluster the sample. By evaluating the clustering results, we find the best algorithm and the hyperparameters that matched our model well. The relevant code, data, and all editions of our questionnaire could be found in <sup>1</sup>.

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<sup>1</sup> Available at <https://github.com/LelouchWu/FGTG>

# **Chapter 2: Genre and Genre Theory in Video Games**

## **2.1 The History of Genre**

As a collective subject, genre theory is conceptualized as an academic approach to establish understanding that most people recognized and improve communication efficiency in the fields of literary genre or rhetorical genre. Literary genre contains many early literary forms, such as literary works, poetry, Movies, music, etc. As the origin of genre theory, the studies of literary genre can be traced back to Northrop Frye's Anatomy of Criticism [1]. According to the discourse of Ted Underwood 2016, some scholars believe that the essence of genre theory is not only reflected in the a method of linking literary works to lasting cultural forms, and more importantly, constantly challenging these existing connections [2]. This view has also been completely verified by history. For example, scholars' research and summary of film types have become a system with the continuous advancement of film science. These studies evolved from the early classic film types Film Noir, Screwball Comedies, Science Fiction and Fantasy, Epics and Sagas, B-Movies, Movie Musicals, Westerns, and Biographies to complex cognitive systems with mixed themes and subtopics [3]. Based on [4], generic structure both enables and restricts meaning, and is a basic condition for meaning to take place. In this process, external factors such as human learning ability, technological progress, and state relations continue to challenge and improve the classic genre theory.

According to the other branch of genre theory, the rhetorical genre studies, since ethnographers have introduced genre into the field of linguistics, linguists have defined and analyzed it in detail. The genre research has three major schools: English for Specific Purpose (ESP), Systemic-functional Linguistics School (SFL) and North Rhetoric (NR) [5–7].

In the SP school, Swales 1980 first defined the genre, which is a group of communicative events with common communicative purposes. This definition is further explained by Bhatia 1993 [8] as:

- Genre is an identifiable communicative event
- Genre is not a general communicative event, but a communicative event with distinctive internal structure and highly established conventions
- When constructing a discourse, one must follow the practice of a particular genre
- Although the genre has conventions and constraints, the insider can convey the intention or communicative purpose of the individual within the framework of the genre

JR Martin in the SFL school suggests that genre is a step-by-step, communicative-oriented social interaction process involving a specific cultural member [9]. That is, the type of genre

is the recognized social behavior in culture. CR Miller from the NR School considers genre to be a social act [10]. Miller points out that genre is not a formal name of a classification, but a social activity, a discourse classification of statutes based on typical rhetorical activities. All three schools believe that the purpose of communication determines the existence of genre, and the graphic structure of the same genre is basically the same. In addition, due to cultural factors or discourse variables, genre users can create creativity and create texts that conform to specific situations without destroying their basic structure.

## 2.2 The Methodology of Genre research

Genre research has attracted the attention of researchers in different disciplines, which determines the interdisciplinary nature of genre research. Discourse analysis based on genre theory is the product of multidisciplinary research. Genre analysis involves both stylistic analysis and discourse analysis. Its fundamental purpose is to explore the purpose of discourse communication and language use strategies. Genre analysis transcends the surface description of discourse language features, tried to explain the discourse construction rationale, focuses on revealing the special way of achieving communicative purposes and the normative construction of discourse [11]. Therefore, the most striking feature of genre analysis is its explanatory nature. In order to reveal the purpose and construction of discourse communication in depth, the genre analysis adopts research methods such as linguistics, sociology, psychology and ethnography [12].

- The linguistic analysis method is mainly used to describe the genre characteristics of discourse, such as the ESP “study step-step” analysis mode, which is mainly used to analyze lexical-grammatical features and textual macrostructure in specific discourses.
- As a social phenomenon and social behavior, its discourse is a discussion of the social and normative nature of discourse and the social and cultural factors that influence the construction of discourse.
- The psychological method pays attention to the cognitive structure and construction strategy of discourse and explores the specific communicative purpose.
- The ethnographic method mainly studies the social statute of discourse formation through means of field observation, interviews and data investigation.

The advantage of genre analysis is that it not only pays attention to the static linguistic feature description of discourse, but also pays more attention to the construction of discourse and explores the social, cultural and cognitive factors behind the discourse.

## 2.3 Video Game Genres

There is a consensus among the scholars of game genres that the definitions used in business and academia are not exactly the same. Next, we will introduce the classification of game types by the major platforms.

### 2.3.1 Business Game Genres

1. From a business perspective, game download platforms, such as iTunes, have not introduced the concept of gaming subgenre. While this may not satisfy game experts or enthusiasts, rather than figuring out a genre, most gamers only want to know which group a game belongs to. Therefore, from the perspective of operators and developers, considering the benefits of their products, there is no need to use a complex genre classification system. We summarize the game themes and corresponding examples from the iTunes XML architecture:

- Action: Super Mario Run, Clash of Clans
- Adventure: Dead Rain : New Zombie Virus, Otto Matic
- Board: AmazeJelly, Catan Universe
- Card: Hearthstone, Ancient Creed
- Casino: Solitaire, Zynga Poker - Texas Holdem
- Casual: Candy Crush Saga, Temple Run: Classic
- Educational: Bingo For Kids, Digit Span - Train of Thought
- Family: Minion Rush, Trivia Crack
- Music: Piano Tiles 2<sup>TM</sup>, Geometry Dash Lite
- Puzzle: Psarakia (Ice Fishing), Slices
- Racing: Mario Kart Tour, Real Racing
- Role Playing: The Quest Classic - Cursed Chess Set, Blade Runner Rogue
- Simulation: slither.io, Hay Day
- Sports: Hooked Inc: Fisher Tycoon, Motorsport Manager Online
- Strategy: Civilization, Fieldrunners
- Trivia: SongPop, Classic Miner
- Word: Word Master Pro, My Name Meaning

2. In addition to mobile gaming platforms, many PC and console platforms still do not use the concept of game subgenre, and even those dedicated to gaming software, such as Steam. This implies that discarding subgenre not because the platform runs many types of applications simultaneously but because of the complexity of subgenre itself. We summarized Steam's game genres and their corresponding examples as:

- Action: Monster Hunter World, One Piece: Pirate Warriors
- Adventure: Destiny 2: Forsaken, Grand Theft Auto V
- Casual: Overcooked, The Jackbox Party Pack
- Indie: Terraria, Brawlhalla
- Massively Multiplayer: ARK: Survival Evolved, Warframe
- Racing: Rocket League, Assetto Corsa
- RPG: The Witcher 3: Wild Hunt, Persona 4 Golden
- Simulation: Euro Truck Simulator 2, War Thunder
- Sports: NBA 2K20, Football Manager 2020
- Strategy: PlayerUnknown's Battlegrounds, Dota 2

### 2.3.2 Research Game Genres

Although the above genre systems given by mobile and PC platforms are not very complicated, these definitions are far from sufficient for academics or game experts. According to Arsenault's Research [13], Arsenault referred to the genre classification of games and subgenres from **MobyGames** in 2009. This content needs to be reorganized due to innovations in gaming devices and new genres. Therefore, we summarized the following game genres up to 2020:

- Basic Genre: Mainstream genres that are well known to the public.
  1. Action: This type of game is considered to be an action-based game in addition to Racing/Driving, role-playing (RPG) and Sports. However, some hybrid genres are allowed, such as Grand Theft Auto-V (GTA-V) is defined as an Action + Racing/Driving game or Action-adventure game.
  2. Adventure: The word "Adventure" derives from the famous game "Colossal Cave" also known as "Adventure". These games are designed to guide the player through dialogue and puzzles, and emphasize players' decisions rather than actions.

- 3. Compilation: Compilations games are collections of specific games, which can be used as prequels and compilations, or games with a same genre.
- 4. Download content (DLC): DLC cannot be played alone, they need to be attached to the original content of a game. These add-ons can be represented in, currency, skin, enemies or maps, etc.
- 5. Educational: Educational Games are usually aimed at children players. Such games try to teach these children some uninteresting skills such as math, English, history, etc.
- 6. Puzzle: Comparing adventure games, puzzle games are less about narrative, and more about logic and tactics.
- 7. Role-Playing (RPG): RPG makes players experience the character development from three dimensions, amassing wealth, narrative, and tactical combat. This process could be represented as all in-game elements like skill learning, talent trees, and equipment upgrades.
- 8. Simulation: Compared to other games, this type of game truly simulates real world phenomena, such as business, architecture, life, management, or war, etc.
- 9. Special edition: These games are usually basic games with additional content and are usually released at the same time as the standard version of the game
- 10. Sports: In Sports games, gamers usually act as athletes or managers in real or imaginary sports.
- 11. Strategy: This genre can be summarized as a combat game or a scene management game that emphasizes tactics and strategies for using in-game resources.
- Perspective: From a developer's perspective, this dimension refers to the angle of the camera that determines the player's perspective. These include 1st-person, 3rd-person, audio game (the game only have audio features or audio visuals), behind view, bird's-eye view (an angle between behind view and top-down view.), side view, text-based (the game only have text features), and top-down (an overhead view that does not have any angle).
- Visual Presentation: Different from perspective, this aspect determines the position of camera, such as, 2D scrolling (scrolling in two dimensions or following a particular object), cinematic camera (the camera position is fixed and cannot be changed by the player to achieve movie-like effects), fixed (using a single fixed screen to display game screen, and when the player reaches the end of this screen, the entire screen is replaced by a new fixed screen), free-roaming, and isometric (creating a pseudo 3D effect using isometric, or double-spaced 2d perspectives).

- Art Style: The art style of the game scenes and characters, such as Anime(Japanese anime style), Augmented reality (using deep learning algorithms to generate game images similar to the real world), full motion video, live action, and video backdrop (taking place against a video background).
- Pacing: The pacing of game updates usually reflects changes in in-game resources and time. Meditative (games that have no objectives and try to relax the players), persistent (even when the player is not in the game, the pace continues), real-time, and turn-based.
- Control: How players operate the gameplay such as direct control (players control a single character by directional buttons which interact with the gaming environment), menu structures (operations are presented through menus), motion control (operations change through the player's body action, which is captured by the camera), multiple units (players can control more than one avatar at the same time), point and select, text parser, and voice control.
- Sports: Games themed around different real-life sports including Athletics, Baseball, Basketball, Bowling, Boxing, Cricket, Darts / target shooting, Dodgeball, Fishing, Football, Golf, Hockey, Horse, Olympiad, Paintball, table tennis, snooker, Racquetball, Rugby, boating, Skateboarding, Snowboarding, Surfing, Tennis, Volleyball, Wakeboarding, Wrestling
- Educational Categories: Games themed around different educational subjects like Ecology, Foreign language, Geography, Graphics, Health, History, Math, Music, Pre-school (teaching per-school children), Reading, Religion, Science, Sociology, and Typing.
- Vehicular Themes: Games themed around vehicle driving, racing, or management. Such as Agricultural, Automobile, Bike, Bus, Flight, Helicopter, Hovercraft, Mecha, Motorcycle, Naval, Off-roading, Self-propelled artillery, Snowmobile, Space flight, Street racing, Tank, Track racing, Train, Transport, and Truck.
- Topic: Games themed around a particular type of background story containing Adult, Comedy, Crime, Detective, Healthcare, Horror, Martial arts, Romance, Spy, Survival, Thriller, and War.
- Downloadable content(DLC): Although DLC is usually available on a separate game platform, it must be attached to an original game version. It may contain Audio (Music, stands for sound effects, and voice), Currency, Customization, Extras, Game mode, Item, Map, NPC, Other, Player unit, Story, and Upgrade.

- Special Edition: Special version of the game for sale. Digital extras (digital version of DLC), Extra content, and Physical extras (additional game related products such as figurines, book, or cup, etc).
- Other dimensions: Fan game (Games are made by fans of novel, book, film, etc.), Licensed game (Games are licensed by novel, book, film, etc.), Regional differences (Different from localized, various versions of games in different countries and/or regions).
- Gameplay: Games with specific gameplay, including 4X (Games that must have strategic gameplay, exploration, expansion, exploitation, extermination, randomly generated environments, structural building, technological advancement, and diplomacy.), Action RPG (real-time and action-based RPG), Arcade, Artillery, Brawler, Board game, Cards, Casino, Chess, City building, Dating simulation, Falling block puzzle, Fight, Game show, Graphic adventure, Hack and slash, Hidden object, Hunting, Japanese-style adventure, Japanese-style RPG, Life, Managerial, Massively Multiplayer, Mental training, Metroidvania (A subgenre of action game), Mini-games, Rhythm, Multiplayer online battle arena, Paddle, Party game, Pinball, Platform, Puzzle elements, Quick time events, Rail shooter, Real-time strategy, Roguelike, Sandbox, Shooter, Stealth, Survival horror, Tactical RPG, Tactical shooter, Tile matching puzzle, Timed input, Time management, Tower defense, Trading, Tricks, Turn-based strategy, Vehicle simulator, Vehicle combat simulator, Visual novel, War-game, Word construction.
- Setting: Background of the game contents or gameplay, which includes Africa, Asia, Ancient China, Classical antiquity, Cold War, Contemporary, Cyberpunk, Ancient Egypt, Europe, Fantasy (Games that have supernatural elements from fictional fantasy), Historical Events, Industrial Age, Interwar, Ancient Japan, Modern Japan, Medieval, Middle East, North America, Oceania, Post-apocalyptic, Pre-Columbian Americas, Prehistoric, Futuristic (Games that have science fictional elements), Sea pirates, South America, Steampunk, Western, World War I, and World War II.

## 2.4 The problem of Genre theories

According to [14], the genre in NR school has 3 main weaknesses. First, the definition of genre is ambiguous, and the genre cognition and concept are too abstract. Second, it is against explicit teaching, thus lacking specific and clear genre analysis or framework. Third, based on case analysis, there is no extensive range of practices. These characteristics have greatly restricted the development of NR research, limited the application and dissemination of its theoretical ideas. The drawbacks of ESP could derive from [15], which suggests that

the academic culture provided by the EAP is not in harmony with the listeners' background culture. This will undoubtedly lead to the failure of intercultural communication. Therefore, anthropological research methods need to focus on preventing possible conflicts between different cultures and educations. SFL also has some shortcomings including the complicated types of genre and the high demands of the genre definer themselves [12].

## 2.5 The problem of Video Game Genres

According to Rachel's research [16], there are also significant problems with the genre system in video games.

- The genre system of video games lacks uniform, official, and concrete identification standards. This can lead to categorizing games with entirely different experiences into the same category due to personal preference. For instance, the Octopath Traveler, Fate grand order, and Pokemon Sword and Shield are all defined as RPG games, however, their gameplay are extremely different.
- The absence of a detailed description makes the definition of genres too abstract, which results in such genres being labeled on a considerable number of games. Rachel mentions that Action Games sold on all platforms accounted for 31.9% of total game sales in 2013.
- Based on [17], some mainstream game genres contain too much information and represent too many dimensions that make players confused about why such genres could represent this information. For example the genre of MMO Real Time Strategy represents the information from 3 dimensions which are time, player number, and mood.
- Few resources provided definitions of genre, resulting in the public unable to clearly understand game genres.

# **Chapter 3: Definition and Measurements of Game Experience**

Before we start discussing the game experience, one should know what is the user experience. The definition of user experience (UX) is rather vague and abstract, which emphasizes an underlying feature. Previous studies and measurements of UX are thus focus on the observable factors that are closely related to UX, or the measurable variables that could directly represent UX in specific dimensions [18]. In addition to UX's property, another factor that prevents establishing the definition is it needs to become a general enough concept to be applied to many academic fields such as HCI, marketing, system performances, design, or Utility [19].

In recent years, with the development of computers and mobile devices, the definitions of UX that have been accepted by public generally come from the design of interfaces, operations, or social communities in software development. But from an academic point of view, these are not enough to explain UX.

## **3.1 What is User Experience?**

The term “User Experience” was first mentioned in 1988 by Donald Norman’s literature [20]. From his research, he emphasized that developers should pay more attention to the needs of users rather than blindly pursue system optimization and interface beautification. More general, Norman wanted to build a user-centric development process. At the earliest stage, UX was only classified in the marketing research, and was more of a market analysis than a design.

With the continuous improvement of the concept, it gradually became a product design architecture based on marketing research. For example, according to Hassenzahl’s works [21, 22], UX has became an umbrella term in the field of HCI. With the development of interactive technology, UX is not only about usability and practicality, but also about fashion. This also indicates that the previous empirical studies of UX need to be improved immediately to be applicable to UX design in the future. Such new approach of designing interactive products adapt to the experience quality of technology, but not the product quality.

Other studies suggest that UX cannot be defined straightforward. According to ELC Law’s research [23], the concepts of UX are “fuzzy, dynamic, and highly depended on developers’ background and interest”. Such properties make the analysis of UX’s unit rather malleable and the relative research more fragmented and obscure. Beyond that, individual’s emotion could also influence the definition of UX. According to Jodi Forlizzi’s literature [24], emotion may also affect the users to assess the outcomes and experiences in interacting with products. Based on this concept, Jodi concludes the definition of UX as the interaction

between users and the product, the community, and the resulting emotions and experiences.

Nowadays, the development process of UX-centered products could be divided into two parts, the UX research and the UX design. Such model is used by a significant number of Internet companies such as Tencent and Giant Network. In the part of UX research, developers collect and analyze data according to the requirements of the enterprise to formulate specific framework and benchmarks, which include usability testing, persona, and the core elements of your products. Such data are derived from the marketing research based on qualitative testing or quantitative testing. In the UX design section, based on the above analysis results and customer needs, developers design the specific functions, such as user interface and client operations, that are highly interactive, efficient, and could be accepted simply by the target user community.

From my own perspective, it does not make sense to struggle with a broad definition of UX. First and foremost, even Donald Norman himself emphasized that UX is built on pragmatism, so it needs to be defined in a particular domain. Second, the definition itself may evolve as technology improvements and aesthetics transformations. Therefore, in next section, we focus on UX's usage and evolution in video game development.

## 3.2 What is Game Experience?

Although game experience (GX) is a branch of UX, they differ in some details. According to Hassenzahl's model of UX's mechanism [22], a product has both utilitarian and hedonic properties. However, when researchers try to define the experience of playing video game, these two parts could not be considered equally important. Though most of video games might be designed with difficulty adjustment, rhythm changing, or visual effects to stimulate the player to pursue personal value, such satisfactions are more likely to manifest themselves in hedonism. Only serious games might apply pragmatism as a vehicle for gaming satisfactions [25]. Therefore, many subsequent studies of GX have focused on hedonism and its observable characteristics. As for Arrasvuori's Playful Experiences (PLEX) framework [26], based on user-centered design, which is a conceptual tool designed to understand the UX from hedonism. The PLEX is made up of 22 categories of experiences that are generally considered to represent playfulness such as, "Captivation, Challenge, Competition, Completion, Control, and Cruelty", etc. Other research on the definition of GX suggests that it consists of 5 elements [27]:

1. Motivation: The player community for which the game is being played and why
2. Meaningful choices: How does the game guide players to make choices through its structure and rules
3. Balance: How to design an appropriate difficulty to make the player feel happy

4. Usability: How to design user interfaces and operations to attract and retain players
5. Aesthetics: How to design visual and auditory effects such as game scenes, characters, and sounds

### 3.3 How to assess Game Experience?

In this section, we will discuss the mainstream measurements of GX from previous research. As mentioned above, defining the level of the game experience is a complicated business. Macroscopically, such evaluation criteria could be divided into the questionnaires based on subjectivity and objectively dominated assessments of technical instruments. To explore how to use GX to categorize games, we summarized these methods in this section and looked for what could be used in our research.

#### 3.3.1 Objective-Based Approaches

According to Lennar's research [25], the game experience can be divided into three categories:

- the experience of the game system
- the experience of the individual player
- the quality of interaction with a particular environment

Each of these categories represents the game experience at a particular stage. More generally, as for game system, when players are new to the game, the content that game developers develop in the game system will directly affect the experience of the player community. Game system development requires constant testing of game software and game balance to influence the game system experience. The system balance needs to be evaluated by big data analysis of the targeted play community or by scientific measurement experiments.

After that, the personal experience may change depending on the individual and the one's situation such as the group of players, their health, their playing time, their family relationships, etc. One can test individual players' levels of gaming experience with specific techniques. For example, some approach use sensor technology to evaluate the individual interaction experience, while other use the game log data to measure the overall game environment experience of all players. In this study, we will only focus on how to evaluate individual player experience, because the measurement of system experience focus on the

application of some conventional software development methods such as mathematical balance testing, device compatibility testing, debug, or localization testing, etc. We summary the objective approaches as:

1. Electromyography (EMG)

EMG refers to the muscle bioelectrical pattern recorded by eclectic graph. It is of great significance to evaluate human activities in man-machine system. We can calculate some basic emotions by the movement of the facial muscles. James put forward a circumplex model of basic complex emotions mapped on complex dimensions [28], and suggestions on the study of the mood in the method used in emotional complex model to match the behavior, cognitive neuroscience, neuroimaging studies and emotional development [29].

2. Electrodermal activity (EDA)

EDA or Psychogalvanic Reflex is used to represent continuous changes in the electrical properties of the human skin. EDA is used by many psychological studies to measure the activity of the nervous system [30]. In recent years the combination of machine learning and EDA results has been used to describe the user experience [31].

3. Electroencephalography (EEG)

The EEG requires the experimenter to wear a device that continuously records brain waves, recording changes in brain activity through a series of behavioral changes. Machine learning is also used to analyze this complex result, and some studies have used this technique to analyze the level of player involvement in the game [32].

4. Functional near-infrared spectroscopy (FNIR)

FNIR is a safe and wearable modality that tracks cortical hemodynamics in response to sensory, motor, or cognitive activation. The analysis of brain activity can also be performed using FNIR, which has also been used in many HCI studies in recent years [33]. To obtain a general assessment, FNIR and EEG can be analyzed simultaneously [34].

5. Eye Tracking

With the development of game device and the popularity of VR games, the role of eye-tracking technology is gradually improving in assessing the GX in such games. For example, Lennart developed a model to support eye tracking studies for three-dimensional (3D) virtual environments [35]. Other research explore if eye tracking can be used to investigate how novices learn to play [36].

## 6. Player Modeling

In recent year, Machine learning have been a mainstream approach to analyze players' in-game behavior. The results are widely used to predict game churn [37]. However, most of such works have not touched deep learning. This problem is lead by either lacking large-scale data set or suitable data form. Other studies also used player-modelling and game data to assess the rating of experience in specific games [38].

## 7. Rapid Iterative Testing and Evaluation (RITE)

Micro-soft Game User Research developed RITE testing [39] to analyze changes after testing day or at the end of each participant, and to make rapid changes to the interface or Game design once a solution is found. This significantly shrinks the duration of game development.

## 8. Game Metrics Behavior Assessment (GMBA)

Different from player modeling, the analysis of GMBA is based on Instrumentation log data which recorded all in-game operations such as clicking mouses, pressing buttons, changing location, or any in-game interaction. In general, GMBA is not a macro comparison of different players' experiences, but rather a study of what each player actually does. The relative research derives from [40].

### 3.3.2 Subjective-Based Approaches

It is rather difficult to design a general and effective game engagement survey. The difficulty derives from the game itself and the individual's internal cause. Besides, how to use qualitative analysis to verify the experimental conclusion is still obscure. Different from the game churn, is hard to clearly define gaming experience level. One might simply evaluates GX by whether or not players churn, but that's not enough to optimize the game itself. According to the research of Federoff 2002 [41], the assessment of GX involves various dimensions such as immersion and flow. In this section, we summary the content and mechanism of mainstream game engagement questionnaires.

1. The first well-established GX measurement derives from IJsselsteijn's research [42], which describes the applicability of traditional usability metrics to user-centred game design. With two benchmarks, the flow and immersion, he describe a multi-measure approach taken by the Game Experience Research Lab in Eindhoven. According to flow experience, mentioned by Csikszentmihalyi [43], flow is an optimum state in which an individual is highly engaged in an activity. He found that flow experience has similar properties for everyone, so which could be used to describe and assess the experience of a community. There are seven factors of flow experience:

- A challenging, skill-demanding activity that may be constrained
  - A targeted task that must has real-time feedback
  - A task that could be focus on by one's hand
  - A sense of control over behavior, and a lack of fear of losing control
  - A fusion of action and consciousness
  - A decrease in self-awareness or self-focus
  - A passage of time
2. Other research further developed his work to extend it to a “GameFlow”, which could be used to assess player enjoyment [44, 45]. To do this, they conducted a survey among university student who are novices of a game. Based on a modified version of Csikszentmihaly’s work, Video Experience Sampling Method, a questionnaire was applied to the triers during gameplay. After playing game, the triers were also required to finish a survey of a gameplay conclusion.
- As for the other benchmark “immersion”, which could also be use to describe the level of involvement. For example, [44]developed a combination method with immersion and flow. [46]defended a gameplay experience model, which includes 3 dimensions within the interaction between games and players, sensory immersion, challenge-based immersion, and imagination immersion. I suppose that IJsselsteijn’s research established an important GX system, which emphasized the nature of GX and the factors to be considered in the GX evaluation.
3. In 2009, the Game Engagement Questionnaire (GEQ) was published by Brockmyer’s team. His research could be divided into two section. In the first section, Rasch Analysis was applied to prove the reliability and functionality of GEQ scores. In the second section, a small-scale survey was conducted to support that GEQ could be used to predict engagement in video games. However, Brockmyer’s contribution focus on the development of violent gaming behavior, but not the general gameplay. Although his GEQ could not be directly used to evaluate GX, as the first work that proposed GX should be evaluated by questionnaire, it played a great role in the subsequent research. The 21-item GEQ could be found in [47].
4. In 2013, IJsselsteijn and his teammates developed their GEQ [46] which is consist of three section, the core questionnaire, the social presence module, and the post-game module. Part 1 is the core of GEQ, which includes 33 items proposed from 7 perspectives, immersion of senso and imagination , flow, competence, positive affect, negative affect, annoyance, and challenge. Part 2 analyze the engagement of psychological and social

behavior of players with 17 items proposed from 3 perspectives. This part should be conducted only when triers play with other co-players. Part 3 evaluates the feeling of players after stopping gaming, which contains 17 items from 4 dimensions, positive experience, negative experience, tiredness, and returning to reality.

5. Another mainstream questionnaire called the Core Elements of the Gaming Experience (CEGE) were developed in [18]. According to this research, the CEGE are necessary but not sufficient to provide a positive experience (enjoyment) during gaming. In this model, “Puppetry” and “Video-Game” are the major sources generated enjoyment. Among these, all factors that may influence the GX could be divided into latent and observable variables. To measure the GX, one should observe the change of latent variables by determine the corresponding observable variables. As for “Puppetry”, ownership , control and facilitators are three latent variables, which are respectively affected by the observed variables big actions, you-but-not-you, personal goals, rewards; small actions, goal, something-to-do, controllers, memory, point-of-view; and aesthetics, time, pre-experience. In the part of “Video-Game”, game-play and environment are two latent variables, which are respectively affected by the observed variables scenario, rules; and graphics, sound. To define the behavior of such latent factors, whose observable factors are investigated by the items in the CEGE questionnaire (CEGEQ). More general, taking latent factors as criterion and observable as items, the CEGEQ contains 38 items, defined by a 7-point Likert scale,from 8 scales which are “CEGE, Puppetry, Video-Game, Control, Facilitators, Ownership, Game-Play and Environment”. The CEGEQ has been used by other research to assess the level. Combining use 3-health, [48]used CEGEQ to define if players, who are the patients with chronic pain, could obtain enjoyment or frustration from a Serious Game designed to help patients restore physical function and eliminate negative emotions.
6. In 2016, Mikki H. Phan developed the Game User Experience Satisfaction Scale (GUESS) [49], a multi-method system, based on some models we mentioned like GEQ, Game-flow, and immersion. Phan' model integrates the dimensions of other models and addresses the limitations of previous work which includes game perspective, genre, lack of social interaction, obscure items, suitable validation. In his model, started with some basic question, such as gender, genre, and age, 55 items from 9 scales, usability, narratives, play engrossment, enjoyment, creative freedom, audio aesthetics, personal gratification, social connectivity, and visual aesthetics. Each item is also assessed by a 7-point Likert scale (7 is strongly agree, 1 is stronger disagree). In his research, he first collected reliable items from established system. The items were then assessed and filtered by expert. After conducted the questionnaire, confirmatory factor analysis (CFA) [50]and exploratory factor analysis (EFA) [51], were used to refine and validate

his model. Both of them are the approached of factor analysis, which are used in developing scale research. In conclusion, the GUESS combines with the method of measuring GX before 2016, so it is more general, and could be well used in players with different skills and games with different genres. As for the scoring the GUESS, Phan suggests that all items should be randomly divided into 11 sub scales, which can be further sorted into 9 scales. One could evaluate GX based on the average scores of such scales, or their sum. However, the concrete standard to define the level of GX is still unclarity. Phan thus only recommends follow-up research could apply the GUESS in different games with a same genre to compare the corresponding gaming satisfaction by simply comparing the scores.

# Chapter 4: Hierarchy of Needs in Video Games

In this chapter, we will discuss the definition, academic evaluation, and the implementations of Maslow's hierarchy of needs.

## 4.1 What is Hierarchy of Needs?

The first well-established and widespread “Hierarchy of Needs” was released by A.H. Maslow in 1943, which is designed to describe a positive theory of motivation to explain and describe the satisfaction of human needs.

According to his theory [52], human-beings have some innate needs which are arranged in a hierarchical order. The lower the needs, the more basic (and animal-like) they are. Conversely, the higher the needs, the more human-like they are. After one meets a lower level needs, the high level needs will appear and be pursued by the individuals.

It should be noted that, in 1943, most researchers believed that Maslow conditioned the appearance of the high-level need on the requirement that one must satisfy the low-level need. However, Maslow refined such ambiguous statement in a follow-up study [53]. He emphasized that the appearance of a higher-level need does not mean individuals meet 100% satisfaction of the corresponding lower-level need. Maslow's model, as it is known, often takes the form of a pyramid, which has been described as physiological needs, safety needs, love needs, esteem needs, and self-actualization needs from the bottom to the top [54].

- Physiological needs

The objective of these basic needs of human could be identified to meet biological requirements, such as maintaining homeostasis, appetites, sexual desire, or sleepiness, etc. Homeostasis represents the health state of the blood stream such as salt content, fat, protein, and oxygen, etc. Maslow regarded such needs as the most important part of the entire structure, and if which is not met by individuals, other levels of needs will not appear. Imagining one is extremely dehydrated or in need of sleep.

- Safety(Security) needs

As the level increases, the behavior associated with satisfying the requirements becomes more complex. Maslow's study focuses more on adults because children are more responsive to risk, however, adults are taught to suppress such reaction in our society. Therefore, the actions adults take to meet their safety needs are not just to maintain health, but also wrapped up in mundane activities such as purchasing insurance, saving account, and dealing with emergencies like war or disease.

- Love(Belonging )needs

Maslow claims that the factors which influence human obtain love needs are most often mentioned in psychopathology. Love needs could be interpreted as the pursuit of family relationships with companion or offspring, and the yearning of friendship and specific social groups. He also pointed out that “love” is psychologically different from “sex”, since the latter is defined as a purely physical need and the former could be defined as a fusion of two feelings — feeling loved and feeling love towards others.

- Esteem needs

At this level, individuals tend to achieve something to gain the respect or gratitude of others. Based on Maslow’s theory, Esteem needs can be satisfied by two types of behaviors. First, the human desire for confidence, freedom, power, or achievement. Secondly, the pursuit of respect or esteem from others, that is, what we call reputation or prestige. The feelings of inferiority or puniness will come out, if one does not meet such needs. According to Saul Mcleod’s research in 2013 [55], among these needs, the first four levels could be defined as basic needs and the top level could be defined as growth needs.

- Self-actualization needs

Even if all previous needs are met, the individuals may often feel unsatisfied and develop new motivations, unless they are doing what “suits” them. Maslow argues that the individuals who fulfill the needs of the ultimate level are very rare, and the criteria for completion also vary according to the individual. For example, one’s the standard is helping others, while other is the achievement of human progress. Maslow summaries these as “What a man can be, he must be”.

Along with some skeptics, Maslow’s subsequent research had refined his model. According to [56], Maslow introduced “cognitive needs” and “aesthetic needs” to emphasize the importance of cognition and learning. They respectively represent the desire for knowledge and beauty. In [57], he then introduced “transcendence needs” as the final needs to describe the needs of individuals who help others realize their own self-actualization. Therefore, at present, Maslow’s hierarchy of needs could be expressed as the following architecture [55].

1. Physiological(Biological) needs
2. Safety needs
3. Social(Love or Belonging) Needs
4. Esteem needs
5. Cognitive needs

6. Aesthetic needs
7. Self-Actualization needs
8. Transcendence needs

Besides that, some researchers [58]questions the definition of “self-actualization needs” which is rather vague, hard to test, and subjective, since Maslow only used the individuals he knew to define these needs. In fact, even Maslow himself continued to refine them in follow-up studies. For example, in 1962, he claimed that “self-actualization” has the attribute of “growth”, which means an individual’s life will be accompanied by “growth”. Those who meet the requirements of “self-actualization needs” could be considered as those who have found and tried things, helped them to achieve self-worth in the process of “growth” [59]. In 1968 and 1970, Maslow Believed that only 2 percent of people could meet these needs [57]. After surveying 18 self-actualized individuals he considered , including president Lincoln and Albert Einstein, he has summed up 15 characteristics of “self-actualization” and 7 leading behaviours.

- These characteristics include:
  1. Very aware of how to face reality, especially dealing with uncertainty.
  2. do not force themselves and others to be what they “should be”.
  3. Ones’ thoughts and actions are not dictated by others.
  4. Ones’ perception is very objective and not self-centered.
  5. Sense of humor brought by High EQ.
  6. Having a profound understanding of life.
  7. Ones are extremely creative in their respective fields.
  8. do not endorse universal education, but do not strongly oppose it
  9. A dream to achieve human progress and happiness
  10. Have a wealth of life experience
  11. do not have a large social circle and are only willing to build deep relationships with a few people
  12. Having specific and lasting spiritual experience, that is, the transcendent moments of pure joy and elation. This experience is known psychologically as the peak experience [60].
  13. Having some personal privacy that they do not want to make public.

- 14. Advocating a human-centered social structure.
- 15. High moral standards and strict ethical standards.
- Maslow claimed the leading behaviours as:
  1. Concentrate on their work and be enthusiastic at all times.
  2. Dare to question authority and remain innovative.
  3. Prefer to judge things by their own feelings, rather than follow the mainstream.
  4. Be honest instead of wearing a mask.
  5. When presenting ideas or policies, be prepared that they will not be accepted by the public.
  6. Working extremely hard, driven by a sense of responsibility.
  7. Be willing to be objective about your achievements and have the courage to give them up.

## 4.2 Why Hierarchy of Needs?

### 4.2.1 The Challenges of Hierarchy of Needs

Although Maslow's model has been reused to analyze individual motivation in many disciplines, such as business, HCI, and education, it has never stopped being questioned.

According to Rutledge's research [61], his model has no description of social Connection and collaboration, which play an essential role in meeting all of needs in each level. Rutledge also believes that social behavior acts as a medium connecting each level and the concept of hierarchy in Maslow's model is very ambiguous in recent society, especially in the development of interactive social media like Facebook.

Wahba and Bridwell [62] also suggested that the validation experiments of Maslow's model did not provide sufficient evidence to prove the Maslow's perspectives of "level of needs" except the "self-actualization needs". He further doubted whether the requirements had to be in a hierarchical order.

In addition to the architecture of the model, most skeptics focused on Maslow's approach. Maslow developed the definition by referring the biographies and writings of 18 experimenters (16 males). This method carries a strongly personal bias, and a small-scale survey could not obtain a general conclusion. Such subjectivity makes his model even difficult to test scientifically. Even Maslow himself noted that his model is more likely to be applied in developed countries where people have a higher living standards [52]. According to [63], some studies showed that the individual may achieve "self-actualization needs" even

if one's living standard cannot meet the "physical needs". (An obvious example is ascetic monks).

#### 4.2.2 The Influences of Hierarchy of Needs

Even if the architecture of Maslow's model and methodology are queried by some researchers, one can't deny the contribution of hierarchy of needs in academia and business.

Maslow's model was used to assess people's happiness. Hagerty's research also demonstrates the feasibility of this approach [64]. To do this, Hagerty built a database, which includes annual quality of life (time series) for 88 countries from 1960 to 1994, covering all five levels of Maslow's needs. The results confirmed that Maslow's model could be used to describe human happiness to a certain extent, but could not assess the overall level of a country, because the model lacks the assessments of living environment.

Another research from Wicker [65] demonstrated that Maslow's hierarchy of needs is arranged in a certain order, not a classless order as the doubters thought. In Wicker's experiment, 272 subjects were divided into four data sets. Maslow's model is verified by investigating the between-goal correlations and partial correlations of different needs' level within each group of surveys. The results of the experiment supported Maslow's order of needs.

In a recent study [66], Louis conducted a very large-scale experiment to validate a model which is very similar to Maslow's. The model contains six levels, basic needs, safety needs, social needs, respect needs, mastery needs, and autonomy needs. To make the results could represent 95 percent of the world's population, his survey spanned 155 countries between 2005 and 2010. Limited to the level of education in some areas, to make the survey acceptable to all the subjects, the questionnaire has been simplified by setting the responding of many items as "yes or no" but not Likert Scale. His conclusion can be divided into two parts. First, the experiment proves that the association between the fulfillment of needs and subjective well-being. Second, based on multilevel item response theory, he prove the the ordering of needs hypothesized by Maslow.

Other follow-up studies have developed models fitted specific academic disciplines based on Maslow's work. For example, taking the concept of "self-actualization needs" as benchmark, Carol developed a eudaimonic well-being model that emerged from perspectives in "clinical, developmental, existential, and humanistic psychology", which focus on motivating the optimal human functioning [67].

Besides, Maslow's model has also been applied to business. According to Philip's research [68], he implemented the business versions of hierarchy of needs to help the employees inspire their potential. Each level of need corresponds to some of the facilities or psychological construction that companies need to provide to their employees. Philip pointed out that

companies such as Google have already used these methods. For example, setting proper lighting, clean facilities, and comfortable airflow to meet “safety needs”, and vesting the power within each position to meet “esteem needs”.

## 4.3 Hierarchy of Needs in Video Game Development

As the popularity of computers and mobile devices increases, the application of Maslow’s model has shifted from traditional industries to HCI. In this section, we focus on its implementations in video game development.

### 4.3.1 Hierarchy of Video Game Rewards

According to Chelsey’ research [69], Maslow’s model was reused to develop a “hierarchy of rewards” model for game design. Chelsey believed that an excellent reward system is an important feature of a popular game, it thus should be developed through a hierarchical structure not a whim. Imitating the early 5-level needs, he defined the hierarchy of rewards from low to high as:

- Rewarding Player Experience: Good gameplay and immersion of game itself
- Core and Long Term Rewards: Essential rewards that players will keep forever
- Major and Mid Term Rewards: Periodic rewards that have staged benefits
- Short Term and Minor Rewards: Trivial rewards that constitute major rewards
- Cosmetic Rewards: Virtual rewards that do not affect game progress

From my personal perspective, though Chelsey used the games like World of Warcraft as examples to explain his idea, his understanding of Maslow’s model itself might be skewed. First and foremost, as for an article published in 2013, he did not use Maslow’s 1970 update, the 8-level needs, as his theoretical basis. Even Maslow himself mentioned that the 5-level needs are incomplete, especially lacks the description of individual curiosity. Second, the individual needs and the reward system design are different in nature. That is, the latter is from the developer’s perspective, while the former is from the experiencer’s perspective. More generally, developers could arrange the different types of rewards they want to design in order of importance. However, such importance could not be directly understood by the experiencer, whose needs are determined by the current stage of their life or game progression. Third, his explanation of the last reward level, like “they are purely cosmetic, serving only as a visual measure of the player’s progress”, might be too vague. This prevents developers from using his models in real work.

#### **4.3.2 Self-actualization in Game design**

Based on [70], Chelsea argued that Maslow's ideas of peak experience and self-actualization has already been used in interactive media development. To do this, some designer took Maslow's 15 characteristics (as mentioned above) of self-actualization as the optimistic factors in software development. For example, the "truthful and honest" could be met in terms of setting the reasonable prices of in-game items and temperately inserting the advertisements. The "beautiful and meaningful" could be met by designing beautiful game scenes and compelling story lines. Besides, as for the peak experiences, game designer should adding more functions to help players find and achieve the highest accomplishment. This can be done by developing the training systems of level and equipment, or adding achievement and trophies like What the platform of Playstation is doing.

#### **4.3.3 In-game Explanations of Maslow's Needs**

Mapping Maslow's model to the game domain is a complex but meaningful task. According to Graham's research [71], he combined Maslow's 5-level needs with Marczewski's gamification user types theory [72], which is used to describe 6 player types and their particular motivations to play games:

- Socialisers: A strong willingness to find and create social connections in any circumstances and taking this as motivation when playing games.
- Free Spirits: Instead of following the rules, they are constantly looking for ways to break through them. Driven by creation and exploration.
- Achievers: Motivated by challenges and the rewards of overcoming them. Always looking to learn new things to improve their ability.
- Philanthropists: Usually in the center of other player types. They take pleasure in helping other players, and have no expectation of reward.
- Players: The most common players, who are playing for themselves, are more interested in learning and using the rules of the game.
- Disruptors: Unlike free Spirits, they delight in ruining the game experience for of players or destroying the game system.

Graham mentioned that a common trait of such two theory is the individual might have more than one player type or hierarchical need. However, they differ in that Maslow believes that the individual's environment determines the dominant needs, while Marczewski suggests

that players' motivation is more dominated by the individual's personality. The evidences support him is a same individual is more likely to show similar player types in different games. Based on these, we conclude Graham's mapping of the 5-level needs as:

- Physiological needs

On the face of it, in-game behavior could not change physiological needs. But Graham believes that game developers could change scarcity and ownership to engage players' primitive desires. The scarcity can be interpreted as an artificially limitation of in-game resources to delay the short-term satisfactions and stimulate long-term desires. This approach is widely used in Japanese mobile CCGs like FGO or Onmyoji. Because mobile game development tends to take up players' trivial time, to extend the game's lasting shelf life, designers attempt to used the concept of "Game stamina" to limit players' daily playing time to stabilize the future DAU. In terms of marketing strategy, this approach could also stimulate consumption by allowing players to buy more "Game Stamina". And the ownership can be interpreted as the in-game resources that players accumulate over time. Such Resources will become more tangible and more cherished by the players as time costs increase. A good example is the virtual gold in World of Warcraft.

- Security needs

Superficially, safety needs also have noting to do with video games. But developers could keep players on their toes by designing systems that may cause the loss of in-game resources such as ranking, point, or gold. One can take the ranking systems of League of Legends(LOL) and Hearthstone as examples. Graham also suggested that the "disruptors" disrupt other players' experience mainly by interfering with their security needs.

- Belongingness needs

At this level of need, players are more eager to reap some social experience than basic game elements. "Socialisers" are thus most likely to be attracted to the games included the in-game elements of social needs. Such elements include forums, chat-rooms, competitions, clans, groups, and ranking list. For instance, many MMO Games build great social systems such as the team system of DOTA, and the guild system of World of Warcraft(WOW).

- Esteem needs

In Maslow's model, esteem needs must satisfy two behaviors, the process of striving for achievement and the process of striving to be respected by others, which also apply

to the video game. The former could be represented by difficulty design and the latter could be shown as player ranking list. More general, gameplay difficulty needs to be controlled in a proper range. If the achievement is considered too easy to obtain, it will not act as an incentive. On the other hand, the overwhelming difficulty will leave players frustrated. From this point of view, Diablo's difficulty design solves this problem, which allows players of different levels to choose the difficulty that suits them and then get rewards accordingly. After combining with the ranking system, the esteem needs of all the players will be met. Graham also mentioned that the needs of gamers who are "Players" will be met at this level. Since the rewards and achievements they receive continue to motivate them and are directly linked to respect.

- Self-Actualisation:

In this level, Graham applied the concept of [66], as we mentioned above, to divided self-Actualisation needs into purpose, autonomy, and mastery. Graham believed that "Philanthropist" are the most common players desired such needs, deriving by their altruistic nature, they are more likely to perform roles of mentor and sponsor.

1. Purpose needs

In this level, players are playing for more than the game itself. Instilling the sense of purpose and reality in players is a higher-order game design task. Some popular RPG games, such as Final Fantasy, achieve this by designing attractive scenarios and tutorials.

2. Autonomy needs

We can intuitively connect autonomy needs with the "free spirit" players, who are willing to keep exploring and innovating. From a game developer's perspective, the trick to meeting the needs of this type of player is to avoid a linear development model. More detailed, one can design complex branches of the talent tree to increase the skill combinations that players could select just like what Xenoblade done. Some better examples are sandbox games such as Grand Theft Auto, and Saints Row. In such games, what the players want to do is often more important than the rules themselves.

3. Mastery needs

Mastery needs are the favourite of the "achiever" players, who is derived by obtaining more achievements both from personal and social reasons. As for game itself, the key to achieving this level of needs is the use of feedback. This feedback must be clearly received by the player to tell them that they are indeed making progress, and they are taking another step towards the master. This could be demonstrated by the achievement system of WOW.

# **Chapter 5: Methodology: Developing a Hybrid Questionnaire of Video Game Classification**

Our goal is to develop a classification system, combined with GX and HONs, to rationally classify video games. So, we first need to find the connection between these two theories. In the section of measuring GX, we summarized the mainstream questionnaires. Among these, the GUESS is the best choice for us to refer, because it is the latest method that incorporated almost all previous factors and questionnaires. According to the GUESS [49], Mikki H. Phan suggests 55 items from 9 factors to measure GX, including usability, narratives, play engrossment, enjoyment, creative freedom, audio aesthetics, personal gratification, social connectivity, and visual aesthetics. In this section, we reused them as one of the benchmarks for our classification model.

The other benchmark derives from the models of HONs. In the last section, we have discussed the previous implementations of HONs in video games. Such implementations gave us clues and methods to describe HONs in GX. However, there is one thing we have to make sure before starting developing the model. No matter the earliest 5-level HONs, or modern 8-level model, and the 10-level model whose self-actualization needs is extended, the most controversial problem is if the "hierarchy order" emphasized by Maslow exists or nor. This problem directly determines whether our model is terraced or parallel. From my perspective, the concept of "order" is indeed contradicted by some phenomena. For example, some workers who lead a miserable life still put their hard-earned money into games, even if this behavior consumes their safety needs. In the game world, they may obtain social needs or even self-actualization needs, even if these are not real. Therefore, needs do not necessarily get in an "order" under certain circumstances.

Furthermore, the "order" seems even fuzzier if we only consider the players' needs in video games. This is mentioned in Graham's research [71], mapping HONs to GX of different types of players, emphasizing that an individual is likely to contain multiple player types or meet multiple random needs. As a result, in our research, we only refer to the hierarchy of needs, and the "order" will not be considered. We selected the most comprehensive 10-level model, including Physiological needs, Security needs, Belongingness needs, Esteem needs, Cognitive needs, Aesthetic needs, self-actualization (Purposeneeds, Autonomy needs, Master needs) and Transcendence needs, as the second benchmark.

## **5.1 Factor Engineering**

In section, combined with the above two theories, we focus on how these elements form relationships with each other to implement a hybrid GX+HONs model to describe the needs in video game experience. To sort such relationships more clearly, we use ten levels of HONs

to categorize them. All of these connections could be found in Figure 1.

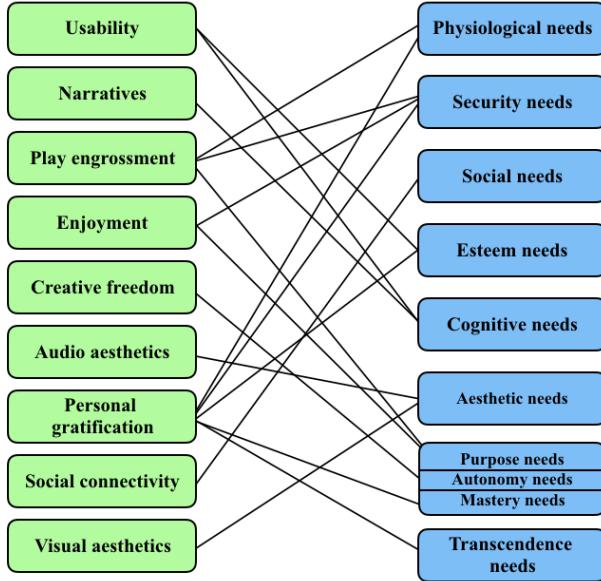


Figure 1: The relationships between the GUESS questionnaire and 10-level hierarchy of needs.

- Physiological needs (PNs):

Play engrossment: As we mentioned above, designers can limit in-game resources' acquisition speed to artificially create simulation scarcities and ownership to increase players' engagement and hunger. This method meets the definition of Play engrossment in GUESS, which defines the Play engrossment is related to the primary in-game resources, such as the restricted daily physical, the times of challenges for the levels, and the maximum amount of currency that could be obtained each day.

- Security needs (SNs):

Enjoyment: Designers can also create SNs through punishment systems, such as losing currency in failure or death, lowering rankings, and enduring a longer resurrection time. Most players get enjoyment as they protect their resources, while the 'disruptor' players gain enjoyment as destroying others' game experience. A most representative example is the PlayerUnknown's Battlegrounds (PUBG), in which a player would obtain enjoyment because of survival and killing other players (destroying others' game experience) in the simulated battlefield.

- Belongingness needs (BNs):

Social connectivity: One can easily take this connection literally. Social systems have become the must-have function for almost any multiplayer online game, which can be achieved through chat interfaces, private letters, or even an open gaming worldview. It is worth noting that such a function's appetite has exploded in recent years, especially in politically stable Asian countries, in which players there must face more pressure to study, work, or survive in the real world. These pressures force them to seek solace in virtual worlds, where they can take off their real-life masks and indulge to a certain extent. In this case, the social interaction system could help them find their favorite communities in the virtual world to get belongingness.

- Esteem needs (ENs):

Usability: Based on Graham, the appropriate design of operation difficulty degree combines with suitable rewards could improve the players' ENs. Since only when both of these conditions are met, players will believe their efforts are worth it. Diablo 3's difficulty selection system is an excellent example of it.

Personal gratification: This can be understood as a way for players to understand their growth process in games through an achievement system or leader board to inspire their satisfaction.

- Cognitive needs (CNs):

Usability: This describes the process from a novice to a skilled player. From the developer's perspective, this experience mainly includes the learning cost of the game and the maximum complexity of the gameplay. The former represents the popularizing rate, and the latter represents the efforts players paid from ordinary players to master players.

Narratives: Such needs are mainly reflected in the narrative of a game, including a clear story background, attractive personalities of characters, and a gripping story line that can improve players' engagement.

- Aesthetics needs (ANs):

Audio aesthetics: No one can deny the impact of game audio on game quality. For example, sound effects during battles inspire user engagement, appropriate background music paints a better picture of the game, original music of anime or movies may excite fan players, and players of Japanese card games are infatuated with the game characters voiced by their favorite actors.

Visual aesthetics: The needs for gaming visuals are very similar to audio. In commercial games, especially mobile games, it is almost the most critical factor of success. Game developers call it the power of intellectual property (IP). Games with similar gameplay and systems can generate vastly different benefits only because of the different images and characters. Some countries have introduced IP protection policies, making it difficult for small companies to exploit interests from well-known IPs, such as Pokemon and Warcraft. These examples do prove the existence of these needs.

- Self-actualization Purpose needs (SPNs):

Play engrossment: These needs can be expressed through game rewards, narratives, and tutorials, stimulating the player's sense of mission and thus increasing their attention and interest.

Enjoyment: Based on Graham, SPNs can also be met through special events in the game, such as festivals in World of Warcraft. By participating in such festivals, players can obtain rare items and gain in-game resources with high efficiency. This enables them to get more enjoyment than regular playtime.

- Self-actualization Autonomy needs (SANs):

Creative freedom: Therefore, the selection of talent tree and skill collocation, giving gamers the freedom of choice, are more classified into enjoyment.

- Self-actualization Mastery needs (SMNs):

Personal gratification: This connection is explained by the player's action to realize his self-worth by becoming elite within the game. These behaviors include pursuing the most robust equipment, improving the leaderboard's ranking, improving the overall winning rate, and successfully developing their original strategy.

- Transcendence needs (TNs):

Personal gratification: This link can be explained by players' behavior to achieve their self-worth by instructing and helping other players grow in the game. Although TNs are not mentioned in Graham's model, they can be achieved in specific games from my perspective. Such games may have a sound social interaction system and a significant player community, which can help master players who have realized self-actualization needs to communicate with new players and then guide them to realize their self-actualization needs. In World of Warcraft, for example, guild leaders may nurture new players. According to Maslow's theory, master players with such behaviors could be defined as pursuing the TNs.

## 5.2 Item Engineering

After obtaining the potential factors from the GUESS and Graham's HONs model, we next further attempt to extract the candidate items from these theories. As for the factor that we could not find clues about it, we first figured out the items based on our experience, and the validity of all items were than tested by statistical techniques.

The all 47 items and their information are shown in Table1. In this study, the items were assessed on a 7-point scale as "0" for "strongly disagree", "1" for "disagree", "2" for "somewhat disagree", "3" for "neither agree nor disagree", "4" for "somewhat agree", "5" for "agree", and "6" for "strongly agree". The content quality of this questionnaire was first proven by **Qualtrics**, which is an official survey development website. It gave us a "Great" level judgement and suggested that our questionnaire may take up 9.1 minutes of subjects. This link <sup>2</sup> connects to the website edition of it. There 10 factors of HONs and 9 factors of GUESS with 14 combinations are involved in this research. In other words, our GX+HONs questionnaire could be considered as a 10-factor or 14-factor survey. Therefore, in the next chapter we will focus on how to select the best number of factor to represent the overall items and the validly of these factors and items to seek if the GX+HONs could generally describe the features of video games.

Needs	Game Experience	Source	Items
Physiological	Play engrossment	Original	This game limits some of the players' daily activities.
Physiological	Play engrossment	Original	This game limits the players' speed or methods of collecting in-game resources.
Physiological	Play engrossment	Graham	The game makes the player to treasure the in-game possessions they have accumulated over time.
Security	Enjoyment	Graham	This game allows players to disrupt (negative) the gaming experience of other players.
Security	Enjoyment	Original	This game may deduct players' points or ranking for their "failure" or "death".
Security	Enjoyment	Graham	This game allows the punishment of players' in-game resource or items for their "failure" or "death".
Belongingness	Social connectivity	GUESS	This game encourages social interaction between players.
Belongingness	Social connectivity	GUESS	This game has a very well designed social interaction system.
Belongingness	Social connectivity	GUESS	This game gives the right to choose whether to play with other players.
Belongingness	Social connectivity	GUESS	It's fun to play with other players in this game.
Esteem	Usability	GUESS	Players feel confident while playing this game.
Esteem	Usability	Graham	Players feel the effort to improve their game skills matches the rewards.
Esteem	Personal gratification	Graham	This game has a well-made achievement system.

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<sup>2</sup>[https://qfreeaccountssjc1.az1.qualtrics.com/jfe/preview/SV\\_e0LMuZ0pPnu2w9n?Q\\_SurveyVersionID=current&Q\\_CHL=preview](https://qfreeaccountssjc1.az1.qualtrics.com/jfe/preview/SV_e0LMuZ0pPnu2w9n?Q_SurveyVersionID=current&Q_CHL=preview)

Esteem	Personal gratification	Original	This game has a well-made ranking system.
Esteem	Personal gratification	Original	Players' "achievements" or "victories" are well represented by the visual and audio of this game.
Esteem	Personal gratification	GUESS	Players' "achievements" or "victories" are well represented to them and other players.
Cognitive	Usability	GUESS	It is easy to understand how to play this game.
Cognitive	Usability	GUESS	It is easy to learn the controls of this game.
Cognitive	Usability	GUESS	This game has clear goals and objectives.
Cognitive	Usability	GUESS	This game's interface is easy to navigate.
Cognitive	Usability	GUESS	This game has a well-made tutorial to train players how to play.
Cognitive	Usability	GUESS	This game always tell players next goal when they finish an event.
Cognitive	Usability	GUESS	This game offers the clear information to finish events.
Cognitive	Narratives	GUESS	This game's story can be clearly understand.
Cognitive	Narratives	GUESS	This game has a captivated story line.
Cognitive	Narratives	GUESS	This game has personalized avatars.
Cognitive	Narratives	GUESS	This game's events can move players' emotions.
Aesthetics	Audio aesthetics	GUESS	This game has well-made sound effects.
Aesthetics	Audio aesthetics	GUESS	This game has well-made background musics.
Aesthetics	Audio aesthetics	GUESS	This game's audio improves the gaming experience.
Aesthetics	Audio aesthetics	GUESS	This game's audio is suitable for its atmosphere and style.
Aesthetics	Visual aesthetics	GUESS	This game has well-made graphics.
Aesthetics	Visual aesthetics	GUESS	This game's graphics is suitable for its atmosphere and style.
Aesthetics	Visual aesthetics	GUESS	This game is visually appealing.
Purpose	Play engrossment	Original	This game's narrative or tutorial give players a sense of purpose.
Purpose	Play engrossment	Original	This game's rewards give players a sense of purpose.
Purpose	Enjoyment	Graham	This game often hold special festivals or events to give players extra rewards.
Mastery	Personal gratification	GUESS	This game constantly motivates players to proceed further to the next stage or level.
Mastery	Personal gratification	GUESS	This game constantly motivates players to improve their skills.
Autonomy	Creative freedom	GUESS	This game allows players to be imaginative.
Autonomy	Creative freedom	GUESS	Players feel creative when play this game.
Autonomy	Creative freedom	GUESS	This game gives players enough freedom to do what they want.
Autonomy	Creative freedom	GUESS	This game gives players the right to express themselves.
Autonomy	Creative freedom	GUESS	This game gives players the right to explore this gaming world.
Autonomy	Creative freedom	GUESS	Players feel their curiosities are aroused when play this game.
Transcendence	Personal gratification	Original	This game encourage players to instruct other players in their skills or strategies.
Transcendence	Personal gratification	Original	This game encourage players to donate their in-game resources or items to other players.

Table 1: Factors of hierarchy of needs and game experience, and sources of 47 items [49, 71]

# Chapter 6: Model Validation: Statistical Analysis

## 6.1 Conducting Survey

From July 15, 2020, to Aug 2, 2020, we conducted the GX+HONs questionnaire among 5 game researchers from G-scale lab and 25 junior game designers (68% male), age between 21 and 25 (Mean=23.2, SD=1.34) from Shanghai Giant Network. All subjects indicated willingness to participate in the survey and read the related content before taking the survey.

	Genre (or Subgenre) A	Genre (or Subgenre) B	Platform
Grand Theft Auto V	Action-adventure	-	PS, Xbox, Windows
The Legend of Zelda: Breath of the Wild	Action-adventure	-	Wii, Switch
Monster Hunter World	Action	Role-Playing	PS, Xbox, Windows
DOOM	Action	First Perspective Shooter*	PS, Xbox, Windows, Switch
Witcher 3	Action	Role-Playing	PS, Xbox, Windows, Switch
World of Warcraft Classic	Role-Playing	Massively Multiplayer Online	MacOS, Windows
Octopath Traveler	Role-Playing	Turn-Based*	Windows, Switch, Stadia
Fate/Grand Order	Role-Playing	Turn-Based*	Android, iOS, Arcade
Pokemon Sword and Shield	Role-Playing		Switch
The Sim 4	Simulation	Life Simulation*	PS, Xbox, MacOS, Windows
Animal Crossing	Simulation	Social Simulation*	Switch
Coming out on top	Simulation	Dating Simulation*	Linux, MacOS, Windows
NBA 2K20	Sports	Simulation	PS, Xbox, Windows, Switch
Mario Tennis Aces	Sports	-	Switch
Mario & Sonic at the Olympic Games Tokyo 2020	Sports	-	Switch
Taiko no Tatsujin: Drum 'n' Fun!	Music	-	Switch
Just Dance 2020	Music	-	PS, Wii, Switch, Stadia
Mario Party	Party	-	Switch
Hearthstone	Digital Collectible Card	-	Android, iOS, MacOS, Windows
Pokemon TCG Online	Digital Collectible Card	Role-Playing	Android, iOS, MacOS, Windows
Yu-Gi-Oh! Duel Links	Digital Collectible Card	Strategy game	Android, iOS, Windows
League of Legends	Multiplayer Online Battle Arena*	-	MacOS, Windows
Brawl Stars	Multiplayer Online Battle Arena*		Android, iOS
Clash Royale	Real-time Strategy*	Digital Collectible Card	Android, iOS
Pokémon Go	Augmented Reality	Pervasive*	Android, iOS
PlayerUnknown's Battlegrounds	Battle Royale	-	PS, Xbox, MacOS, Windows
Mario Kart 8	Kart Racing*	-	Wii, Switch
Real Racing 3	Racing*		Android, iOS

Figure 2: Genres and platforms of 28 video games where \* represent the sub genre.

The survey is consisted with 2 parts, and the first part was conducted in G-scale lab, based on different game genres and the popularity, researchers first selected 28 representative or research-worthy games as shown in Figure 2. Then each researcher was asked to complete the questionnaire comparing the games they were familiar with. After a preliminary analysis, we believed that the results of these games were diverse enough to support our next investigation.

In the next part, 25 game designers were first asked to pick up 9 games they were familiar with from these 28 games. Since almost all of these games are very popular, they all did not choose less than 9 games. Therefore, we finally got 247 samples of GX+HONs questionnaire, which is then need to be analyzed by statistical methods to prove validity of it.

### 6.1.1 Exploratory Factor Analysis

Although part of GX+HONs derives from the GUESS, Exploratory Factor Analysis (EFA) still needs to be introduced to verify the rationality of the quality and quantity of factors. The verification process can be divided into three parts. First of all, we need to check whether EFA could be used in our questionnaire. Secondly, we need to investigate whether our hypothetical factor number is feasible. Finally, we need to determine the correspondence between each factor and item.

For the first task, based on [73], when the proportion of the number of items and the sample size is greater than 1:5, EFA can be used. As we have 247 data points and 47 items in this study, we then introduced the Kaiser-Meyer-Olkin(KMO) and Bartlett's Test of Sphericity to further verify our model. According to Hutcheson, G.D [74], KMO greater than 0.6 and Chi-Square less than 0.05 could be regarded as the criteria to conduct EFA. As shown in Figure 3, KMO is greater than 0.6, which meets the prerequisite requirements of factor analysis, indicating that the data can be used for factor analysis research. Besides, the Bartlett sphericity test ( $P < 0.05$ ) also indicated the feasibility of the analysis.

KMO		0.717
The Bartlett's test of sphericity	Approx. Chi-Square	21923.515
	df	1081
	Sig.	0.000

Figure 3: Kaiser-Meyer-Olkin(KMO) and Bartlett's Test of Sphericity of 47-item questionnaire.

For the second part, we introduced the Total Variance Explained [75], used to describe the initial solution, extracted components, and rotated components to try to reduce the complexity of the questionnaire by defining the number of factors.

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	10.425	22.18	22.18	10.425	22.18	22.18	6.838	14.549	14.549
2	6.717	14.291	36.471	6.717	14.291	36.471	5.214	11.093	25.642
3	4.744	10.093	46.564	4.744	10.093	46.564	4.744	10.094	35.736
4	3.583	7.623	54.187	3.583	7.623	54.187	4.279	9.104	44.839
5	3.155	6.712	60.899	3.155	6.712	60.899	3.449	7.338	52.178
6	2.585	5.501	66.399	2.585	5.501	66.399	3.294	7.008	59.185
7	2.355	5.011	71.41	2.355	5.011	71.41	3.236	6.886	66.071
8	2.081	4.428	75.838	2.081	4.428	75.838	2.862	6.089	72.16
9	1.603	3.41	79.248	1.603	3.41	79.248	2.312	4.919	77.078
10	1.139	2.423	81.671	1.139	2.423	81.671	2.158	4.592	81.671
11	1.107	2.356	84.027	-	-	-	-	-	-
12	0.996	2.12	86.147	-	-	-	-	-	-
13	0.888	1.89	88.037	-	-	-	-	-	-
14	0.76	1.616	89.653	-	-	-	-	-	-
15	0.666	1.417	91.071	-	-	-	-	-	-
16	0.596	1.268	92.339	-	-	-	-	-	-
17	0.52	1.107	93.446	-	-	-	-	-	-
18	0.44	0.935	94.381	-	-	-	-	-	-

Figure 4: Total Variance Explained of 47-item questionnaire.

As shown in Figure 4, the Total column represents the eigenvalue of each factor which measures the contribution of each factor before rotation. The sum of this value matches the number of items, and the greater the value, the greater the factor contribution. The Variance column represents the ratio of the variance of each component in percentage terms to the total variance of all variables. The Cumulative column represents the percentage of variance of the components corresponding to the number of factors. In this research, we have three schemes to determine the number of factors, which are 8, 10, and 14. The first one derives from the basic levels of HONs include Physiological needs, Security needs, Belongingness needs, Esteem needs, Cognitive needs, Aesthetic needs, Self-Actualization, and Transcendence needs. Based on this, the second one derives from separating Self-actualization into

Purpose needs, Autonomy needs, and Master Needs. The last one derives from the connections between GUESS and HONs as show in Figure 1. From Figure 4 one can see that if we set the factor number as 8, after the rotation, less than 73 percent of the information will be expressed. So, 8 factors are not enough to convey our measurement information. We finally chose 10 as the number of factors, because 10 features could convey more than 80 percent of the information which was not significantly different from 14 factors' (eigenvalue is less than 1), and could also reduce the complexity of our questionnaire.

We also introduced Scree plot to visually help us explain our choose. As shown in Figure 5, one could find a significant change in the slope between 10 and 11, so it makes sense to choose 10 as the number of factors.

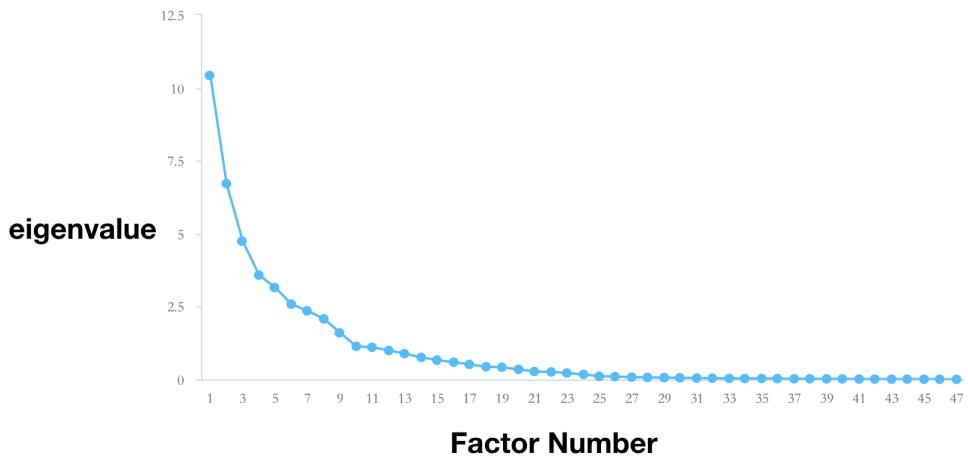


Figure 5: Scree plot of 47-item questionnaire.

We next focus on exploring if our items are enough to measure the corresponding factors. To do this, we introduced reliability research based on the coefficient of Cronbach' alpha [76] of each factor as shown in Figure 6 to Figure 15. In theory, there are three optimization criteria that we need to follow. First, as for the Cronbach' alpha, if it is between 0.7 and 0.8, then reliability is good. If it is between 0.6 and 0.7, then reliability is acceptable. If it is less than 0.6, then reliability is poor and the item may need modification. If it is less than 0.5, the reliability is unacceptable and items need to be optimized. Second, if the correlation of correction items is below 0.3, we could consider deleting the corresponding item. Third, if the Cronbach' alpha after deleting this item is significantly higher than the Cronbach' alpha, we could also discard the corresponding item. Based on all these criteria, we found that there are 3 factors that need to be optimized, which are factor 2, 4, and 7. So, we need to fix these factors.

In factor 2, since the third item did not have any positive effect on this factor, we just discard it and then got the new analysis as shown in Figure 16, which finally met the criteria. In factor 4, we chose to discard the fourth and the fifth item since their correlation is less than 0.3. The revised result is shown in Figure 17. Although, the Cronbach alpha is still close to 0.6 and the correlation of the fourth item is still close to 0.3, considering the information we want to measure, we finally chose to keep all of these item. We made the same choice in factor 7, whose third item is much valuable for us, so we kept it. Because we believe this problem may come from sample itself but not our questionnaire. After the EFA, we got a 44-item questionnaire.

Item	Mean	SD	correlation of correction items	Cronbach $\alpha$ after deleting this item	Cronbach $\alpha$
F1:This game limits some of the players' daily in-game activities.	2.16	1.99	0.497	0.649	0.703
F1:This game limits players' speed or methods of collecting in-game resources.	3.52	1.86	0.647	0.442	
F1:The game makes players to treasure the in-game possessions they have accumulated over time.	3.56	1.65	0.435	0.71	

Figure 6: Coefficient of Cronbach' alpha test of Factor Physiological needs.

Item	Mean	SD	correlation of correction items	Cronbach $\alpha$ after deleting this item	Cronbach $\alpha$
F2:This game allows players to disrupt the gaming experience of other players.	2.28	1.97	0.469	-0.18	0.409
F2:This game may deduct players' points or ranking for their "failure" or "death".	2.56	2.37	0.524	-0.412	
F2:This game allows the punishment of players' in-game resource or items for their "failure" or "death".	1.12	1.73	-0.14	0.809	

Figure 7: Coefficient of Cronbach' alpha test of Factor Security needs.

Item	Mean	SD	correlation of correction items	Cronbach $\alpha$ after deleting this item	Cronbach $\alpha$
F3:This game encourages social interaction between players.	3.64	2	0.467	0.552	0.703
F3:This game has a very well-made social interaction system.	2.72	1.89	0.435	0.638	
F3:This game gives the right to choose whether to play with other players.	2.44	2.14	0.215	0.732	
F3:It's fun to play with other players in this game.	3.56	2.06	0.771	0.308	

Figure 8: Coefficient of Cronbach' alpha test of Factor Belongingness needs.

Item	Mean	SD	correlation of correction items	Cronbach $\alpha$ after deleting this item	Cronbach $\alpha$
F4:Players feel confident while playing this game.	3.2	1.13	0.3	0.345	0.429
F4:Players feel the effort to improve their game skills matches the rewards they should get.	3.76	1.11	0.409	0.289	
F4:This game has a well-made achievement system.	2.8	1.72	0.306	0.316	
F4:This game has a well-made ranking system.	1.88	2.07	0.059	0.497	
F4:Players' "achievements" or "victories" are well represented by the visual and audio of this game.	3.8	1.1	0.046	0.461	
F4:Players' "achievements" or "victories" are well represented to them and other players.	3.4	1.7	0.223	0.376	

Figure 9: Coefficient of Cronbach' alpha test of Factor Esteem needs.

Item	Mean	SD	correlation of correction items	Cronbach $\alpha$ after deleting this item	Cronbach $\alpha$
F5:It is easy to understand how to play this game.	3.44	1.98	0.387	0.868	0.866
F5:It is easy to learn the controls of this game.	3.68	1.8	0.408	0.865	
F5:This game has clear goals and objectives.	4.04	1.4	0.403	0.864	
F5:This game's interface is easy to navigate.	3.56	1.39	0.664	0.85	
F5:This game has a well-made tutorial to train players how to play.	3.12	1.82	0.684	0.846	
F5:his game always tell players next goal when they finish an event.	3.12	1.37	0.562	0.856	
F5:This game offers the clear information to finish events.	3.88	1.11	0.515	0.859	
F5:This game's background story can be clearly understand.	2.76	2.25	0.71	0.842	
F5:This game has a captivated storyline.	2.36	2.3	0.696	0.844	
F5:This game has personalized avatars.	2.56	2.45	0.563	0.855	
F5:This game's events can move players' emotions.	2.44	2.19	0.688	0.844	

Figure 10: Coefficient of Cronbach' alpha test of Factor Cognitive needs.

Item	Mean	SD	correlation of correction items	Cronbach $\alpha$ after deleting this item	Cronbach $\alpha$
F6:This game has well-made sound effects.	3.88	1.42	0.571	0.862	0.869
F6:This game has well-made background musics.	3.64	1.35	0.682	0.846	
F6:This game's audio improves the gaming experience.	3.88	1.68	0.59	0.861	
F6:This game's audio is suitable for its atmosphere and style.	4.2	1.26	0.578	0.859	
F6:This game has well-made graphics.	4.08	1.32	0.693	0.845	
F6:The game is visually appealing.	4.28	1.11	0.688	0.848	
F6:This game's graphics is suitable for its atmosphere and style.	4.28	41 1.31	0.767	0.835	

Figure 11: Coefficient of Cronbach' alpha test of Factor Aesthetics needs.

Item	Mean	SD	correlation of correction items	Cronbach $\alpha$ after deleting this item	Cronbach $\alpha$
F7:This game's narrative or tutorial give players a sense of purpose.	3.08	1.81	0.306	0.265	0.432
F7:This game's rewards give players a sense of purpose.	3.48	1.42	0.339	0.214	
F7:This game often hold special festivals or events to give players extra rewards.	2.12	2.37	0.17	0.551	

Figure 12: Coefficient of Cronbach' alpha test of Purpose Physiological needs.

Item	Mean	SD	correlation of correction items	Cronbach $\alpha$ after deleting this item	Cronbach $\alpha$
F8:This game constantly motivates players to proceed further to the next stage or level.	3.92	1.72	0.597	-	0.746
F8:This game constantly motivates players to improve their skills.	3.72	1.91	0.597	-	

Figure 13: Coefficient of Cronbach' alpha test of Mastery Physiological needs.

Item	Mean	SD	correlation of correction items	Cronbach $\alpha$ after deleting this item	Cronbach $\alpha$
F10:This game encourage players to instruct other players in their skills or strategies.	2.56	2.14	0.438	-	0.609
F10:This game encourage players to donate their in-game resources or items to other players.	1.48	2.14	0.438	-	

Figure 14: Coefficient of Cronbach' alpha test of Transcendence Physiological needs.

Item	Mean	SD	correlation of correction items	Cronbach $\alpha$ after deleting this item	Cronbach $\alpha$
F9:This game encourages players to be imaginative.	2.96	1.78	0.517	0.862	0.86
F9:Players feel creative when play this game.	3.36	1.55	0.569	0.851	
F9:This game gives players enough freedom to do what they want.	3.04	1.64	0.737	0.822	
F9:This game gives players the right to express themselves.	2.8	1.77	0.72	0.824	
F9:This game gives players the right to explore this gaming world.	2.56	2.21	0.656	0.838	
F9:Players feel their curiosities are aroused when play this game.	3.2	1.72	0.744	0.821	

Figure 15: Coefficient of Cronbach' alpha test of Autonomy Physiological needs.

Item	Mean	SD	correlation of correction items	Cronbach $\alpha$ after deleting this item	Cronbach $\alpha$
F2:This game allows players to disrupt the gaming experience of other players.	2.28	1.97	0.683	-	0.809
F2:This game allows the punishment of players' in-game resource or items for their "failure" or "death".	2.56	2.37	0.683	-	

Figure 16: Revised Coefficient of Cronbach' alpha test of Factor Security needs.

Item	Mean	SD	correlation of correction items	Cronbach $\alpha$ after deleting this item	Cronbach $\alpha$
F4:Players feel confident while playing this game.	3.2	1.13	0.409	0.379	0.517
F4:Players feel the effort to improve their game skills matches the rewards they should get.	3.76	1.11	0.306	0.452	
F4:This game has a well-made achievement system.	2.8	1.72	0.351	0.406	
F4:Players' "achievements" or "victories" are well represented to them and other players.	3.4	1.7	0.215	0.541	

Figure 17: Revised Coefficient of Cronbach' alpha test of Factor Esteem needs.

### 6.1.2 Confirmatory Factor Analysis

We next focus on the section of Confirmatory Factor Analysis(CFA), which is usually conducted with 3 techniques, content validity, discriminant validity, convergent validity, and common method variance test. The first one was finished by Qualtrics which is an official questionnaire developing website. Our description of all items were judged to be intelligible and fluid. The Second one is to verify the independence of factors. And the third one works to measure if items under the corresponding factor could really describe the factor. In this research, our objective is to use the questionnaire, based on GUESS and modern HONs, to objectively classify video games, but not to measure the subjective player experience of each player. Therefore, as for the CFA, we did not conduct common method variance test, since we do not compare games by putting all the items together.

Factor Index	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10
AVE	0.574	0.879	0.628	0.468	0.546	0.851	0.49	0.57	0.541	0.576
CR	0.798	0.931	0.819	0.865	0.901	0.944	0.8	0.721	0.869	0.722

Figure 18: Average Variance Extracted(AVE) and Composite Reliability(CR) of 10 factors.

In the convergent validity test, we introduced Average Variance Extracted (AVE) and Composite Reliability(CR) as the parameters . The AVE is a statistic that verifies the internal consistency of structural variables, and the CR refers to the reliability of the composite score. In the first experiment, we found that the 10th and 11th items of Factor 5 would seriously affect the overall CR. So we discard them and got the result of 42 items as shown in the Figure 18. As the for the standard, generally, the convergent could be verified when AVE and CR are greater than 0.5 and 0.7 respectively. However, according to Fornell's research [77], for those cases that the AVE is less than and close to 0.5, if the CR is greater than 0.7, the convergent could also be proved. In our model, the AVE of factor 4 and 7 failed to get 0.5. This result is consistent with the conclusion we got from EFA before. To measure player satisfaction at each level of HONs, we kept the problematic items from esteem needs and purpose needs. We suggest that the lower AVE might be the quality of the dataset or the subjective nature of these two factors, which makes them difficult to measure. Anyway, the convergent of the entire questionnaire was still be proven.

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10
Factor 1	0.758									
Factor 2	0.275	0.938								
Factor 3	-0.006	0.412	0.792							
Factor 4	-0.454	-0.444	-0.164	0.684						
Factor 5	-0.091	-0.473	-0.356	0.417	0.739					
Factor 6	-0.305	-0.318	-0.12	0.589	0.404	0.922				
Factor 7	0.302	-0.233	-0.349	0.206	0.617	0.37	0.7			
Factor 8	0.254	0.137	0.01	0.297	0.433	0.393	0.674	0.755		
Factor 9	0.016	0.111	0.107	0.157	0.292	0.254	0.309	0.471	0.736	
Factor 10	0.215	0.511	0.663	-0.123	-0.16	-0.109	-0.02	0.338	0.372	0.759

Figure 19: Pearson's Correlation coefficient and square root AVE of 10 factors.

In the discriminant validity test, we used Pearson's Correlation coefficient(PCC) [78] and a comparison with square root AVE(SAVE)to verify the our questionnaire. The PCC is a technique to measure the association between two variables. In this case ,we use it to explore if there is any correlation between our factors. The Discriminant validity could be demonstrated if the SAVE of a factor is greater than all PCCs of that factor. The result is shown in Figure 19, where the blue cells represent the SAVE of each factor, the other cells represent the PCC. In theory, if PCC is more than 0.8, high correlation could be defined, which did not happen in our test. However, we have 3 PCC cells, the red ones, could be

defined as general correlation. Fortunately, all SAVEs are greater than the corresponding PCCs. In other words, though there are 3 correlation factors, the discriminant validity of our entire questionnaire still could be proven. For the deep reason about these 3 flaws, the problem of Factor 4(ENs) and Factor 7(SPNs) has been discussed above. The item of Factor 5(CNs)that has the greatest influence on the result is “This game has a well-made tutorial to train players how to play”. We suppose that it does has some meaning about the purpose needs, which could be refined by future works. Therefore, the final GX+HONs questionnaire after EFA and CFA is show in Table 2.

Factor	Items
Physiological	This game limits some of the players' daily activities.
Physiological	This game limits the players' speed or methods of collecting in-game resources.
Physiological	The game makes the player to treasure the in-game possessions they have accumulated over time.
Security	This game allows players to disrupt (negative) the gaming experience of other players.
Security	This game may deduct players' points or ranking for their “failure” or “death”.
Belongingness	This game encourages social interaction between players.
Belongingness	This game has a very well designed social interaction system.
Belongingness	This game gives the right to choose whether to play with other players.
Belongingness	It's fun to play with other players in this game.
Esteem	Players feel confident while playing this game.
Esteem	Players feel the effort to improve their game skills matches the rewards.
Esteem	This game has a well-made achievement system.
Esteem	Players’ “achievements” or “victories” are well represented to them and other players.
Cognitive	It is easy to understand how to play this game.
Cognitive	It is easy to learn the controls of this game.
Cognitive	This game has clear goals and objectives.
Cognitive	This game’s interface is easy to navigate.
Cognitive	This game has a well-made tutorial to train players how to play.
Cognitive	This game always tell players next goal when they finish an event.
Cognitive	This game offers the clear information to finish events.
Cognitive	This game’s story can be clearly understand.
Cognitive	This game has a captivated story line.
Aesthetics	This game has well-made sound effects.
Aesthetics	This game has well-made background musics.
Aesthetics	This game’s audio improves the gaming experience.
Aesthetics	This game’s audio is suitable for its atmosphere and style.
Aesthetics	This game has well-made graphics.
Aesthetics	This game’s graphics is suitable for its atmosphere and style.
Aesthetics	This game is visually appealing.
Purpose	This game’s narrative or tutorial give players a sense of purpose.
Purpose	This game’s rewards give players a sense of purpose.
Purpose	This game often hold special festivals or events to give players extra rewards.
Mastery	This game constantly motivates players to proceed further to the next stage or level.
Mastery	This game constantly motivates players to improve their skills.

Autonomy	This game allows players to be imaginative.
Autonomy	Players feel creative when play this game.
Autonomy	This game gives players enough freedom to do what they want.
Autonomy	This game gives players the right to express themselves.
Autonomy	This game gives players the right to explore this gaming world.
Autonomy	Players feel their curiosities are aroused when play this game.
Transcendence	This game encourage players to instruct other players in their skills or strategies.
Transcendence	This game encourage players to donate their in-game resources or items to other players.

Table 2: Final edition of 42-item GX+HONs questionnaire with 10 factors

## 6.2 Experiment and Results

We have completed the validation of the questionnaire, and then we will use the survey results to categorize the commercial video games and start the discussion about the comparison between our model and genres. In this research, we selected 28 video games, shown in Figure 2, with 21 different genres (or subgenres) across 10 platforms and we chose them from 4 perspectives.

- Some of them, like WOW and LOL are extremely popular and thus has a high research value.
- Some of them with the same genre but have extremely various play experience, such as the Sim 4 and Animal Crossing.
- Some of them have more than two genres(or subgenres), such as the Witcher 3 has been ever define as Action, Role-playing, and Adventure game.
- Some of them has a unique genre that was defined, such as Mario Party is defined as the Party game.

Besides, considering the drawbacks of the genre itself, we purposely chose the games that could enlarge the problem of genre. First, the game genre does not have a clear description or definition. For example, the GTA-V has the almost all in-game elements, described officially, of Action, Adventure, Racing, Simulation, Strategy game, however, it is judged as the Action-adventure game. What's more, when a game meets the definition of multiple genres at once, we have no genre priority to refer to. In other words, we use totally subjective judgment to define this kind of games. Second, new game technologies may create new game genre which might not be familiar to the public. This leads to confusion among players about a game with a unique genre. For instance, Pokemon Go is defined as an AR game as it combines the technology of mobile phone camera to develop game functions with AR elements. However, not only most players, but even IOS platform has not confirmed that it

is an AR game so far. This subjective deviation exists between the game developer and the user, which needs time to be accepted by the public. Third, some subgenres are so complex and indistinguishable that they could be merged. This makes the genre system even more bloated. Taking Simulation games as examples, the life simulation, social simulation, and dating simulation have a huge number of overlapping game elements, but are divided into three categories because of some small details. Based on these reasons, we finally selected these 28 games and explored if our GX-HONs questionnaire could relieve such problem. To do this, we grounded these game into 5 subset to conduct 5 comparison analysis and discuss the performance of our model.

- Group A

In the first group, we chose 5 video games that are defined as Action or Action-adventure game. Figure 20 presents the score of all items of these 5 games. As for Figure 21, the annulus represents the ratio of the percentage of each factor's total score to the sum of the percentage of all factors' total scores after normalization. And the center represents the ratio of total score to full score for each game and we extracted the three factors with the largest standard deviation, the SNs, PNs and TNs to use them in our subsequent analysis.

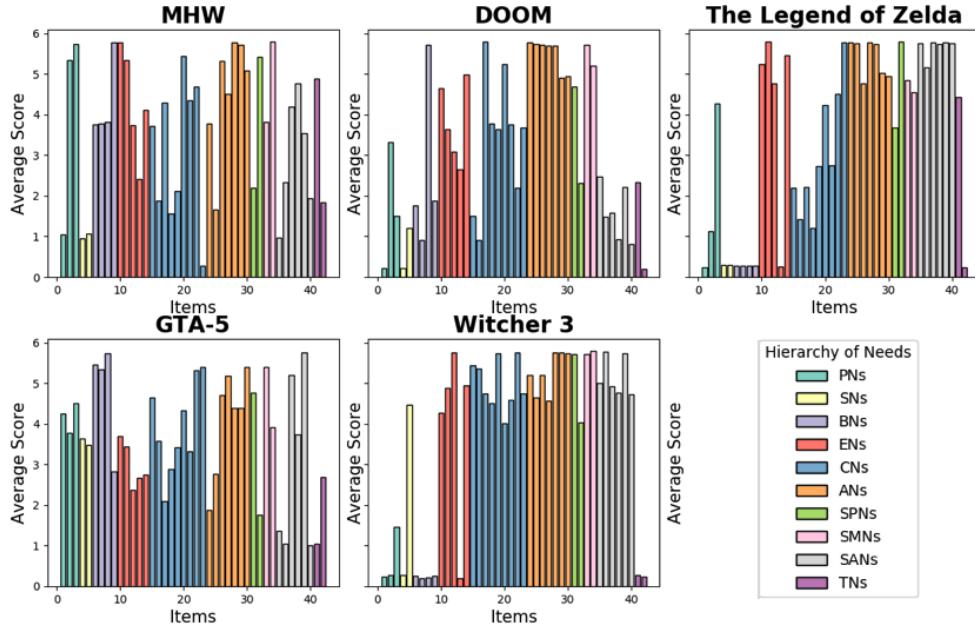


Figure 20: Scores of each item of the games in Group A

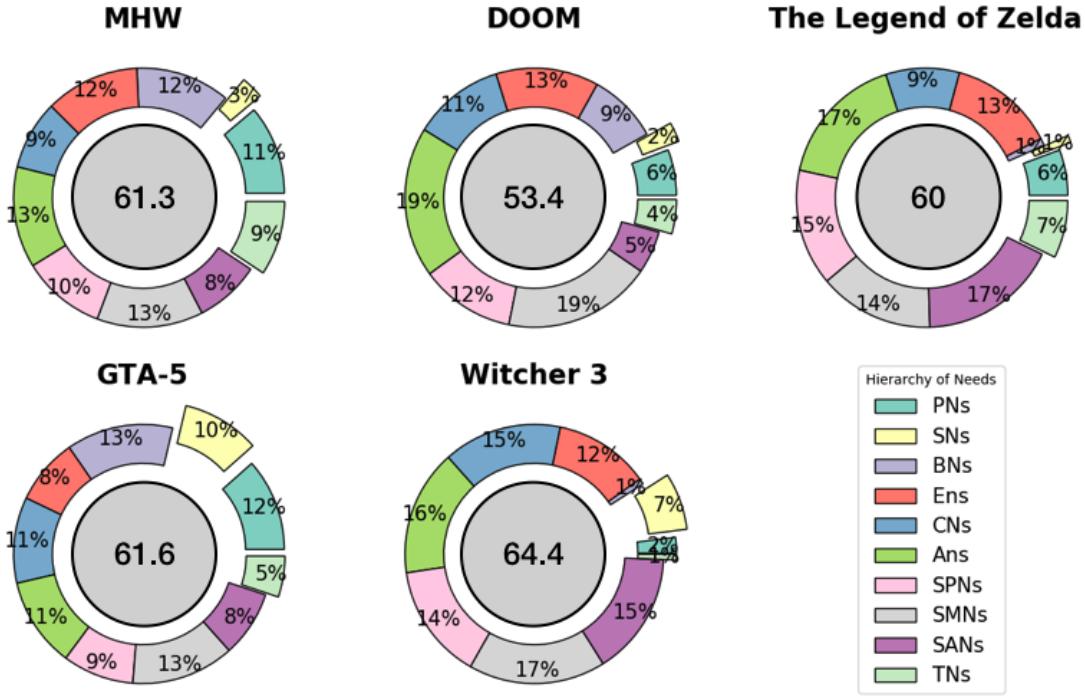


Figure 21: Percentages of each factor and overall scores of the games in Group A.

It's worth mentioning that the overall score in Figure 21 only represents the degrees of HONs levels, but not the quality or player experience of the game. Therefore, one can not simply use it to define which game is better. If the overall score is much high, it only describe this game has many elements developed in all levels of HONs. Taking Zelda as an example, which does not have any social interaction function or failure penalty. In our HONs model, it hardly get any score in SNs and BNs, however, that could not hinder it from being one of the best games of the last few years.

Based on the classification of genres, these games could be divided in 2 classes. The MHW, DOOM, and Witcher 3 are Action games, and the GTA-V and Wither 3 are Action-adventure games. But even the games that have the same genre play like two extremely different game.

In these 3 Action games, one can easily find that the DOOM and Zelda have similar in-game elements, which are markedly different from MHW's. More detailed, the main reasons can be summarized as the following points:

1. MHW has rich social interaction elements and functions to satisfy players' BNs. But these do not get much attention in DOOM, and Zelda does not even have a related function.
2. MHW sets many daily quests and limits the speed of collecting in-game resource to motivate players to log in daily. This strategy is widely used in MMO and mobile games to satisfy players' PNs. Although DOOM and Zelda do have some of these elements, they do not rely too much on these features to prevent users churn. Such difference is essentially caused by various ways of guiding players to consume. The MHW is a free-to-play (FTP), and the other are pay-to-play (PTP).
3. According to the TNs, based on the social interaction and group systems, the MHW supports skilled players to instruct novice players and carry them to challenge high level bosses to obtain better resources. However, these kind of needs could only be satisfied by ways out of the game, such as wiring game strategies or making puzzle-solving video.

As for the 2 Action-adventure games, they are also hugely different with each other in these aspects:

1. GTA-V supports multiplayer mode provided with social interaction elements to meet players' BNs. However, Witcher 3 only has single-player mode.
2. Witcher 3 does little to limit the speed of the player's game progress, so it hardly has any elements about PNs. However, GTA-V has daily quests and the corresponding reward to motivate players.
3. According to SANs, Witcher 3 gives players far more freedom than GTA-V.
4. Witcher 3 has more attractive storyline and avatars, and thus meets more CNs of players.
5. Witcher 3 provides players clear objectives to satisfy SPNs.
6. GTA-V encourages skilled players to donate in-game resources, and thus meets more TNs of players.

In summary, based on our model, although defined by different genres of games, MHW and GTA-V are more like the same kind of games, which develop in-game elements to satisfy the player's PNs, BNs, and TNs. Within other 3 games, the similarities between Witcher 3 and Zelda are also high. These could be represented by high autonomy they give to players and the abandonment of multiplayer mode. The case of DOOM is

complex and cannot be intuitively defined. Though it has multiplayer mode, it does not give as much autonomy as MHW and GTA-V and also does not meet much PNs of players. So we will discuss it with the help of machine learning to deeply analyze it.

- Group B

In the second group, we picked up 4 representative RPG games from PC, mobile, and console platform. The results are shown in Figure 22 and 23. WOW is the most famous MMORPG game in past twenty decays. FGO is one of the best-selling mobile games in Asian market. Octopath and Pokemon Sword and Shield are extremely popular on Switch platform in 2019. We also chose two games, PUBG and LOL, that had a large number of players in the same year. According to game genres, these games could be divided into 4 or 5 classes. The uncertain factor reflected in whether Pokemon Sword and Shield is defined as a Turn-base RPG or RPG game. The reason is turn -base elements are only a part of its gameplay. In addition to this, we have MMORPG, Turn-based RPG, MOBA, and Battle Royale. We will discuss each game separately and then came up with a summary based on the HONs model.

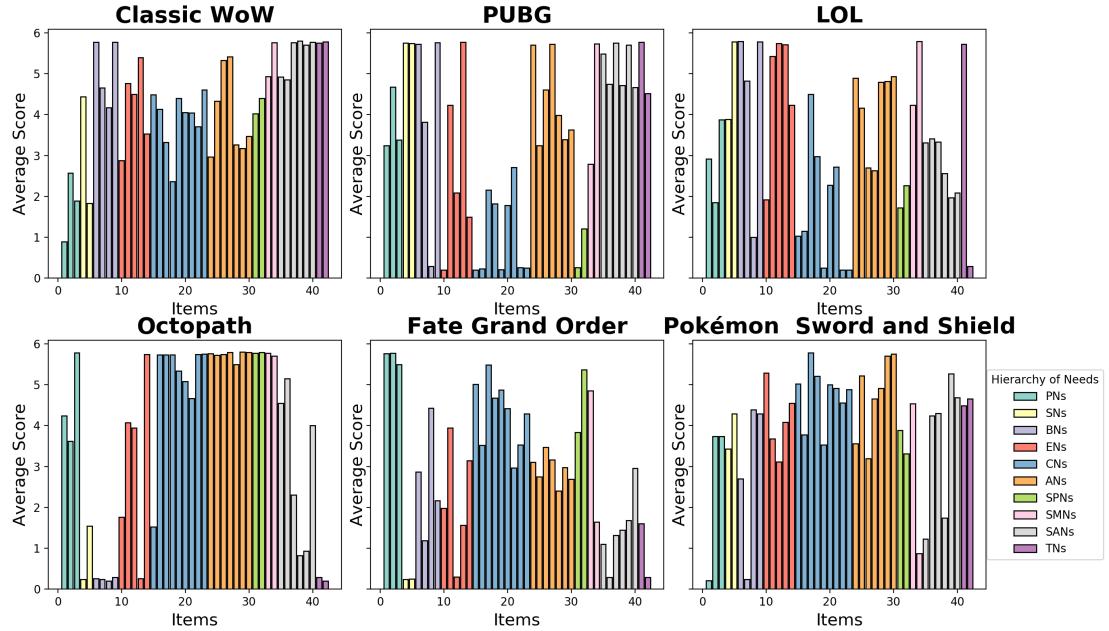


Figure 22: Scores of each item of the games in Group B



Figure 23: Percentages of each factor and overall scores of the games in Group B.

### 1. Octopath

Octopath is defined as a Turn-based RPG game. From the analysis from HONs, one could find that it does not meet much BNs and TNs of players. This could derive from the deficiency of multiplayer mode. Besides that, it provide players with some autonomy to meet SANs. As a platform game, it does not meet much PNs by punishing players excessively for their failures. Except these, its in-game elements satisfy most of the other needs of the player.

### 2. FGO

FGO is also defined as a Turn-based RPG game, however, as a mobile game, it severely limits the player's daily activities and revenue to satisfy the PNs. Because of this strategy, FGO does not penalize players for losing to meet SNs. Although the multi-player mode is not supported, some social interaction functions are built into the game such as, chat and leasing avatars. As a result, a certain amount of BNs and TNs are met. The limited number of levels reduces the player's freedom leading to low score of SANs.

### 3. Pokemon Sword and Shield

Pokemon Sword and Shield is classified as a Turn-based RPG game or pure RPG game. Comparing other Turn-based RPG games, it sets game elements at all level of needs, and thus does not have obvious limitations. According to figure, we could find the BNs, PNs, and SMNs do not get very high scores. The BNs is limited by its social interaction system, which is not as comprehensive as MMO games. It does not support players to communicate with each other. For the SMNs, the gameplay also does not encourage players to keep improving their battle skills. As a PTP game, it does not set limits on players' daily earnings to stimulate PNs.

### 4. WOW

WOW is classified as a MMORPG game, which provides a well-made social interaction system to players. Comparing with Pokemon Sword and Shield, the BNs is the biggest difference. Besides that, WOW is also an open-world game, giving players great freedom to meet SANs. In general, it's the most comprehensive game with the highest total score in these 28 games we chose.

### 5. PUBG and LOL

Though these 2 games are considered as different genres, they show a high degree of similarity in our model. The differences derives from SANs and TNs. For the former, PUBG gives players more autonomy due to the regulations and map size. It also support players to exchange equipment to met more TNs. However, these differences couldn't sway us to classify them as the same kind of game.

In summary, in second group, we would only classify PUBG and LOL as one type of game which has a mature social interaction systems to meet BNs and satisfies the SNs by Ranking systems, giving players a strong sense of insecurity about winning or losing. Besides, these games do not focus on story line and creating a sense of mission to improve CNs and SPNs. For WOW, it is the most comprehensive game in our research and thus should be defined as a unique case. According to other 3 RPG game, their gameplay make them different with each other and thus couldn't be defined as a same class.

- Group C

In the third group, 3 Simulation games with different subgenre, and 3 Sports games were selected. The results are shown in Figure 24 and 25. It worth mentioning that some researchers believe Sports game is a subgenre of Simulation game, since such games attempt to simulate the practice or management of sports. Therefore, according

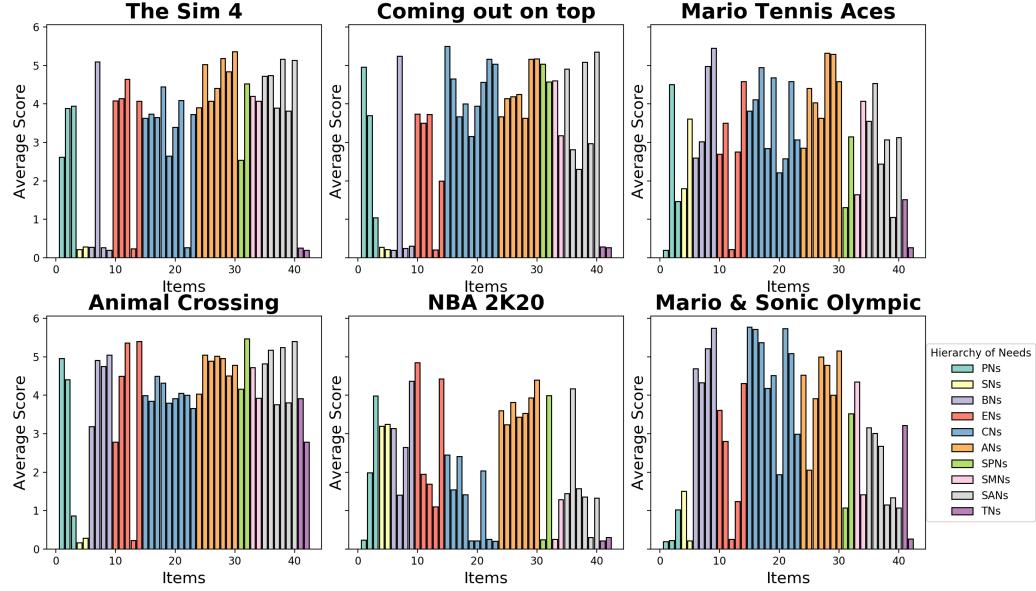


Figure 24: Scores of each item of the games in Group C

to the classification of game genres, these game could be considered as all simulation games, 4 kinds of simulation games with subgenre, or the Simulation game class and Sports game class. Based on our HONs model, we next explore how to classify them with player needs.

### 1. The Sim4 and Coming out on top

Although these 2 games are defined as life simulation game and dating simulation game, respectively, according to Figure 24, they show a very high degree of similarity in HONs. The minor differences exist only in that the former's open game world gives the player more SANs, and the latter needs to pay attention to narration and characterization to make the dating more compelling, and the score of CNs is thus much higher. However, these 2 game still could be defined as the same kind of game.

### 2. Animal crossing

Also a simulation game, Animal crossing presents a vastly different HONs composition with the above two games. It adds a lot of social interaction elements to satisfy BNs while maintaining the quality of narrative and characterization. An-

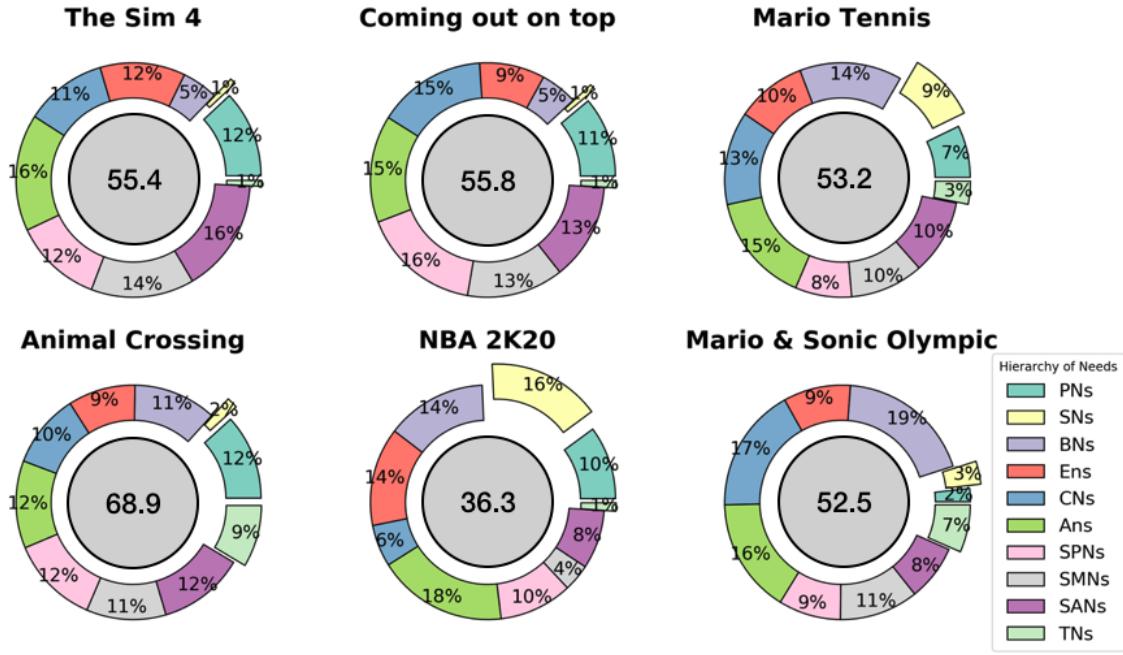


Figure 25: Percentages of each factor and overall scores of the games in Group C.

other significant distinction is that it allows players to donate in-game resources and encourage players to learn the island architecture of the master player. Such functions could further improve the TNs. In general, Animal crossing is the second most comprehensive game in our research. Comparing with WOW, it does not motivate the players' SNS by creating insecurity.

### 3. Mario Tennis and Mario Sonic Olympic

The common characteristics of Mario series games can be well represented by our model. Instead of setting clear purposes or limiting resource to motivate daily log, these games use entertaining art and music, and simple operation to create a relaxed and enjoyable atmosphere, which encourages social interaction with players and has a low learning cost. As a result, they usually have a low score of PNs, SNSs, SPNs, and TNs, and have a high of BNs, CNSs, and ANs. Since Mario Tennis supports online battle and develops a ranking system, it got a relatively high SNS.

### 4. NBA 2K20

Though NBA2K20 has a same genre with the above 2 games, it shows like a different game with them. This perhaps because its background story is based on the reality and its marketing strategy is more focused on specific fans than the general public like the Mario series games, it does not spend many game elements to raise players' CNs. Since it support players to manager teams and experience the career of famous basketball players, it got a high score of ENs. Besides, its lottery and ranking system also improve the PNs and SNs, respectively.

In conclusion, based on our model, we prefer to divide Sim4 and Coming out on top into one category, which is separated from Animal crossing. Because the latter, on the basis of the former, pays more attention to the interaction between players in terms of entertainment and help. For the 3 sports games, we would like to classify Mario Tennis and Mario Sonic Olympic as the same kind of game, since NBA 2K20 has a collection system and does not require excessive cognitive costs.

- Group D

In the fourth group, 2 music games, 2 racing games, and 1 party game were selected. The results are shown in Figure 26 and 27. As for the racing games, some researcher would also like to classify it as a subgenre, the vehicle simulation, of simulation games. But, because it covers so many games, most people tend to lump those games into a specific category. In this group, Mario Kart 8 is also defined as a kart racing game, which is a subgenre of racing game. Besides, as we discuss above, party game is extremely special, which are developed to provide interaction and enjoyment when social gatherings. Since there is a huge number of music and racing elements in Mario Party, we finally put it into this group.

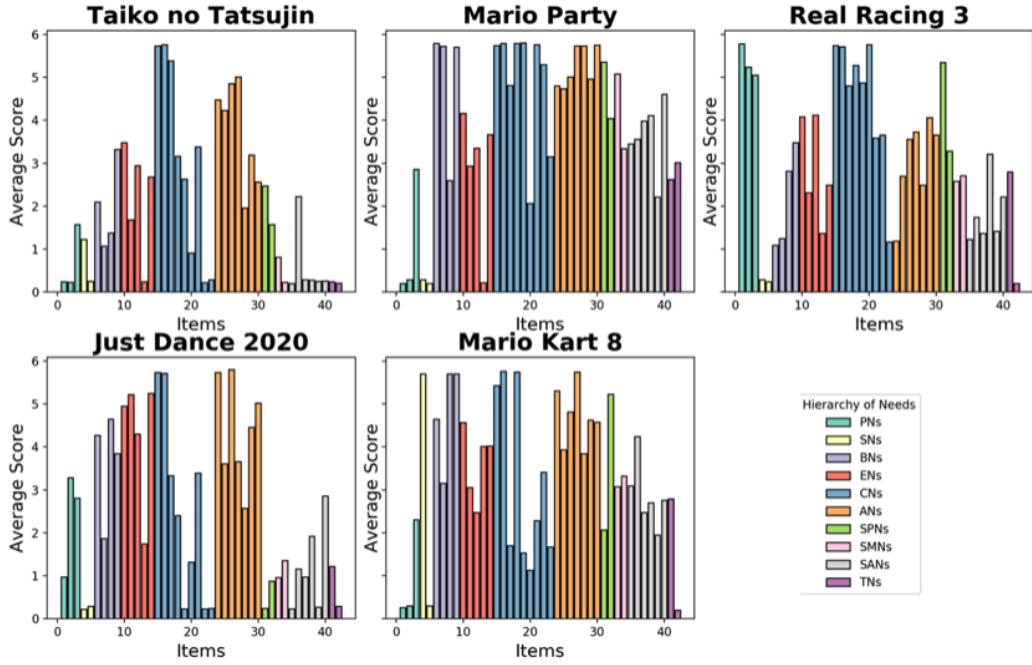


Figure 26: Scores of each item of the games in Group D

### 1. Taiko no Tatsujin and Just Dance 2020

According to Figure 26, these two games express a similar proportion of needs. As two music games, they all have well-made and suitable game audio and video, which leads to high scores and proportion of ANs. In addition to this, other level of needs do not seem to be getting much attention. Within these, since Taiko no Tastujin's gameplay is pretty monotonous, it makes more effort to develop tutorials and set the purpose for players to improve the CNs and SPNs. On the other hand, Just Dance does not provide tutorials, since its regulation could be directly understood.

### 2. Real Racing 3

Real Racing 3 is racing game released on mobile platform. We could find that its proportion of needs is very similar to FGO, which is also a mobile game. They all strongly emphasize on limiting the player's daily activities and revenue to improve the PNs and motivate daily log in. Because of the limited number of games or

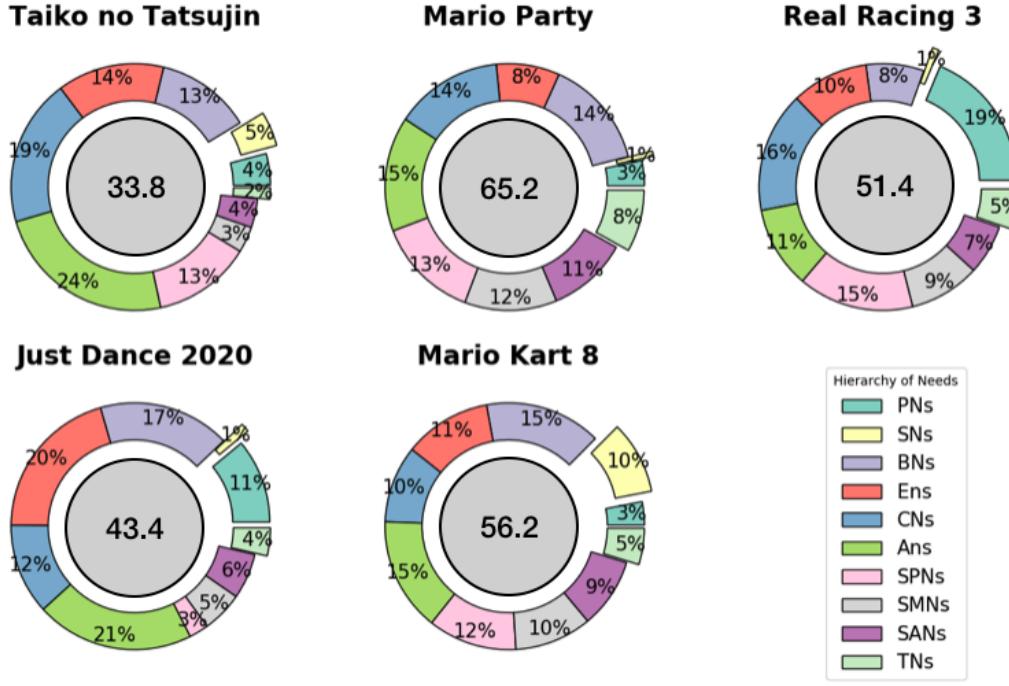


Figure 27: Percentages of each factor and overall scores of the games in Group D.

hours played per day, they do not penalize the player for failure, and there is thus almost no SNs. Except that, the other strategy they used to prevent users churning is adding a number of rewards to encourage players to keep playing. This gives players intense feelings of purpose to meet their SPNs.

### 3. Mario Kart 8

Comparing with Real Racing, Mario Kart 8 presents like a totally different game. On one hand, as a PTP game, it does not need to prevent user churn by creating feelings of starvation, and the score of PNs is thus pretty low. On the other hand, as a Mario series game, social interaction and aesthetic quality are what these games try to promote. This leads to a higher score of BNs and ANs. Besides, the higher SNs score derives from it encourages the conflict between players by using items to attack each other.

### 4. Mario Party

We believe that the classification Mario Party couldn't be defined directly, which needs further analysis by machine learning. Although it does have the features of

Mario series games as we mentioned above, its overall gaming atmosphere is more relaxed and less competitive, leading a low score of SNs. Because it contains many small games of different types, including chess, racing, shooting, music, fight, and so on. Such games differ in their preferences, making it difficult to judge accurately.

In summary, we suggest that Taiko no Tastujin and Just Dance 2020 could be classified as the same kind of game. However, Real Racing 3 and Mario Kart 8 are much different, the former focuses more on rewards and daily quests to encourage players to play continuously, while the latter focuses more on interaction and aesthetic design. For Mario Party, we would like to discuss it later.

- Group E

In the last group, we picked up 3 Digital Collectible Card (DCC) games, and 3 popular mobile games. The results are shown in Figure 28 and 29. Among 3 DCC games, Yu-Gi-Oh! and Pokemon TCG are also defined as RPG and Strategy game, respectively. Based on this comparison we seek to find if it is necessary to further classify DCC Games. In addition to this, though with the different genre, Clash Royale and Brawl Stars are products developed by Supercell, and they have similar art and music styles. And Pokemon go has unique genres, which is much valuable for our research. Actually, all these 6 games were published on mobile platforms. Based on this set of experiments, we hope to explore whether our model is sensitive to mobile games.

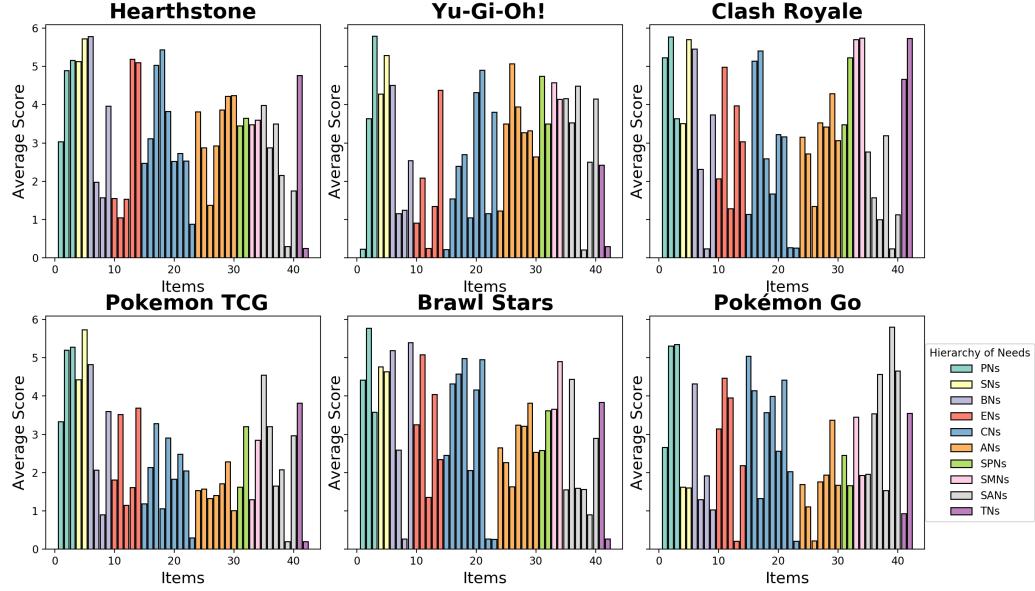


Figure 28: Scores of each item of the games in Group E

### 1. Hearthstone, Yu-Gi-Oh!, and Pokemon TCG

Based on the HONs model, these 3 games show a similar proportion of needs. In Figure 28, we could find that they all have very high scores of PNs and SNS. This is because they all have daily requests and card collection functions, and also well-made ranking systems, which will give a penalty or reward according to the player's victory or defeat and opponent's level. Besides, since they all support multi-player mode and have a large player community to share decks or strategies, the BNs and TNs are also relatively high. Anyway, though Yu-Gi-Oh! And Pokemon TCG are also considered as PRG and Strategy game, there is no significant difference within these 3 games.

### 2. Clash Royale

Clash Royale is defined as a real-time Strategy and DCG game, which has a strict ranking system and a huge card collection system to meet PNs and SNS. However, its regulations and card upgrade system limit player creativity and the diversity of strategies in ranking battles, leading a low score of SANs. In contrast, from the very high TNs scores, we could find that many interviewees believe this game encourages to refer to the tactics of master players.

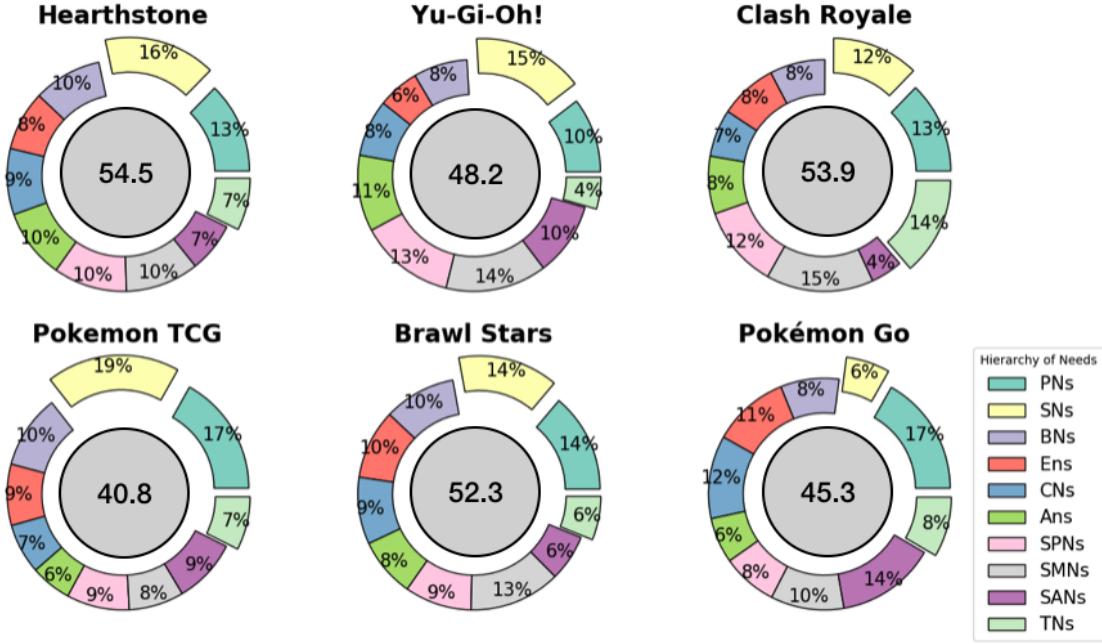


Figure 29: Percentages of each factor and overall scores of the games in Group E.

### 3. Brawl Stars

Brawl Stars is considered as a MOBA game, which is the same as LOL. However, as a mobile and FTP games, it meets much PNs to prevent users churning by providing daily tasks and rewards. This strategy is more similar to the 3 DCG games than LOL. Even though there are no card elements in the game, the characters, skills, and upgrade resources are obtained from the lottery system. Therefore, we prefer to put it in the same category as DCG games.

### 4. Pokemon Go

With the development of game technology, more and more new game genres have been created. One of the good example of these is Pokemon Go, which is classified as a AR or Pervasive game. The definition of Pervasive game is the RPG or Live Action RPG game whose experience could happened in the real world. However, based our HONs model, we could find that it shows a needs pattern as high score of PNs and CNs, and low score of SNs. Such pattern matches the features of 2 mobile games, FGO and Real racing 3, which have daily tasks, daily play times limitations, and collection system to meet PNs to prevent users churning. SNs

is discarded since those game do not want to upset players with limited playing time.

In conclusion, in the group of mobile games, we would like to classify Hearthstone, Yu-Gi-Oh!, Pokemon TCG, and Brawl Stars as a same category, which have a collection system to meet a high score of PNs, and online battle modes with ranking system to meet a high score of SNs. As for Clash Royale, it gives the player less autonomy and encourages learning from the strategy of the master player. So, we prefer to distinguish it from the above games as a more competitive game. Besides, though defining as a unique genre, Pokemon Go is classified as the same category with FGO and Real Racing 3, since they have a similar pattern.

# Chapter 7: Model Validation: Machine Learning

In this section, we introduced machine learning algorithm to further analyze the results of our GX+HONs questionnaire, and there are thus 3 problems need to be solved. They are, respectively, the selection of supervise learning and unsupervised learning, the selection of the algorithm, and the selection hyperparameters we need to classify or cluster.

As for the first question, we finally chose unsupervised learning in this research. Since we are the first research that attempts to use HONs to classify games, there is no previous data sets or patterns we could refer to as the input. Besides, we also couldn't find the method to label the data, as such method is what our research tried to develop. Therefore, we can only use unsupervised learning to cluster these 28 games so far, however, after we cluster and label these games, in the future research, when investigating the classification of a new game, one could conduct supervised learning combined with our labeled dataset to find which class has the most similar pattern with such game. We believe that the generality and reliability of the classification will definitely increase with the expansion of the data set.

According to the second question, to seek which algorithms fit our model, we chose 2 clustering algorithms from each of 2 clustering methods, which are K-means++ [79] from partition-based methods, Agglomerative [80] from hierarchical methods. The reason that we did not choose the density-based methods is our dataset sample is not large and dense enough. This may lead to a worse performance if we use these kind of algorithms like DBSCAN [81]. Actually, we did try DBSCAN algorithm, which has the best result with  $\text{epi} = 0.5$  and  $\text{minsample} = 2$ . But its classification did not make a lot of sense in our 28 games, so the density-based approach was abandoned in this research. To find the answer of the third problem, we next conducted experiments with these two algorithms respectively, and then determined the appropriate parameters by combining the measurement standards and the actual effect of game classification.

## 7.1 K-means++

As a partition-based clustering algorithm, the classic K-means algorithm would first select K cluster centers randomly from the dataset and then compute the distance from each data point to these centers. After calculation, K-means then classifies each data point to the center point with the smallest distance from it. Since the initial center point is randomly selected, K-means then calculates the cluster center according to each class and repeats the previous process until the center point no longer changes. In order to avoid the algorithm is too sensitive to the choice of the initial center point, we introduced the modified K-means++ algorithm, which just picks the first center at random. As for the other centers, the farther the candidate point is from the current cluster center, the higher the probability it will be

selected as the next cluster center.

To find the best parameter of K-means++, the number of K, we first conducted 8 experiments, from  $K = 5$  to  $K = 12$ , as shown in Figure 30 to Figure 33. To visualize the results in 3D figures, we introduced the Principle Components Analysis to map the data from the original 10 dimensions to 3 dimensions and then plot them based on the clustering result.

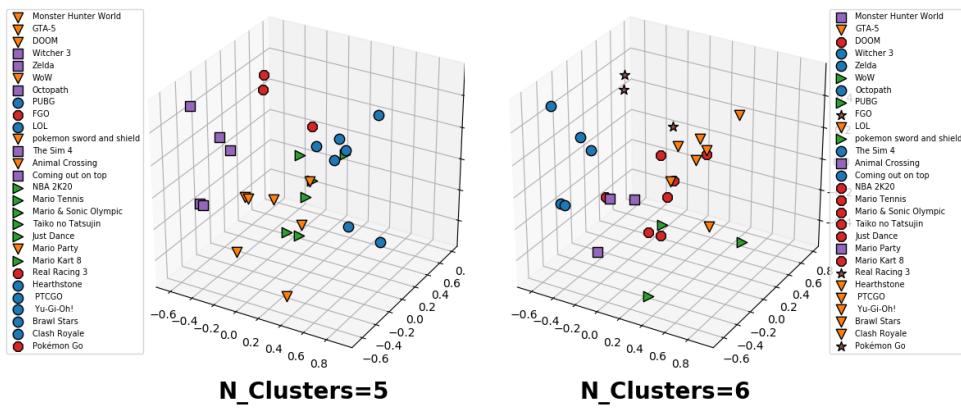


Figure 30: Using Principle Components Analysis to plot clustering with  $K=5, 6$ .

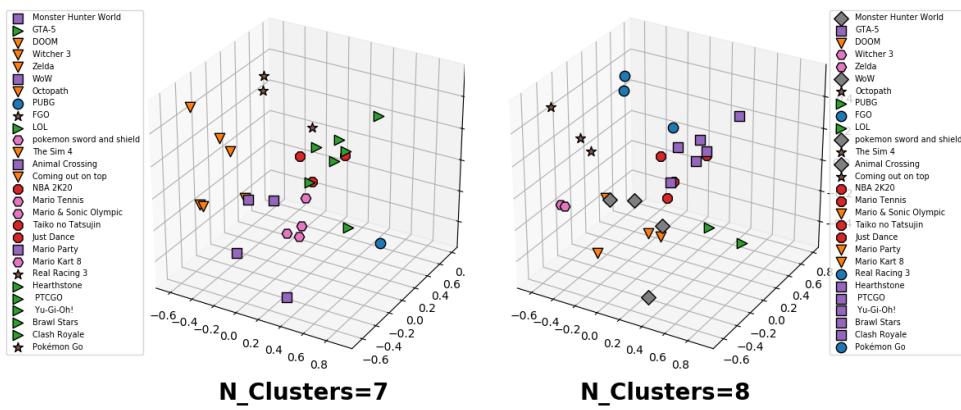


Figure 31: Using Principle Components Analysis to plot clustering with  $K=7, 8$ .

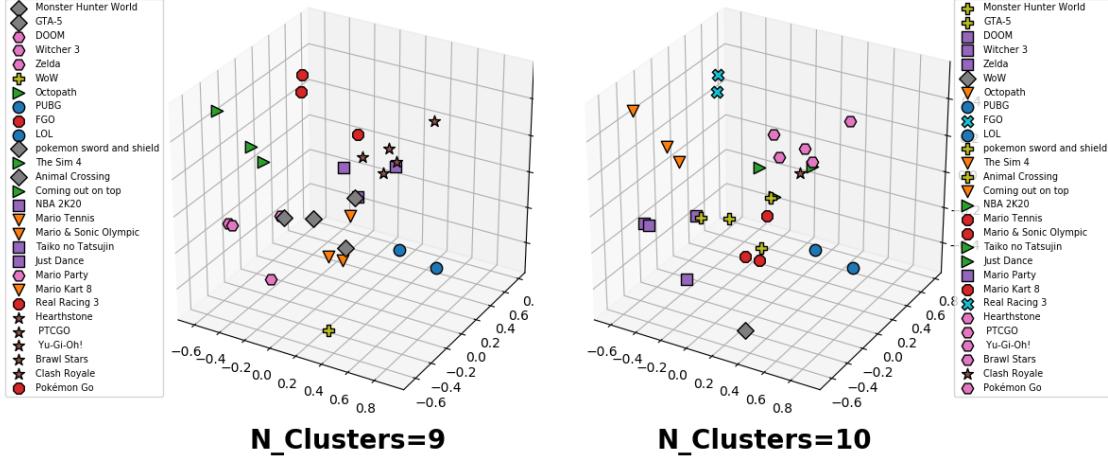


Figure 32: Using Principle Components Analysis to plot clustering with K=9, 10.

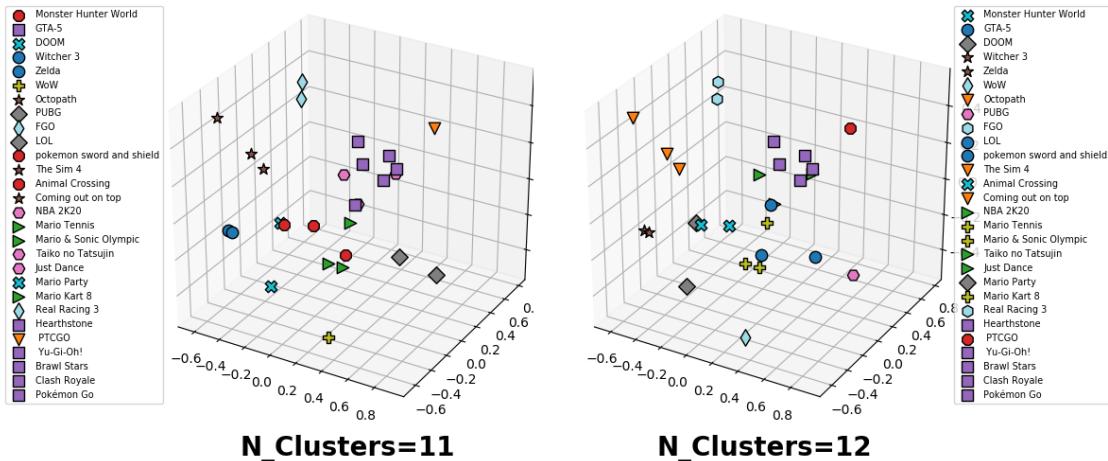


Figure 33: Using Principle Components Analysis to plot clustering with K=11, 12.

To seek the best number of clusters, we used two measurement criteria, which are the sum of the squared errors (SSE) and silhouette coefficient (SC) [82]. As a mainstream method to define the quality of clustering, the SSE describes the clustering error of all

samples. In theory, with the increase of K, the aggregation degree of each cluster will gradually increase, which leads to the gradual decrease of SSE. Moreover, when K is less than the optimal clustering number, the increase of K will greatly cause the decline of SSE. However, after K reaches the optimal clustering number, the rewards of aggregation degree obtained by increasing K will decrease rapidly, so the decline amplitude of SSE will be sharply reduced, causing the subsequent SSE curve to become flat. Therefore, in most cases, the best parameters are near the corner of the curve. The SSE could be calculated as

$$SSE = \sum_{i=1}^k \sum_{p \in C_i} |p - m_i|^2 \quad (1)$$

where  $C_i$  represents the each cluster,  $p$  represents the every sample belonged to  $C_i$ , and  $m_i$  is the center of the  $C_i$ .

On the other hand, SC was developed by Peter J. Rousseeuw [83] who believes a good clustering model should have two features that the samples within the same cluster should be dense enough, and the samples between different clusters should be distant enough. To make a tradeoff of these two features, the SC calculates the average distance between a particular sample and other samples in the same cluster, as well as the average distance between the sample and all samples in the nearest cluster. The difference between the former and the latter is divided by a large distance as the SE of this sample, and the average value of all samples' SE is used to measure the performance of the model. The bigger the overall SC is, the better the model is. The SC could be calculated as

$$SC = \frac{b - a}{\max(a, b)} \quad (2)$$

where  $a$  represents the avenger distance with a sample and the other samples in its cluster, and  $b$  represents the avenger distance with a sample and the other samples in the nearest cluster of it.

Shown in Figure 34, according to the SSE curve, the slope changes after  $k=10$  or  $11$ , which means these are the potential parameters that could be chose. On the other hand, based on the SC curve, after  $k=10$ , the point where the value is high is  $k=10$  or  $12$ . As a result, we finally decided to use the k-means++ algorithm to divide the 28 games into 10 categories.

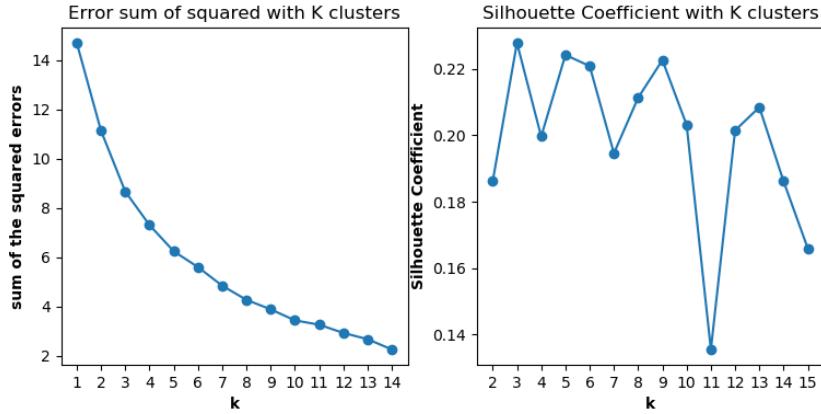


Figure 34: Error sum of squared and Silhouette Coefficient of different number of clusters

## 7.2 Agglomerative

Hierarchical clustering algorithm does not produce a single cluster, but a cluster hierarchy to form a hierarchy tree. Agglomerative Clustering first makes one cluster for each sample, then merge these clusters gradually until meeting the desired cluster number or achieving other termination conditions. In our study, we set the termination cluster number as 2, since it will help us further understand the similarity between these 28 games. In theory, such similarity is determined by the distance between clusters, the similarity between clusters with short distance is high, while that between clusters with long distance is low. To find the best method to calculate the distance, we selected 4 methods, the single assigns, complete assigns, average assigns, and ward assigns, and then compared them based on matching degree with our classification analysis. These methods could be calculated as

$$d_{single}(u, v) = \min(d(u[i], v[j])) \quad (3)$$

$$d_{complete}(u, v) = \max(d(u[i], v[j])) \quad (4)$$

$$d_{average}(u, v) = \sum_{ij} \frac{d(u[i], v[j])}{|u| * |v|} \quad (5)$$

$$d_{ward}(u, v) = \sqrt{\frac{|v| + |s|}{T} d(v, s)^2 + \frac{|v| + |s|}{T} d(v, t)^2 - \frac{|v|}{T} d(s, t)^2} \quad (6)$$

where  $u$  is the newly joined cluster consisting of clusters  $s$  and  $t$ ,  $v$  is an unused cluster,  $T$  is sum of the number of elements of  $v$ ,  $s$ , and  $t$ . The results of these methods are shown in Figure 35.

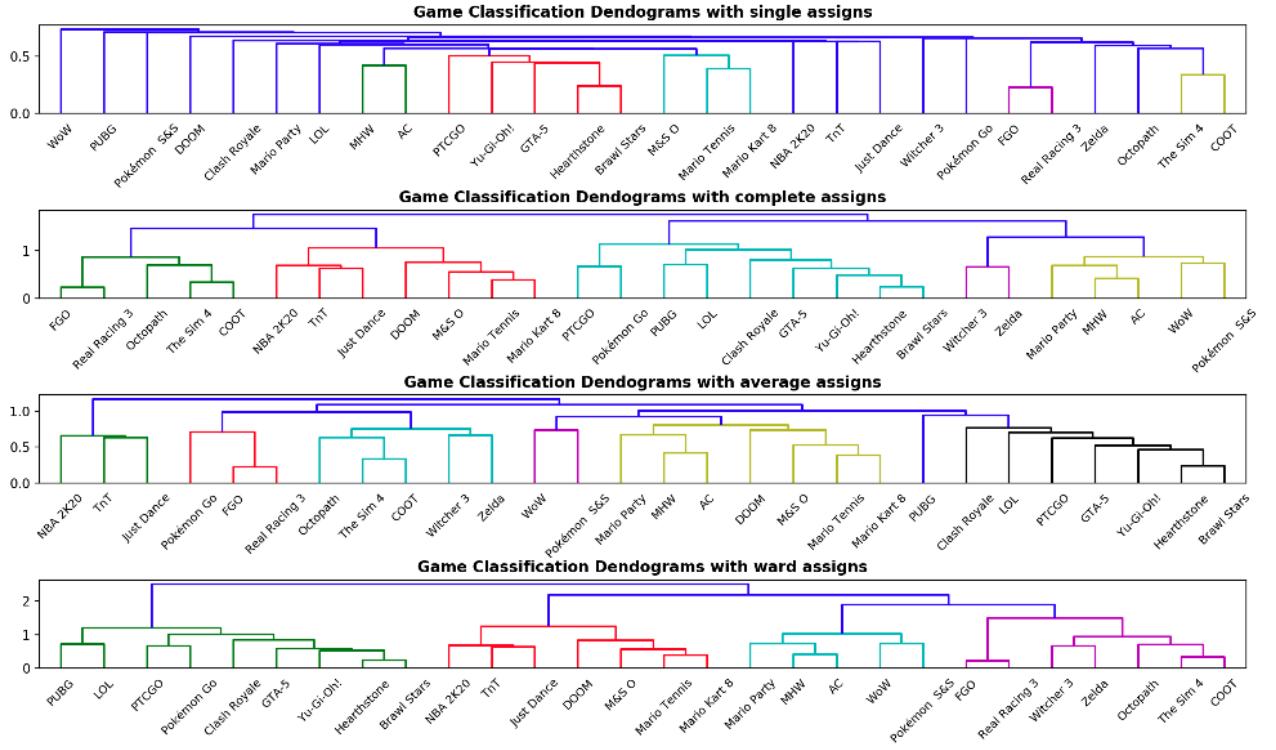


Figure 35: Agglomerative clustering results of single assigns, complete assigns, average assigns, and ward assigns.

### 7.3 Discussion

According to the results of K-means++ clustering, we finally selected the model with 10 clusters as it meets the criteria of SSE and SC. So based on this algorithm, the 28 video games were classified as 10 categories.

1. Monster Hunter World, GTA-V, Pokemon Sword and Shield, Animal Crossing
2. DOOM, Witcher 3, The legend of Zelda: Breath of the Wild, Mario Party
3. Classic WOW
4. The Sim4, Coming out on top, Octopath
5. PUBG, LOL

6. Taiko no Tatsujin, Just Dance 2020, NBA 2K20
7. Mario Tennis Aces, Mario Kart 8, Mario and Sonic at the Olympic Games Tokyo 2020
8. Fate Grand Order, Real Racing 3
9. Clash Royale
10. Hearthstone, Pokemon TCG, You-Gi-Oh!, Brawl Stars, Pokemon Go

Based on this classification, one could find most results are perfectly matching our analysis in chapter 5. However, there are still some deficiency including the classification of Mario Party, Octopath, and NBA 2K20. As for Mario Party, it defined as the same class with the games that has low score of SNs and PNs. Octopath was grouped with the games that has low score of SNs and TNs. And NBA 2K20 was classified with the games that has the highest proportion of ANs. Although these categories do not seem very sensible in terms of the game experience, they all successfully reflect the greatest features of the game. Anyway, in general, K-means++ has a excellent performance in our GX+HONs model.

According to the classifications of Agglomerative clustering, the clusters with the average and complete assigns have the better performance in our model. Based on Figure 35, they have a clear division for all games, which could be summarized as:

1. Fate Grand Order, Real Racing 3
2. The Sim4, Coming out on top
3. Taiko no Tatsujin, Just Dance 2020
4. Mario Tennis Aces, Mario Kart 8, Mario and Sonic at the Olympic Games Tokyo 2020
5. PUBG, LOL
6. Pokemon TCG, Pokemon Go
7. Animal Crossing, Monster Hunter World, Mario Party
8. Witcher 3, The legend of Zelda: Breath of the Wild
9. Hearthstone, You-Gi-Oh!, Brawl Stars
10. Classic WOW, Pokemon Sword and Shield

This result is closer to our analysis based on the game experience. It took the games that we considered to be more specific and separates them out, such as DOOM, NBA 2K20, Octopath, and Clash Royale. However, it has the same problem of Mario Party with K-means++ clustering. Anyway, Agglomerative clustering with average and complete assigns also fitted our model well. We synthesized the two algorithms' conclusions and sorted out the games with the same classification results and the corresponding Patterns in Table 3. Follow-up studies can use this to label new games.

<b>High Needs</b>	<b>Low Needs</b>	<b>Games</b>
Physiological,Cognitive	Security	FGO, Real Racing 3
Physiological,Aesthetics,Autonomy	Security	The Sim4, Coming out on top
Aesthetics	Security,Transcendence	Taiko no Tatsujin, Just Dance 2020
Aesthetics, Cognitive,Belongingness	Physiological	Mario Tennis Aces, Mario Kart 8, Mario and Sonic at the Olympic Games Tokyo 2020
Aesthetics,Security,Belongingness, Master	Cognitive	PUBG, LOL
Physiological,Security,Belongingness, Master	—	Hearthstone, Pokemon TCG, You-Gi-Oh!, Brawl Stars
Aesthetics,Autonomy,Purpose,Master	Belongingness	Witcher 3, The legend of Zelda
Aesthetics,Physiological	Security	Animal Crossing, Monster Hunter World
All needs	—	Classic WOW
Security,Physiological,Transcendence, Master	Autonomy	Clash Royale

Table 3: Patterns of the Games that have the same classification result with 2 clustering algorithms

## Chapter 8: Conclusion

In this research, we first discussed the definition of genre and summarized mainstream game genres from commercial and academic perspectives. After listing the deficiencies of video game genres, we proposed an original game classification model combining two theories, the GX and HONs, that could help us express the similarities and differences of different video game.

As for GX, we introduced the background of UX and GX, and collected all of potential measurement techniques could be used in our model. The GUESS was finally selected as one of the benchmarks since it is the newest and comprehensive method that contained almost all factors and perspective from previous GX questionnaires. According to the HONs, we first introduced the 3 various HONs models including the Maslow's very early 5-level HONs model, modern 8-level HONs model, and Self-Actualisation expanded model. Though an analysis of the implement of these models in video game research, we finally chose the last one as the second benchmark.

Combined such benchmarks, we conducted factor and item engineering to develop a GX+HONs questionnaire with 47 items. To do this, we first conducted a survey among G-scale researchers to find out 28 video games that have the worthy of researching. The second survey was then conducted among 25 junior game designers in Shanghai Giant network. The results of original model was then validated by statistical approaches, the EFA and CFA, to seek the best combination of factors to represent it, and to revise or discard the ambiguous or negative items. Though this process, there are 42 items listed in the final edition of GX+HONs questionnaire.

Based on the results of the final edition GX+HONs, after grouping and comparing, we first suggested a reasonable classification method in terms of the gameplay. Two algorithms of unsupervised learning, K-means++ and Agglomerative clustering, were then introduced to make a further analysis to find the similar patterns of these 28 games. After the selection of the hyperparameters, we believe that K-means++ clustering with 10 clusters and Agglomerative clustering with the average and complete assigns successfully match our expectations, and these thus should be used in the future work.

Finally, we would like to express our sincere appreciation to all the subjects from G-scale lab and Shanghai Giant Network.

## Chapter 9: Future Work

Although the GX+HONs questionnaire seems to solve most of classification problems of video games, we hope that the future research can start from the following points to improve this model:

- Based on Figure 19, Pearson's correlation coefficient shown a high score between CNs and SPNs. We suppose this is because cognitive needs and purpose needs overlap in definition or understanding. Such overlap needs to be found, and corresponding items need to be improved.
- The generality of our approach still needs to be investigated by large-scale quantitative experiments. To do this, one could find more game researchers to investigate, or ask the same researchers to compare more new games. The former may increase the generality of classifications of particular games, while the latter may increase the generality of the whole model.
- Since we only implemented three algorithms in this study, more clustering models could be used to find if there is a best one fit our research.
- Since we only implemented three algorithms in this study, more clustering models could be used to find if there is a best one fit our research.
- We hope that subsequent research could develop a data set by clustering a large number of video games. One could label each video game by the characteristics of corresponding cluster to establishing a new classification system of video games. With this system, we could define the categories of a new game through supervised learning and its score of GX+HONs questionnaire conducted among game researchers.

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