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Exploring Curiosity in Games: A Framework and Questionnaire Study of Player Perspectives

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ABSTRACT

In game design, curiosity is often a critical driver of player engagement, yet its complex role in influencing player experience remains underexplored. The present study aims to delineate the categorisation and representation of curiosity in game playing and how it contributes to the game experience. A survey of 482 participants was conducted to investigate the multifaceted nature of curiosity. The findings indicate that game-related curiosity encompasses seven broad categories and 13 separate performance dimensions. Notably, the study reveals players' pronounced preference for games that foster social interaction, offer strategic challenges, and strike a delicate balance between uncertainty and the anticipation of future rewards. The results also highlight that beyond appreciation for high-quality games, those that effectively tap into diverse dimensions of curiosity can sustain player engagement. This nuanced comprehension of curiosity within game environments highlights the potential for more focused and efficacious design strategies, potentially augmenting player satisfaction and fostering loyalty.

KEYWORDS

Player curiosity; game design; questionnaire; curiosity categorisation; player engagement

1. Introduction

Games captivate audiences by offering diverse experiences, ranging from the thrill of competition to the joy of narrative immersion (Bateman, 2016; Lazzaro, 2009; Oswald et al., 2014; Phan et al., 2016; Seiwald, 2019). As part of their work, designers often intuitively have taken advantage of curiosity, a crucial psychological trait, for its potential to amplify engagement and deepen narrative absorption (Costikyan, 2013; Klimmt, 2003). Despite the recognized potential of curiosity in enhancing player engagement, scholarly discourse on deliberately integrating curiosity-centric design within games remains limited. Our framework seeks to fill this gap, proposing strategies for the intentional incorporation of curiosity elements in game design, thereby directly addressing our research objectives. This integration is challenging because while game designers strive to harness curiosity to enhance player engagement, its study has often been merged with related constructs such as uncertainty (Costikyan, 2013), ambiguity (Muscat & Duckworth, 2018) and explorative drive (Acevedo et al., 2022). Existing research provides valuable information, however, a clear, systematic framework for embedding curiosity within the game design process is yet to be established. A conflation of concepts is prevalent, with practitioners frequently conflating curiosity's manifestation in games with aspects such as exploratory behaviour and considering it as the embodiment of curiosity's information gap theory proposed by Loewenstein (1994) in the game. Such simplifications risk diminishing the rich, multifaceted nature of curiosity, leading to potential confusion in case of erroneous use of different yet related terms interchangeably.

These challenges highlight the need for a nuanced approach to dissect and refine curiosity-driven design in games. In this study, we aim to dissect and understand the role of curiosity in game design and player engagement. By examining how curiosity manifests in games and influences player behavior, our research seeks to establish a framework for integrating curiosity effectively into game design. This study initiates the development of a theoretical framework aimed at directly addressing the identified challenges in understanding curiosity in games. Our approach involves introducing a structured questionnaire designed to gather insights from game players, thereby elucidating the various facets of curiosity within gaming contexts. This step is integral to refining our framework, ensuring it aligns closely with our primary research objective of deepening the theoretical understanding of curiosity in games. Furthermore, our research presents the preliminary survey findings, shedding light on the effect of player-specific traits on game design curiosity and prevalent mechanisms within games that resonate with players.

By exploring the specific definitions, manifestations, design methodologies, and appealing attributes of curiosity in games, we help designers and academics recognise the precise role and potential of curiosity. This insight is intended to guide developers in creating more engaging and captivating game environments, ultimately elevating the overall player experience.

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2. Related work

The methodology for selecting the relevant literature for this review was systematic and targeted. We aimed to build a comprehensive understanding of curiosity in psychology and its application in game design. To achieve this, we utilized academic databases PubMed, PsycINFO, and Google Scholar, focusing on key terms like "curiosity," "game design," and "player engagement." Priority was given to peer-reviewed articles, seminal works, and recent studies that provide a contemporary understanding of curiosity. We also included interdisciplinary research to capture the multifaceted nature of curiosity, spanning psychology, game studies, and human-computer interaction. This approach ensured a thorough and balanced review, enabling us to categorize curiosity's dimensions as relevant to game design.

2.1. Defining curiosity in psychology

Curiosity has long captivated psychologists, evolving into a robust concept. It was defined by Loewenstein as the drive to close an information gap (Nerantzaki et al., 2021). Grossnickle further refined this definition, characterising curiosity as a longing for knowledge or information and a reaction to or search for variables of experience (including novelty, complexity, ambiguity, challenge, and uncertainty), accompanied by positive emotions, enhanced arousal, or exploratory behaviour (Grossnickle, 2016).

2.2. Dimensions and classifications of curiosity

While mature in psychology, translating curiosity to the domain of games necessitates additional discourse, especially given the lack of standardised definitions in game studies for concepts such as novelty or ambiguity. The first step in translation is to clearly define and categorise curiosity in game players. Such categorisation is crucial for game designers seeking to craft more engaging and immersive experiences, as it allows for a targeted approach in eliciting player curiosity. Fortunately, the field of psychology provides a strong foundation for this classification. Building on this foundation, we conducted a thorough review of literature on curiosity and broadly categorised the different dimensions of curiosity, literature was split into groups based on how curiosity is defined and observed in that context, as demonstrated in Table 1.

Many scopes overlap within these categories. For example, curiosity of the deprivation type and curiosity of the interest type are considered to fall under the Specific Curiosity category (Spielberger & Starr, 1994). This is because the classification principle is based on the dimensions and manifestations of viewing curiosity, not actually belonging to different types. The relationships between each category are more akin to interactive or hierarchical relationships, rather than being distinctly separate (Litman & Spielberger, 2003; Reio et al., 2006). This situation makes it difficult to divide and study curiosity solely based on a single classification system. In the last two decades of the twentieth century, boundaries and even the correctness of theories classifying curiosity as breadth and depth, specific and diverse, as well as state and trait, have been highly debated in the field of psychology (Ainley, 1987; Boyle, 1989; Byman, 1993), and these debates are still ongoing. However, there is robust evidence supporting the categorisation of curiosity into physical, social, epistemic, and perceptual types and how to distinguish their boundaries (Litman, 2005; Reio et al., 2006; Renner, 2006). These four categories are at the highest level of all curiosity classifications, and any other category essentially falls under only these categories. These four categories are based on the object of a certain type of curiosity (Grossnickle, 2016), meaning they have a clear target, and this target is the recipient of curiosity. This concept is useful for classifying curiosity in game design, as for players, the elements in the game are the recipients of their curiosity. Compared with other classifications of curiosity, physical, social, epistemic, and perceptual curiosity aid in understanding how different elements within games can become focal points of player curiosity, demonstrating our framework's applicability to game design.

2.3. Curiosity theoretical underpinnings in games

Games, as comprehensive systems, have consistently been identified as fertile grounds for the exploration of human curiosity, serving as a rich terrain for inciting a broad spectrum of emotional reactions and experiences (Yannakakis & Paiva, 2014). Despite the recognised potential of curiosity, its explicit role and impact in the sphere of game design remain to be well-defined (Gómez-Maureira et al., 2021; Yannakakis & Paiva, 2014).

In seminal works, influential figures such as Costikyan and Klimmt have underscored the indispensable nature of curiosity. Costikyan articulated the role of uncertainty in games as a significant allure, positioning curiosity as a vital motivating factor for players (Costikyan, 2013). Klimmt posited curiosity as the central pillar of a conceptual model for player engagement, highlighting its importance in influencing a player's decision to engage in games (Klimmt, 2003). Echoing these sentiments, Schell detailed how game designers can stimulate curiosity by creating environments that foster questioning and exploration within the game's framework (Schell, 2008).

2.4. Player profiling and curiosity

Player profiling is a striking aspect of curiosity in the context of a game. Considerable effort has been expended on delineating player archetypes informed by a blend of personality traits and motivations, within which curiosity features are prominent (Schaekermann et al., 2017). The BrainHex model proposes seven unique player archetypes (Nacke et al., 2011). This profiling aligns with Kashdan et al.'s multifaceted curiosity model, which portrays the diverse dimensions of curiosity (Kashdan et al., 2018). A prime example is the "daredevil" archetype in the BrainHex model,

Table 1. Definitions and comparisons of curiosity dimensions.

Dimensions Based on Object of Curiosity I	
Physical Curiosity	Probing and altering oneself and the immediate environment (Dewey, 1910)
Perceptual Curiosity	Undertaking exploration through sensory channels (like vision or hearing) to gather newfound knowledge (Litman & Spielberger, 2003)
Social Curiosity	Utilising language to initiate inquiries and ask other people for information or having a desire to learn about others (Dewey, 1910; Renner, 2006)
Epistemic (Intellectual or Cognitive) Curiosity	The hunger or longing for understanding, details or navigating scholarly territories (Litman, 2010)
Dimensions Based on Object of Curiosity II	
Breadth Curiosity	An inquisitive attitude about a diverse array of topics ideas, or experiences, persistently pursuing variation (Nerantzaki et al., 2021)
Depth Curiosity	A focused inquisitive mindset, channeled intensively toward a singular topic or domain (Levitt et al., 2009)
Dimensions Based on Degree of Stability	
State Curiosity	A transient expression of inquisitiveness evoked in response to environmental elements (Nerantzaki et al., 2021)
Trait Curiosity	A lasting inclination within individuals to yearn for novel knowledge or experiences, prompted by curiosity-inducing environmental aspects or proactive pursuit of curiosity-generating situations (Litman & Silvia, 2006)
Dimensions Based on the Reason for Curiosity I	
Diversive Curiosity	The intent to amplify arousal and mitigate monotony by embracing uncertainty and fresh experiences (Kashdan et al., 2009)
Specific Curiosity	The intent to diminish uncertainty by targeted exploration of certain stimuli (Spielberger & Starr, 1994)
Dimensions Based on the Reason for Curiosity II	
Interest-type Curiosity	The wish to acquire fresh information for the joy or intrigue it brings (Litman, 2005)
Deprivation-type Curiosity	The wish to obtain new information to alleviate a lack of knowledge or feelings of unawareness (Litman, 2005)

epitomising the successful amalgamation of player traits with the dimension of thrill seeking-related curiosity.

2.5. Empirical studies and game design

Beyond the realms of theoretical conjecture, the significance of curiosity in games has be en extensively studied from the practical perspective. Researchers have been attentive to players embarking on both spatial and conceptual explorations, whether steering an avatar through unfamiliar terrains or solving complex logic puzzles (Cross, 2007; To et al., 2016). The exploratory behaviour observed in players, far from being a mere whimsical activity, represents a critical aspect of creativity and is deeply interwoven with player satisfaction. This concept is a key component of our framework, illustrating how curiosity-driven exploration can enhance player engagement, thus aligning with our research's aim to understand and utilize the role of curiosity in game design (Phan et al., 2016).

Harmonising game design with curiosity is a challenging task. All design methodologies may not successfully incite state curiosity, even when they seem to align with the player's curiosity, an inherent trait. This predicament underscores the critical need for empirical design-centric research within and beyond game contexts. Such research should aim to tackle the complex constructs while extrapolating actionable insights for future design improvements (Cross, 2007). The foundation for this strategy lies in the evolution of universal design principles. Pioneering studies, such as those by To et al. (2016) (based on the curiosity model by Kreitler et al., 1975), and Gómez-Maureira and Kniestedt (2019) have laid the groundwork in this realm, highlighting how game designs can evoke curiosity by employing various triggers identified through established curiosity models. These contributions are fundamental to our framework, offering a foundation for examining how different curiosity types can be effectively integrated into game design (Gómez-Maureira et al., 2021).

Furthermore, games serve as a fertile ground for investigating curiosity dimensions and a robust tool for quantifying curiosity. This perspective was exemplified in a seminal study conducted in 2012 that used games to quantitatively assess scientific curiosity amongst children (Jirout & Klahr, 2012). This novel method highlights the multifaceted applications of game design, transcending through mere entertainment and skill augmentation, thus establishing it as a potent tool for empirical curiosity evaluation. This use case presents a nuanced, behaviour-based metric as an alternative to traditional self-reporting tools, thereby emphasising the key role played by games in refining our understanding of curiosity and emphasising its relevance to the discourse surrounding curiosity and games.

In summation, although substantial efforts have been undertaken to investigate the role of curiosity in games, there is still a need to understand curiosity in games more specifically. A pivotal aspect of our framework is the clear definition and categorization of curiosity within game contexts. This specificity is essential to our objective of developing a nuanced understanding of curiosity's role in game design, differentiating it from its standard psychological definition.

2.6. Measuring curiosity

In the pursuit to measure curiosity, many curiosity-related studies have been conducted. In traditional psychological frameworks, curiosity measurements are largely categorised into the following groups (Grossnickle, 2016):

- Self-Report Trait Curiosity Measures
- Self-Report State and Task-Specific Curiosity Measures
- Teacher and Parent Reports, Observational Measures
- Manipulation of Curiosity

Based on the fundamental categories, researchers have developed several models and scales, selecting the measurement method that best fits their research context. Grossnickle emphasised that 92.3% of methodologies employed involve self-report questionnaires (Grossnickle, 2016), underscoring a consensus amongst scholars that self-report questionnaires can effectively measure curiosity.

When curiosity is applied to the field of game design, its measurement to establish empirical evidence holds equal relevance. The foremost requirement for curiosity measurement is establishing a set of operational definitions (Grossnickle, 2016). Yet, as Engelhard and Monsaas (1988) argued decades ago, the myriad of theoretical models has led to numerous operational definitions. Presently, there is no universally accepted operational definition of curiosity within game studies, which limits the direct application of the diverse curiosity measurement models to this field.

In games research, notable efforts have been made to capture and categorise curiosity. Gómez-Maureira and Kniestedt (2019) applied the psychology-based 5DC curiosity scale to assess player curiosity and further explored curiosity through the analysis of player behaviour (Gómez-Maureira et al., 2021). Schaekermann et al. (2017) measured in-game curiosity, using "Destiny" as a case study and integrating curiosity-related elements from four established scales. Their factor analysis affirmed the new scale's validity and its strong correlation with distinct types of curiosity, which explained how different in-game behaviours correlate with these types.

These investigative efforts have undoubtedly expanded our understanding of curiosity in games, yet they also highlight areas ripe for further inquiry. For example, Gómez Maureira et al.'s 2019 study (Gómez-Maureira & Kniestedt, 2019) used the 5DC scale to measure curiosity in five dimensions (Kashdan et al., 2018). Despite the versatility of the 5DC scale, its application in game contexts could benefit from tailored adjustments to better capture in-game curiosity. Furthermore, establishing a clearer connection between the scale's dimensions and specific in-game behaviours could enhance its relevance for game design analysis. The subsequent study in 2021 by the same team (Gómez-Maureira et al., 2021) provided valuable insights into the exploratory behaviour, yet a broader scope could shed light on the additional facets of curiosity. Lastly, the comprehensive work by Schaekermann et al. (2017) presents a robust foundation; however, a rationale for the selection of the four types of curiosity examined would amplify their applicability to in-game curiosity categorisation. Additionally, while the case study on the game "Destiny" presents detailed findings, exploring a variety of games could enhance the generality of the results in different genres of games.

An adaptable, game-specific definition of curiosity, which is the crucial underpinning for any measurement of curiosity in specialised contexts, is lacking in the existing literature on in-game curiosity (Grossnickle, 2016), presenting challenges for the foundational rationale and the reliability of the research, highlighting a critical area for future inquiry.

3. Advancing the theory of curiosity in game design

Our research is centred around refining the study of curiosity, specifically within the games domain. Rather than redefining curiosity, we endeavour to investigate the multifaceted nature of how curiosity manifests and influences players in diverse game playing contexts. By honing in on game environments, our research sheds light on the intricate layers of player engagement and the various catalysts that incite curiosity during gameplay. In line with Grossnickle's definition, we define curiosity as the pursuit of knowledge and the reaction to a complex of interrelated stimuli such as novelty, complexity, ambiguity, challenge, and uncertainty, accompanied by emotional engagement, physiological arousal, or exploratory behaviour (Grossnickle, 2016). Specifically, our work focuses on identifying the distinct types and presentations of curiosity in games as a means to resolve a concrete challenge in game design: engineering games that effectively stimulate player curiosity. In addition, we adhere to the foundational, broad definition of curiosity, which may be useful for designers to better understand the relevance and application of the categories and manifestations we identify in their work.

The theoretical contribution of our study is twofold. The first element of our theoretical framework is grounded in the psychological perspectives on curiosity, integrating the physical, social, epistemic, and perceptual dimensions for its categorisation. Originating from the work of Dewey (1910) and expanded upon by Berlyne (1954), this categorisation serves as a comprehensive model for distinguishing different aspects of curiosity, which are readily applicable in the game context. It stands as a superordinate curiosity classification from which all subsequent categories are derived (Grossnickle, 2016), suggesting that any game curiosity classifications or manifestations we propose could align with these four foundational categories.

The second element of the framework is based on the curiosity classification framework derived from the groundbreaking attempts in game studies, that is, the model proposed by To et al. in 2016 (To et al., 2016), which divided curiosity in games into perceptual, manipulatory, conceptual, and adjustive-reactive types and curiosity about the complexity or ambiguity. This theory is based on a classic operational definition model of triggering factors for various types of curiosity in psychology (Kreitler et al., 1975), and curiosity classification in this definition is based on the first part of the framework. This represents a natural commonality and complementarity between the two parts of the theory. The affirmation of To et al.'s theory in recent studies on curiosity in games and the emphasis on the possibility of developing curiosity design methodology (Acevedo et al., 2022; Gómez-Maureira & Kniestedt, 2019; Schaekermann et al., 2017) ensure the reliability of the theory.

Drawing from these comprehensive frameworks, we initially identified six distinct categories of curiosity in games and then outlined the specific characteristics of each type, leveraging existing research into the multifarious nature of curiosity.

3.1. Perceptual curiosity

Perceptual curiosity stems from humans' desire to engage with the world through their senses, such as sight, smell, touch, and hearing (Berlyne, 1954). This form of curiosity manifests in games in three ways.

First, by incorporating relevant background sounds that synchronise with the game's events, it can evoke certain emotions, motivate player actions, and augment the immersive quality of the game (Collins et al., 2004). This can be achieved through background music, the integration of sound effects in action scenes, and the use of auditory cues such as drum rolls, cheers, and applause.

Second, by unveiling novel elements as a player progresses through the game, games can stimulate perceptual curiosity (Vidler, 1977). These novel elements could be the introduction of new levels, visually appealing items, treasure chests, or any features that diverge from the norm.

Third, by encouraging players to engage in exploration and experimentation, games can cater to this curiosity (Collins et al., 2004). Players' exploratory behaviour or experimentation can be facilitated through hidden missions or treasures strategically placed within the game landscape.

In summary, these strategies serve to stimulate a player's perceptions and emotions.

3.2. Manipulatory curiosity

The instinctive inclination to interact with objects for understanding their properties and functionalities results in manipulatory curiosity (Kreitler et al., 1975). In the context of gameplay, it primarily surfaces in the affinity to engage with physical game components such as game pieces. This could involve experimenting with unfamiliar game interfaces or deciphering the cause-and-effect relationship between the controller operations and the ensuing in-game movements (To et al., 2016).

Realising these concepts in game design could involve introducing a unique interactive item or an object with multiple functions that can satisfy this curiosity type.

3.3. Curiosity about complexity and ambiguity

Curiosity about complexity and ambiguity stems from the motivation to unravel and understand intricate and ambiguous situations or information. This curiosity type propels individuals to investigate complex or uncertain subjects in their quest for clarity and understanding (Kreitler et al., 1975).

In the domain of games, this form of curiosity can manifest as experimenting with different combinations, changing team setups, exploring variations in hit rates, directing against adversaries, or studying other players' tactics (To et al., 2016). The presence of such unpredictable elements promises continuous evolution as the game advances, thereby sustaining player engagement and curiosity.

3.4. Epistemic curiosity

Epistemic curiosity is characterised by the desire for deep knowledge acquisition and active pursuit for information (Kang et al., 2009), encompassing the inherent urge to understand the mechanism of how things operate (Litman, 2010).

In games, this curiosity arises by the quest for hidden strategies, uncovering Easter eggs, understanding unique game mechanics, or seeking information outside the gameplay context. Factors that trigger epistemic curiosity range from consciously designing a game antagonist resembling a renowned figure to mining deeper into the game to discover elements concealed from other players.

3.5. Adjustive-reactive curiosity

Adjustive-reactive curiosity pertains to the exploration of everyday environment (Kreitler et al., 1975). In the context of games, this form of curiosity arises when games allow interactions with objects mimicking reality, thereby enabling the player to execute mundane tasks and assess their authenticity. This further facilitates the acclimatisation of players with the game world and its rules (Caillois, 1961; To et al., 2016).

Examples illustrating these motivations include mundane activities such as sitting on chairs, navigating graphically rendered surroundings, and executing commonplace tasks. Unravelling the genesis of these motivations can be intricate, yet numerous games embodying such mechanics have garnered considerable success. A prominent instance of such games is "The Sims," a life simulation video game as implied by its nomenclature.

3.6. Social curiosity

Social curiosity encircles the inclination to glean information from dialogue or merely an impulse to learn about others. It can also manifest as a propensity to engage with the real world (Dewey, 1910; Renner, 2006). Living people are only part of the real world, which also includes real nature, history that happened, architecture that exists, and so on, and the tendency to associate with these things is also attributed to social curiosity.

Within the game domain, this form of curiosity encompasses communication between players, information exchange, virtual exploration in real-world spaces, exploration of the "reality scene" in games, search for online game guidance, and participation in game communities.

3.7. Future rewards maximization curiosity

In addition to the aforementioned six types of curiosity, we introduce a seventh type, inspired by the Gruber and Ranganath's study from 2019 (Gruber & Ranganath, 2019). This study delineated various objectives of introducing curiosity and the objectives that resonate with Grossnickle's refined definition of curiosity including novelty, complexity,

ambiguity, challenge, and uncertainty. Although novelty, complexity, and ambiguity are well represented within the six identified types of curiosity, the aspects of challenge and uncertainty had not been fully captured. To bridge this gap, we introduce the concept of "Future Rewards Maximise Curiosity" based on the theory of Dubey and Griffiths (2020). The hypothesis posits that curiosity serves as a mechanism for optimising future rewards. It describes a scenario where an agent is presented with a series of stimuli, each associated with specific responses. If the agent can recall and apply the correct responses upon future encounters with these stimuli, they are awarded points, thereby enhancing their score. Given the impracticality of mastering all correct answers, the essence of the model lies in prioritising responses to the stimuli with a higher expected value, signifying a greater likelihood of recurrence and memorisation.

In the domain of games, the agent is analogous to the player, the stimuli to game scenarios or targets such as enemies, and the responses to the desired outcomes or rewards. This theory can be elegantly integrated into games and is in harmony with the elements of challenge and uncertainty in the game context, where these aspects pertain to the players' strategic choices and their ability to triumph amid diverse challenges and uncertainties.

The rationale for adopting this theory lies in its exceptional applicability and empirical robustness. Machine learning agents developed based on this theory produce a curiosity curve that is consistent with the findings from all current empirical studies on curiosity (Dubey & Griffiths, 2020).

In essence, this form of curiosity is characterised by a motivation to maximise potential future rewards or gains. It is particularly pertinent in scenarios where decisions based on incomplete information at present can lead to substantial future benefits.

In the game design, this suggests that players explore various facets of a game or experiment with different strategies, seeking the most advantageous paths for future gameplay. This approach is commonplace in strategic and role-playing games, where optimising current actions and decisions can help players unlock hidden abilities, acquire valuable resources, or secure strategic positions.

4. Questionnaire design

The choice of a questionnaire as our primary research tool was driven by several key considerations. First, questionnaires allow for the collection of a large and diverse set of data efficiently, which is essential given our objective to explore curiosity across a wide range of game types and player experiences. This method enables us to gather detailed information on player habits, preferences, and perceptions on a scale that would not be feasible through other means such as interviews or observational studies. Second, the questionnaire format allows for anonymity and comfort for respondents, encouraging more honest and reflective responses, particularly regarding their gaming habits and preferences. Finally, the structured nature of a questionnaire enables us to systematically categorize and analyze the manifestations of curiosity in gaming, providing a solid foundation for our exploratory factor analysis.

Given the pursuit of a generalized outcome, filtering demographic details from participant responses was not allowed in this study. We acknowledge the demographic bias of our survey respondents. The diverse platforms used for distribution, including social media, may have introduced variances in age, gaming preferences, and cultural backgrounds. This diversity could influence the study's findings, especially in terms of game choice and perceived curiosity elements. However, in order for the data to fulfil the element of generalisability, we used an anonymous questionnaire in this study and did not perform further disaggregation. This shortcoming is not something that must be borne in subsequent segmentation studies.

The questionnaire was crafted to allow participants' freedom of choice, imposing no restrictions on the types or names of games for evaluation and discussion, provided they align with the criterion of "the game that appeals the most to you." This approach ensures the collection of a diverse range of data interpretations of "games" (e.g., video, board, RPG, sports, etc.), thereby advancing our understanding of different game preferences.

We synthesised responses from a meticulously structured game questionnaire. These responses primarily belong to one of the two categories:

1. Self-reported data, which details participants' game habits:
2. Game Genre, game Locale, Length of Experience, Length of Play session, Daily game Schedule.
3. Participants' assessments of the manifestations of the seven types of game-based curiosities, as delineated in the previous section, within their selected game.

Participants were prompted to select the game they found most captivating. This survey, uniquely tailored for our research, strategically omitted the explicit mention of "curiosity." This conscious decision was influenced by previous studies like Gómez et al. (2019) [30], which adhered to the psychological definition of curiosity but faced interpretative ambiguities due to the term's absence in their survey tool. Such ambiguities arose from the tendency of individuals to equate curiosity predominantly with exploration (Kashdan, 2009).

Our approach aimed to mitigate this by using indirect yet purposeful language. We hypothesized that the core essence of curiosity inherently enhances a game's appeal to its players. Thus, the survey question was deliberately formulated as "Which game do you find the most attractive?" This rephrasing was designed to subtly evoke elements that spark curiosity, without overtly mentioning it, thereby eliciting authentic responses that better represent the inherent allure of the games.

In general, the choice to indirectly measure curiosity, rather than asking participants directly about their curiosity

levels, was made to capture a more genuine reflection of curiosity as it manifests in gaming behaviour.

In line with our aim to comprehensively evaluate the multifaceted nature of game-based curiosity, the survey probed whether participants recognized and valued specific curiosity-driven features in their selected games, aligning with our categorization of seven types of curiosity (see Table 2).

Finally, to gauge Future Rewards Maximization Curiosity, the survey posed the targeted questions for the following objectives: (1) It allowed participants to express if they can clearly understand the impact of their choices and actions within the game. (2) It queried whether players could recognise objectives varied by difficulty levels, time investment, and associated rewards, and which objectives they found most and least compelling. (3) It sought insights into which attributes, such as difficulty, time investment, or rewards, if altered, would significantly increase the appeal of the least appealing objectives.

5. Questionnaire data processing

In compliance with ethical research practices, this study adhered to the necessary ethical guidelines for conducting human research. Approval for this research was obtained from the University of York's Human Research Ethics Committee. All participants in this survey were provided with detailed information about the study's purpose, methods, and data handling procedures, and their informed consent was obtained prior to participation. No personal data that could lead to the identification of individual participants were collected. Furthermore, participants were not offered any remuneration or rewards for their participation in the study, ensuring voluntary and unbiased engagement throughout the research process.

In this study, the questionnaire ran from June 2023 to August 2023. We used an online questionnaire created with Qualtrics to conduct the survey and circulated the questionnaire via a shared link. The primary channels for distribution included various social media platforms such as Facebook and X (formerly known as Twitter), as well as personal networks for recruitment. Furthermore, given our unique background, the questionnaire was also distributed on Chinese Internet platforms, allowing us to access a more comprehensive and larger dataset of players. In our study, we used a hybrid sampling method. We primarily targeted gamer communities and media platforms through purposive sampling, focusing on individuals relevant to our research topic. Additionally, we employed convenience sampling by reaching out to participants through general channels. This combined approach helped us gather focused data while also expanding our reach. Initially, a total of 643 responses were collected. To ensure the quality and reliability of data, a 3-tier screening process was enacted, which included response time screening, long-string analysis, and semantic testing. These screening methods were designed with reference to specific literature. For response time screening, a threshold time of 2 s was set for each question (Huang et al., 2012), and any responses lesser than 2 seconds were considered invalid. In long-string analysis, the repetitiveness of responses in the numerical sections was evaluated; the responses were deemed invalid if more than a half of the consecutive responses in the numerical sections were repetitive (Curran, 2016). Semantic testing involved two specific questions related to future rewards maximisation curiosity. The consistency of responses to these questions was checked to ensure data reliability (Curran, 2016). After screening, 482 responses were considered valid and used for further analysis.

For the collected game name text data, we processed them using a text matching algorithm to ensure their standardisation to official names, thereby avoiding name confusion. For series games, we catalogued the series name. While this approach disabled the possibility of analysing a few individual games, we considered this treatment acceptable owing to a low frequency in the data and because series games tend to follow the same set of game design logic. For the same reason, we did not differentiate between the names of the different platform versions of a game, such as PC and mobile versions. However, we retained the classification of the games chosen by the participants for further analysis.

In the 482 valid responses collected, Honour of Kings (HoK) was identified as the most frequently chosen game by 230 participants. This necessitated a discussion on whether the participants who chose HoK should be considered a distinct group, especially in the evaluation of the seven types of curiosity. The group that chose HoK might provide answers inconsistent with those of other groups. To address this concern, data verification and processing were deemed necessary.

Table 2. Dimensions of curiosity and their manifestations in games.

Dimension of Curiosity	#	Manifestation in Games
Perceptual Curiosity	1.	Ambient sounds align with the situation.
	2.	New emotional scenarios/items appear as the game progresses
	3.	Rewards for full exploration
Manipulatory Curiosity	4.	Availability of interactive objects for specific purposes
Curiosity about Complexity and Ambiguity	5.	Complex in-game elements with uncertain outcomes
	6.	Game elements resulting in unpredictable outcomes
Epistemic Curiosity	7.	Mechanics or Information beyond Basic Tutorials
Adjustive-Reactive Curiosity	8.	Interactions with real-world-like objects to verify in-game expectations
Social Curiosity	9.	Opportunities to interact with other players/characters
	10.	Benefits of real-world interaction
	11.	Player community sharing information
	12.	Multi-player gameplay options
Future Rewards Maximization Curiosity	13.	Choices affecting future gameplay

Table 3. Numerical columns with significantly different analyzed result values.

Variable	*p*-value	*d*-value
Perceptual.2	.0226	.0497
Perceptual.5	.0050	.1425
Perceptual.8	.0084	.1538
Epistemic.1	.0131	.1838
Epistemic.2	.0010	.2928
Future rewards.2	.0442	.0536

Table 4. Categorical questions with significant differences and their analytical values.

Variable	*p*-value	*V*-value
Game Experience	.00008	0.203
Time in Game	.00002	0.194
Morning (Time in a Day)	.0019	0.096
Afternoon (Time in a Day)	.0014	0.102
Night (Time in a Day)	.0025	0.092
Perceptual	.00004	0.156
Perceptual.3	.0007	0.115
Perceptual.6	.0001	0.180
Manipulatory	.0002	0.167
Complex or Ambiguous	.0004	0.157
Complex or Ambiguous.3	.0002	0.134
Epistemic	.0001	0.182
Adjustive-Reactive	.0009	0.147
Social	.0022	0.096
Social.3	.0025	0.093
Social.6	.0003	0.129
Social.9	.0012	0.108
Future rewards.3	.0001	0.188

The survey data comprised not only categorical text data but also non-normally distributed numerical values. Therefore, we applied the Mann–Whitney U test to the numerical columns and used Cohen's *d* to measure effect sizes. In certain numerical columns, questions would be skipped if the participants chose "no" in response to the existence of specific types of curiosity designs in their selected games, resulting in missing values. These missing values were non-random, and the data were not uniformly distributed. Therefore, multiple imputations were used to fill in the missing values, a robust method under such circumstances. The application of multiple imputations for handling missing data was chosen due to its robustness in dealing with non-random missing values. This method involves creating several complete datasets by filling in missing values with plausible data points and then combining the results to produce comprehensive estimates. This approach enhances the validity of our findings, ensuring that the conclusions drawn are not biased due to incomplete data. (Lazzeroni et al., 1990; Van Ginkel, 2010). The results are presented in Table 3.

The p values and Cohen's *d* for these columns were low, which implied that although the data were statistically significant, the differences were not practically meaningful. In other words, for at least these numerical columns, we can consider the two groups as one.

For categorical questions, such as the time chosen to engage in the game and whether the players believe that a certain type of curiosity design exists in the game, we used chi-square tests and measured the effect size using Cramer's V. The results are presented in Table 4.

The results indicated that the differences between the two groups in the categorical columns were significant. Thus, we chose to treat the two groups (HoK players and other participants) separately when considering these categorical questions.

6. Results of questionnaire data

6.1. Comprehensive analysis for part I

General player characteristics were as follows:

- Game Type: Most (68%) of the respondents showed a preference for Mobile Games, while 17% leaned toward PC games.
- game Venue: The home emerged as the predominant venue for game activities.
- Duration of experience: Almost half of the participants (48%) have been immersed in the game world for 4–7 years, with a notable 24% having a shorter game period of 1–3 years, and a minority (4%) having a rich experience of over a decade.
- Play Session Length: The majority (67%) typically engage in games for intervals of 1–2 h, whereas 16% were engaged for 2–3 h.
- Frequency of play: A predominant portion of the participants, accounting for 48%, have been engaged in game activities 2–3 times a week, whereas approximately 25% people played 4–5 times a week.
- By combining the first two figures and taking the median of the options, an overall average of the time spent by the participants in playing was calculated as approximately 5.28 h per week.
- Daily game Window: The afternoon sees the highest game traffic with 57% of respondents playing during this time, closely followed by the night with 47% of the players. The morning game was relatively less popular, attracting only 12% of the players.

6.2. Analysis of selected games and corresponding curiosity dimension scores

For the second part of the questionnaire, we collected 87 different game titles, of which the top 10 (in terms of frequency and percentage) are listed in Table 5. To ensure data representativeness and statistical stability, we analysed only the top 10 games in terms of frequency of occurrence and focused on the top five games in terms of frequency of occurrence for discussing specific games as variables.

While analysing the questionnaire results, we obtained 26 numerical columns, which were grouped two by two, as shown in Figure 1. Each group corresponded, in turn, to the participant's score for each manifestation of the same curiosity in Table 2. Within each group, the first column showed the participants' rating of how well or poorly the corresponding manifestation of that curiosity was designed in the selected game, and the second column showed the participants' rating of how much the introduction of such a design in the game would enhance the appeal. As shown in Figure 1,

the median score for all curiosity design dimensions was 8, and the mean score ranged between 7 and 8.

Based on the top 10 games and their rating by the participants who chose them for each curiosity design, a heat map was plotted, as shown in Figure 2. In the heatmap, the chromatic gradation, transitioning from a deep blue (indicative of scores closer to 5.0) to a pronounced red (suggestive of scores nearing 9.0), serves as an intuitive visual indicator, allowing swift comparative assessments. Several salient observations can be discerned regarding the weighted average scores attributed to each game in various calculated columns. First, a significant clustering of scores is evident within the range of 7.0–8.5, indicating a marginal variability in the ratings amongst the majority of the games. The consistently high performance of "War of Three Kingdoms The Card Game" is the most striking feature, especially within the "Perceptual.2" metric where it boasts a score of 9.43, suggesting a favourable reception during that specific evaluation period. In contrast, the game "Basketball" manifests a considerable fluctuation in its ratings, ranging from 5.86 to 8.14 in the columns, indicating a great deal of inconsistency in the attraction experience of players in different dimensions. "Genshin Impact" exhibited remarkable stability, consistently obtaining scores >8.0 in the matrix, reinforcing its sustained popularity and acceptance within the game community. An intriguing anomaly is the metric "Future rewards.2," in which every game surpassed the benchmark of 7.0. Finally, two patterns were observed in the heatmap for these most mentioned games; the first was the steadily fluctuating ratings in each column within a range, and the other was large fluctuations, which may be because of differences between the amount of data for individual games.

Table 5. Frequency and percentage of the top 10 values in the game column.

Game Name	Frequency	Percentage (%)
Honour Of Kings	230	47.72
PUBG	38	7.88
League of Legends	21	4.36
Egg party	13	2.70
Genshin Impact	13	2.70
frisbee	8	1.66
Basketball	7	1.45
Crossfire	7	1.45
War of Three Kingdoms the Card Game	7	1.45
Crazyracing Kartrider	7	1.45

6.3. Factor analysis of curiosity-based numeric results from the questionnaire

We further sought to validate the efficacy of the novel scale developed in this study to measure curiosity within the realm of games. Analogised as a unique ruler designed exclusively for gauging curiosity, we ensured its accuracy and consistency prior to utilisation. Because the reliability of our classification system has hitherto remained untested empirically, we conducted an exploratory factor analysis (EFA) to determine the inherent associations between the studied variables.

Recognising the aptness of our data for the intended analysis, a preliminary Kaiser-Meyer-Olkin (KMO) test was executed to confirm the sufficiency of sample size vis-a-vis factor analysis. A KMO value of 0.695 substantiated the suitability of our data for factor analysis. Bartlett's Test of Sphericity demonstrated a statistically significant p value (<.001), suggesting strong correlations between the variables, thereby validating appropriateness of the data for factor analysis.

Subsequently, a Scree plot was generated, with eigenvalues on the y-axis, to ascertain the number of factors potentially constituting our scale. Visual representation suggested that our scale could be sub-divided into 2, 10, or 13 discrete factors. We employed varied rotation methods to investigate these possibilities by observing how items on our scale loaded onto these factors. Varimax rotation presumed factor

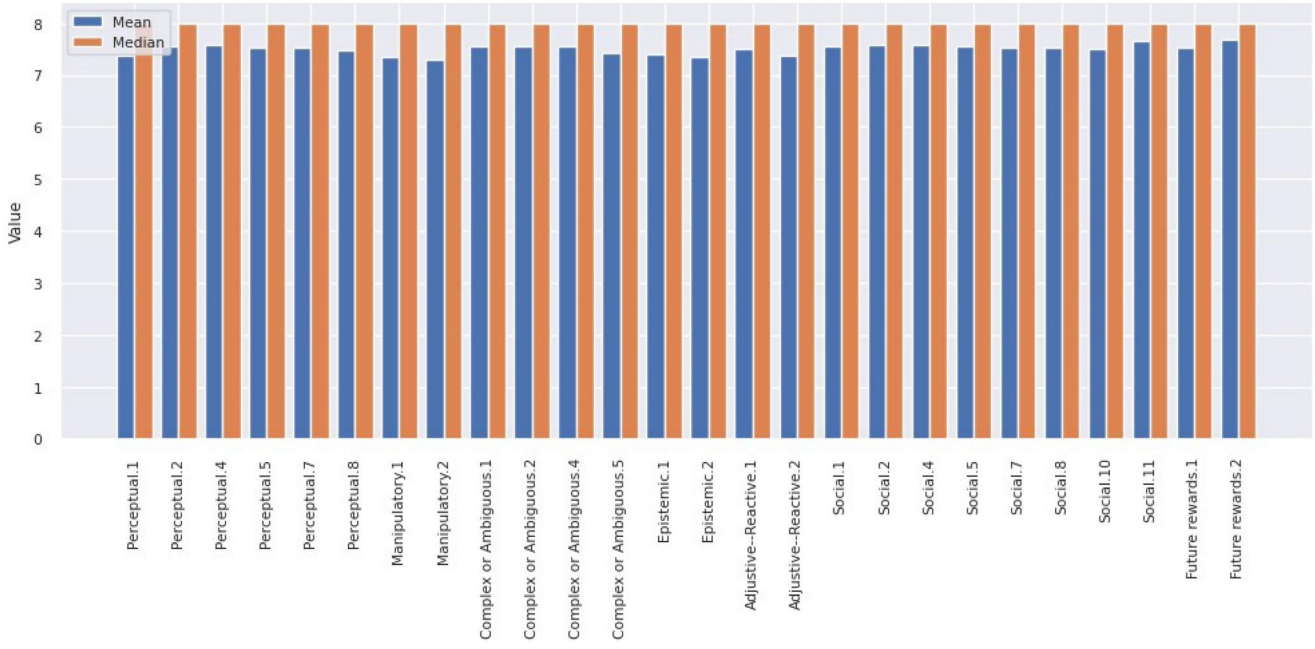

Figure 1. Mean and median of each non-text column in questionnaire.

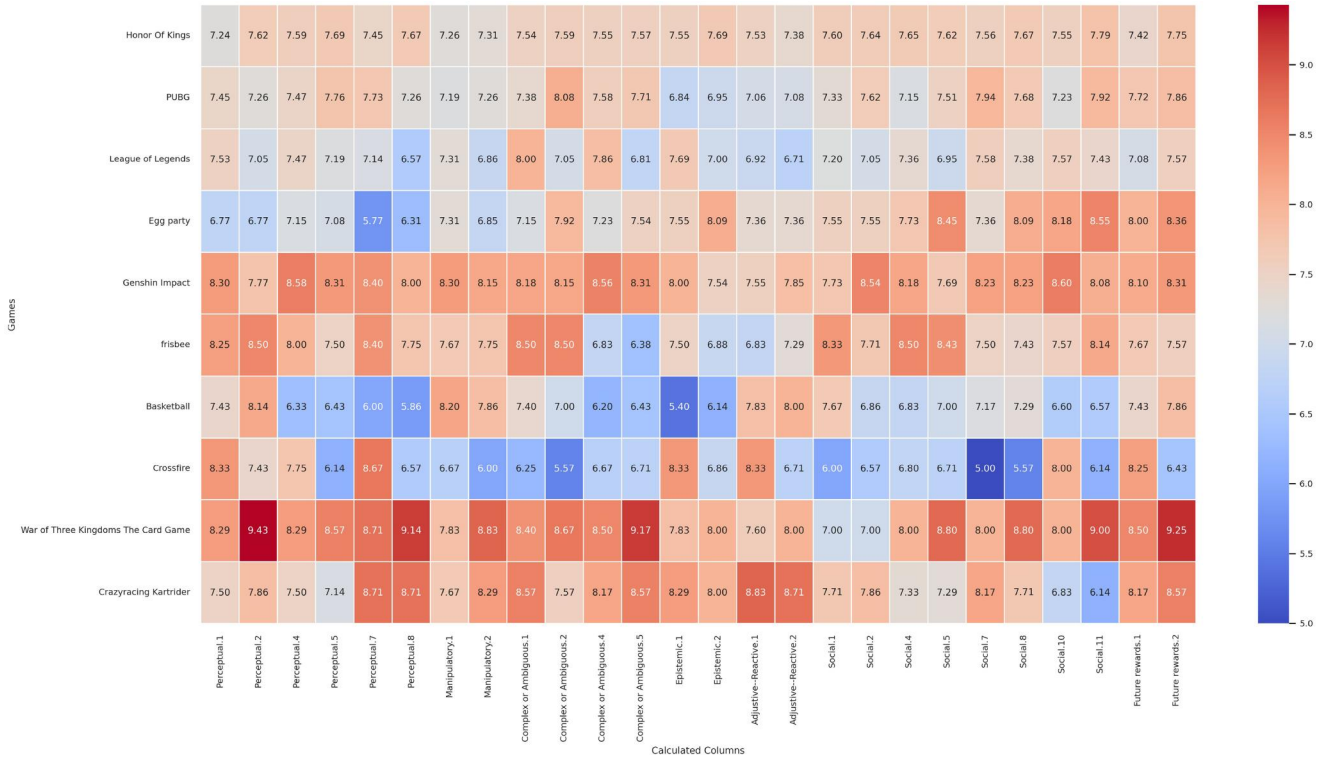

Figure 2. Weighted averages for each of the top 10 games in calculated columns (filtered).

independence, whereas promax rotation permitted correlation amongst factors, and our subsequent heatmap visualisation portrayed the distinct yet consistent factor structure subject to the statistical assumptions.

Following meticulous scrutiny, a 13-factor structure demonstrated the most coherent interpretation of our scale, visually represented in Figure 3. The factor structure under orthogonal (varimax) and oblique (promax) rotations exhibited factor consistency, albeit the positions varied based on rotation method, indicating that factor relationships fluctuate according to the rotation method.

Despite the observed correlations, these factors may still be treated as independent explanatory variables, specifically in case of moderate correlations. A confirmatory factor analysis (CFA) using oblique rotation further corroborated this notion, supporting the independence of these factors, as indicated by the factor correlation matrix (Phi matrix) produced during the analysis. To further ascertain these findings, we performed a CFA employing these 13 variable clusters to structure the 13 factors. We harnessed the "semopy" library (Semopy Developers, 2023), whose default setting for CFA models indicated no correlation amongst the latent factors (with a covariance of 0). The resulting fit indices indicated a solid model fit:

- CFI: Value 0.927635
- TLI: Value 0.893581
- RMSEA: Value 0.060713

In summary, our findings confirmed that 13 independent factors constitute the most practical structure of the developed scale and provide a nuanced understanding of the multifaceted nature of game-based curiosity. Each factor represents a distinct dimension of curiosity, as it manifests in gaming. These factors range from aspects related to game mechanics and design to player psychology and behaviour. The practical implications of these factors are critical for game designers, as they offer targeted avenues for enhancing player engagement and curiosity. For example, one factor may represent the curiosity aroused by game narratives, while another may reflect the curiosity driven by social interactions within the game. Understanding these distinct factors allows for more precise and effective incorporation of curiosity-inducing elements in game design, aligning with the study's objectives to elucidate the complex role of curiosity in gaming experiences.

6.4. Data interpretation for "future rewards maximisation curiosity"

In the analysis of questionnaire responses, emphasis was placed on the discrete category "Future rewards.3" because of the marked divergence between the participants' responses, especially when considering those who chose HoK versus those who did not. Specifically, 31.1% of participants who chose HoK responded "Yes," in contrast to 50.6% of non-HoK participants, underlining a profound disparity in their understanding of the consequences of their in-game choices. This categorical distinction is a remarkable finding of this study; however, due to space and thematic constraints, this study does not discuss all the significant disparities identified in different categories, which we aim to explore in future research. We determined that excluding a specialised discussion of these additional categorical findings

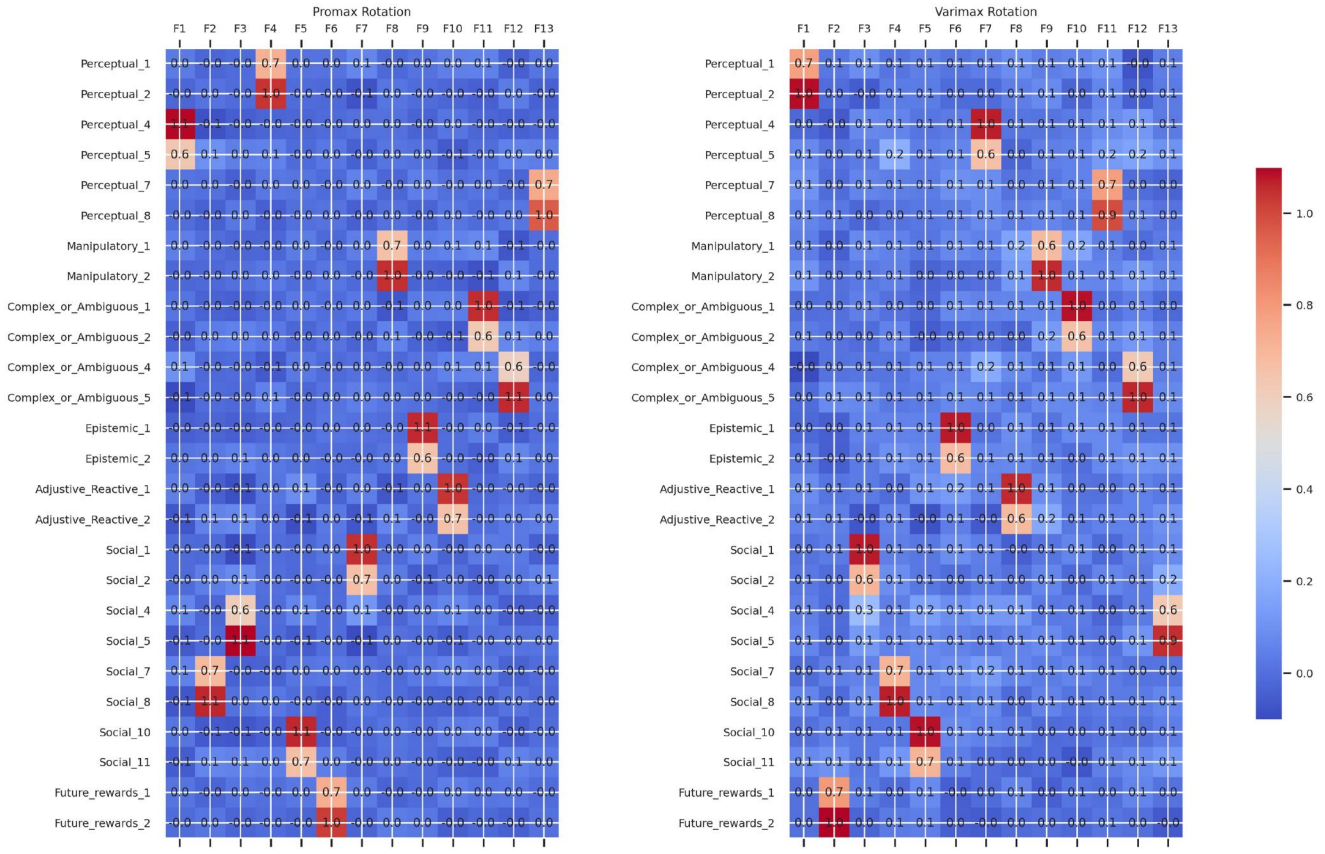

Figure 3. Exploratory factor analysis of 13 factors.

does not detract from the analysis and conclusions presented in the study.

Analysing the preferences revealed by the penultimate questionnaire questions, about objectives with varied levels of difficulty, time investment, and rewards, we observed that a notable 59.6% of the participants preferred challenging and time-intensive objectives with high rewards, while 60.5% showed a decreased interest in less demanding objectives characterised by a low difficulty level, rewards, and time investment. The objectives with medium difficulty attracted an average interest from 47.8% of the respondents.

In addressing the preferences for goals rated "far below average," the participants exhibited diverse inclinations. For high-difficulty level objectives with significant rewards and time requirements, 50% of the participants preferred to reduce the difficulty ("difficulty down"), while 20.4% wished for a reduced time commitment ("time taken down"). In terms of medium-difficulty objectives, preferences varied: 35.7% were in favour of increased rewards ("benefit increase"), 21.4% or more challenge ("difficulty increase"), and 17.9% for decreased occurrence ("frequency of occurrence down"). For objectives with a low-difficulty level, rewards, and time consumption, most participants (64%) sought higher rewards ("benefits up"), and others indicated a preference for greater difficulty (17%) or reduced frequency (16%). These findings offered a nuanced understanding of the elements considered essential by participants in enhancing the appeal of various objectives perceived as "far below average."

7. Findings and discussion

7.1. Reflection on the general data from part I

First, despite the inclusivity of diverse forms of games in this study, ranging from card games to sports, the data showed the predominant appeal of mobile games amongst players. This prevalence might not be exclusively attributed to the intrinsic allure of the games but rather correlated with the contemporary avenues through which players access games and the time they can allocate for game engagements. The direction and extent of curiosity's role on the mobile gaming side of the equation is perhaps different from elsewhere as a result. However, this phenomenon underscored the imperative for an intensified scholarly focus on mobile game design. Academic exploration in this realm is not consistent with the elevated status and proliferation of mobile games in the current game landscape.

Second, the data indicate a discernible decrease in the duration of weekly game sessions compared with previous studies (Evans et al., 2023; Kraemer et al., 2022; Neily et al., 2022; Sauter et al., 2021). This decrease may partly be due to variances in the individual circumstances of the participants and potential inaccuracies in estimations, particularly because of the exclusion of outliers. Nevertheless, this significant decrease also reflected the context of mobile games and fragmented time. The finding suggests a shift and fragmentation of attention amongst players, highlighting the importance of incorporating curiosity-stimulating designs to enhance the appeal of games.

7.2. Analysis on participant-selected games and the scores for each curiosity dimension

Of the 87 games analysed, the 10 most discussed shared a critical element: the incorporation of multiplayer competition. Multiplayer competition not only sparks social curiosity, but also incites challenges and uncertainty, which are essential to fostering a deeper form of curiosity. These games elicit social curiosity through interactions, epistemic curiosity about game victory logic and competitive tactics, and strategic curiosity for optimising actions to maximise future rewards.

The nature of curiosity stimulated here diverged from the manipulatory and adjustive-reactive forms. Rather than being fleeting or momentary, this form of curiosity reflected a sustained, long-term engagement and exploration of the game's possibilities and mechanics. The boundless scenarios presented in multiplayer modes further protracted the exploration, preventing quick exhaustion of the game's potential, mechanics, and content. This phenomenon elucidated the commonality of multiplayer competitive modes in the top 10 most captivating games and signified the indispensable role of a robust multiplayer competitive element in maintaining the long-term appeal and engagement of a game.

Furthermore, the most attractive games are not necessarily synonymous with the highest-quality games. The absence of renowned high-quality games such as "The Legend of Zelda" and the "GTA" series from the list of preferred games suggests that exceptional games do not invariably retain player engagement over time. The way curiosity works and takes off in games may not be directly related to the quality of the game itself but rather based on some more direct and simple logic. For example, the variables that multiplayer modes can bring to the table by their mere existence can greatly stimulate curiosity. These good games might be viewed as brilliant but transient meteors, whereas games capable of nurturing key aspects of curiosity, like social curiosity or curiosity about complexity and ambiguity, may foster a more enduring player commitment and engagement, providing insights for the consideration of this aspect in commercial game evaluation.

Examination of the mean and median scores showed commendable performance of the selected games in various dimensions of game curiosity. This observation was substantiated by two key findings: first, all games secured scores exceeding seven, qualifying as respectable ratings; second, the ratings corresponding to each curiosity dimension aligned closely with the participants' perceived enhancement of game appeal due to design aspects tailored to those dimensions. The widespread high scores in multiple dimensions aligned with the expectations, as the participants were asked to select games that they deemed the most captivating. A uniform distribution of substantial scores in various dimensions, juxtaposed against the overall allure of the game, reinforces the validity of the measurement approaches adopted, suggesting the lack of major discrepancies and oversights in the prevailing theories of game design or the curiosity models articulated in this study. These findings suggest that game designers should focus on incorporating multiplayer competition elements, which not only spark social curiosity but also challenge and uncertainty, essential for a deeper form of curiosity.

7.3. Findings and discussion for factor structure of the curiosity numerical results section of the questionnaire

A clear inference was drawn from the factor analysis. Curiosity in the game is not solely encapsulated by seven autonomous types; for players, each kind of curiosity is manifested uniquely within the game, and these manifestations are likewise independent. In other words, to stimulate the player's curiosity and enhance the game's appeal, at least 13 different facets should be considered for refinement. Furthermore, these facets do not significantly overlap or interfere with each other, offering a clear delineation of categories for toolkits. This discovery is pivotal in fulfilling our research aim of developing a nuanced understanding of curiosity's various manifestations in game design.

7.4. Findings and discussion for data results for additional questions on future rewards maximisation curiosity

According to the preliminary results, the participants who selected HoK expressed a discernibly lower inclination to affirm clarity in predicting the consequences of their in-game actions and choices than those who selected other games. This may be attributed to infusing a degree of uncertainty within HoK's gameplay mechanics, where players confront ambiguities about the assurance of desired outcomes resulting from specific choices or actions. Considering HoK's dominance in the selection and an average affirmation rate of 50.6% from participants regarding the appeal of other games, we infer that such a strategy can effectively enhance the game appeal. The aforementioned approach sustained player engagement by continually evoking the "Future Rewards Maximisation Curiosity." The game maintained sustained allure by maintaining an optimal level of uncertainty, corresponding to the repeatedly corroborated U-shaped curiosity fluctuation curve in comprehensive curiosity research. This implied that curiosity escalated when individuals perceive a partial yet incomplete understanding of a subject, in accordance with previous research findings (Metcalfe et al., 2023; Spitzer et al., 2023). This feature is necessary for game design with reference.

In the evaluation of the concluding questions, initial observations uncovered a significant player preference for objectives that present challenges and offer substantial rewards, showing diminished player interest in the objectives perceived as low-value. The insights from these questions uncover three dominating player preferences within the game's objective landscape:

- Preference for High-Return Objectives: The participants unmistakably preferred the objectives associated with high returns. This preference aligned seamlessly with the

innate essence of "Future Rewards Maximisation Curiosity." The pursuit of heightened returns emerges as a central player trait.

- Aversion to Time-Consuming Objectives: A universal sentiment amongst the participants leans towards reducing the time commitment required for objectives. A preference for the decreased occurrence of such objectives indicated an inclination towards goals that prevent prolonged engagement, consequently nurturing a player experience devoid of burdensome, time-intensive pursuits.
- Affinity for Challenge-Infused Objectives: A substantial trend amongst the participants emphasised the appeal for challenging goals. The attractiveness associated with the intrinsic challenge embedded within objectives was tangible, regardless of the prospective returns, enhancing their appeal even in the absence of significant rewards.

These articulated preferences support each other, emphasising the critical influence of high returns, efficient time management, and intrinsic challenges in maximising player attraction and retention within the game environment. Also, players' attitudes towards different target characteristics can be taken into account in further research or game design.

8. Limitations and Future research directions

In addition to considerable contributions to the understanding and categorisation of curiosity within the game, this study offers several pathways for future research, which can be summarised as follows:

Inconsistencies in Participant Responses: Each subcategory of curiosity allowed us to inquire whether participants viewed such elements within their chosen games. If a participant chose "no," we omitted subsequent questions regarding that particular type of curiosity. Ideally, participants' responses on a singular game should demonstrate a high degree of consistency. Nevertheless, substantial disparities in the feedback were observed for certain games. This pattern did not arise within games with larger datasets such as HoK and PUBG. Hence, we were uncertain whether insufficient data from specific games or participants' misunderstanding of the questionnaire language accounted for these inconsistencies. Therefore, it would be necessary to conduct a more comprehensive investigation involving a larger participant pool to confirm the results' stability.

Cross-Platform Version Considerations: We included different platform versions of games in our study, while acknowledging the potential value of distinct analyses. A future research trajectory could target player platform preferences and aim to understand how games adapt their engagement strategies across multiple platforms, including curiosity induction.

Sport Games and Their Implications: Our data showed that analogue sports games, such as basketball, were recurrently selected, complying with our initial intention of surveying across game genres. These unique games offer meaningful elements divergent from general video games, offering variable experiences based on play conditions and companionship. Exploring how these long-standing games stimulate player curiosity could provide beneficial insights for future game design, meriting a more in-depth investigation.

Lack of a Persuasive Overall Conclusion from Game Rating Analysis: Despite generating rating graphs for the top 10 games, a persuasive overall conclusion could not be reached. The stability of average scores in games with large datasets, which rarely displayed outliers, posed an issue. Consequently, outlier analyses for selected games risk being insignificant or attributed to inadequate data. Subsequent research should expand the dataset or engage in separate analyses for a more comprehensive understanding.

Factor Analysis: Orthogonal vs. Oblique Rotation: Positioning of the factor space during factor analysis varied between orthogonal and oblique rotations, yet the factors remained independent. This difference hinted at a potential discussion around the independence of factors and the sophistication of the theoretical model. The results suggested that the manifestation of curiosity could be intricately complex, implying a need for a nuanced theoretical model in game design. Future research directions can explore the impact of inter-factor relationships on game design and player behaviour or test the universality of these factors in different cultural and game contexts.

Lack of Qualitative Work: This study primarily utilized quantitative methods, which limited our exploration of deeper cause-effect relationships in player curiosity. Future research should integrate qualitative approaches, such as player interviews, to complement our findings and provide a more comprehensive understanding of curiosity in gaming contexts.

An In-depth Exploration of the Seven Types of Curiosity: Although we have already made clear distinctions and definitions of the seven types of curiosity embedded in games in our research and have also preliminarily explored their applications and possibilities in game design. However, there is undoubtedly a great deal of room for exploration within these categories of curiosity, and this would be a clear direction to explore.

In addition to the seven types of curiosity identified in our study, it is important to recognize the broader context in which game curiosity operates. The role of marketing and player expectations, especially in well-established game franchises, cannot be overlooked. Marketing campaigns and pre-release information shape players' anticipatory curiosity, influencing their expectations and engagement with a game. For instance, the excitement generated by teaser trailers or developer interviews can significantly amplify curiosity about game content and features.

Similarly, the advent of emerging technologies in game design presents new avenues for stimulating curiosity. Augmented reality games like Pokémon Go have demonstrated how blending the digital and physical worlds can create novel, engaging experiences, driving curiosity in ways traditional gaming platforms might not. The potential for generative AI in game design also hints at a future where

player interactions and game environments can be dynamically tailored, further enhancing the curiosity and engagement of players.

While our research primarily focuses on the intrinsic types of curiosity within game environments, acknowledging these external factors—marketing, player expectations, and technological advancements—provides a more holistic understanding of the complex interplay of elements that foster and sustain curiosity in the realm of game design.

9. Conclusion

This research thoroughly examined curiosity in-game environments, providing valuable insights for the game industry and academics. Based on the experiences of 482 players, we identified seven broad categories of game-related curiosity and introduced 13 key performance dimensions critical for developing engaging games that can secure sustained attention and long-term involvement of players. Our findings underscore the importance of games that encourage social interaction and offer strategic challenges and skilfully balance uncertainty with the promise of rewards, offering insights critical to advancing our framework's objective of enhancing the understanding of curiosity in game environments.

Notably, this study presents the concept of future rewards maximisation curiosity, a newly recognised type that holds high relevance to game strategies and player engagement. Our understanding of player motivations has the potential to inform more effective and targeted game design strategies.

Our analytical approach, encompassing factor analysis and various statistical tests, offers a robust structure within our framework for dissecting the multifaceted nature of curiosity in games. This approach aligns with our research objectives, highlighting how game design strategies can be optimized to evoke curiosity and enhance player engagement. Although the proposed theoretical model of curiosity needs to be further developed, this study laid the groundwork for future research to explore these areas in detail. We advocate for an expanded investigation into the nuances of curiosity across various game platforms for a more intricate understanding of player engagement with games, potentially integrating qualitative research methodologies, and considering the impact of game ratings.

Ultimately, our research provides a basis for the creation of immersive and gratifying game experiences using curiosity as a powerful engagement mechanism. The academic significance of our research lies in its contribution to the burgeoning field of game studies, particularly in understanding player psychology. Our identification of seven categories of game-related curiosity and 13 key performance dimensions offers a new lens through which academics can study player behavior and game design. This framework can guide future research in developing more refined theories of player engagement and satisfaction. From an industrial perspective, our study provides actionable insights for game developers. By understanding the nuanced aspects of player curiosity, game designers can create more engaging and immersive experiences, potentially leading to higher user retention and commercial success. Our findings about "future rewards maximization curiosity," in particular, offer a novel approach to game design that aligns player motivations with game objectives, enhancing player engagement and long-term commitment to the game.

In conclusion, this study posited that tapping into the diverse aspects of curiosity can lead to enriched, more engaging game experiences. With the evolution of the game industry, the synthesis of design, player psychology, and technological advancements can amplify the role of curiosity in shaping the future of game engagement.

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