IEEE Access
Multidisciplinary : Rapid Review : Open Access Journal

Received April 13, 2021, accepted April 22, 2021, date of publication April 27, 2021, date of current version May 5, 2021.

*Digital Object Identifier 10.1109/ACCESS.2021.3075954*

# Objectivity and Subjectivity in Games: Understanding Engagement and Addiction Mechanism

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This work was supported by a grant from the Japan Society for the Promotion of Science, in the framework of the Grant-in-Aid for Challenging Exploratory Research under Grant 19K22893.

**ABSTRACT** The gaming industry had rapidly been expanding globally, where it encompasses more than the purpose of recreational and increasingly becomes more immersive and engaging, and potentially leads to pathological gaming behaviors that lead to addiction. Such experience of engagement and addiction involves understanding the fundamental functions of the human mind's dynamic state. This study uncovers the mind's underlying physics via the analogy of motion (i.e., mass, velocity, etc.) using games as the source of information. This study also conjectures that the law of conservation in mind occurred in games where momentum and energy were conserved over time, where game-playing experience relative to the gambling psychology and perceptive force were identified from the objective and subjective perspectives. It was found that momentum conservation provides new engagement measures while energy conservation, considering several other factors, provides the necessary components of understanding the addiction mechanism in the game-playing context. This measurement is examined in various domains, such as popular boards and sports games, and public gambling, where its effectiveness is determined.

**INDEX TERMS** Gaming, user experience, addiction, engagement, motion in mind.

## I. INTRODUCTION

The gaming industry is an industry that undergoes continuous innovation and rapidly expands on a global scale [45]. While games can exist in many forms, it is essential to distinguish what constitutes 'video game,' specific to this study's scope. Game and gaming can generally be defined as the activity and action of playing games, respectively. In recent years, video games had been increasingly linked with potential benefits from the perspective of social, cognitive, and motivational [27]. Although playing games for recreational purposes could promote relaxation, challenge, and socialization [88], unrestricted gaming may become counter-intuitive where vulnerable individuals could be exposed to pathological gaming behaviors [12] and ultimately be addicted [45].

Generally, video games involved five interrelated focal points: familiar medium (i.e., screen or computer monitor), creative artworks (i.e., animation, narrative), professional artists (i.e., designer, programmer), creation influence (i.e., society, corporations), and target audience (i.e., players) [6]. The term 'video game' was used as an umbrella term to represent the myriad games, both online and offline, that can be played across devices (laptops, gaming consoles, mobile phones) with varying levels of engagement represented by different manifestations of the cyber-gaming playground (''digital-gaming'' or ''video-gaming'') [38]. With the advent of the ubiquitous computing platform and its interfaces [71], many games were transformed into an online platform and blurring the boundary between real and virtual experience. Meanwhile, Nitsche discusses video games by expanding such terms into canonical space experiences divided into five conceptual planes (rules, mediation, fiction, play, and social spaces) [62]. Since board games, sports, and public gambling games existed that conform to Nitsche's scope, this study considered them as part of the 'video game' form.

Video game addiction had followed many work proposal of inclusion as a provisional status of ''internet gaming disorder'' (IGD) in the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) [4] and

The associate editor coordinating the review of this manuscript and approving it for publication was Taehong Kim.

was recognized as an official disorder adopted at the World Health Assembly in May 2019 as the $11^{th}$ Revision of the International Classification of Diseases (ICD-11) [1], [45]. As defined in the ICD-11, video game addiction is a severe pattern of gaming behavior that can be characterized by impairment in personal, family, social, educational, occupational, or other vital areas of functions and control, which persisted for at least 12 months and was evident over their gaming behavior [45], [73].

Negative consequences associated with the rising use of digital technology and technology-related disorders, specifically, gaming addiction, have been generally diagnosed via temporal scales as an indicator [38]. Such a condition also causes increased priority on gaming overtaking other interests and daily activities despite negative consequences. The term ''addiction'' is generally interpreted in the psychological context [31], which encompasses elements of tolerance, withdrawal, craving, and over-dependence on a stimulus that substantially difficult to discontinue [64]. It could also be tied to socio-functional impairments from the stimulant overuse of an individual [13].

A recent study suggests that gaming disorder is associated with anxiety that prompts greater use of video games, potentially associated with video game addiction [66]. Some study relates gaming disorder with problematic gaming that resulted from maladaptive coping strategies to deal with the state arising from stressful or adverse life situations, leading to addictive-like symptoms [7]. Jhee et al. [38] argues that time is an inadequate criterion to ascertain video game addiction since video games shifted from a leisure activity to a viable career option. Such a condition warrants the need for combining physiological-based criteria and contextual understandings of video game dynamics. It is essential to note the differences between video game addiction from its gambling counterpart, where the former focuses on excessive behaviors while the drug-like psychological struggle characterizes the latter [31], [38].

Studies suggest that video game addiction affects only a small proportion of people who were engaged in gaming activities. Lehenbauer-Baum et al. [49] examined significant motivational differences between addicted and engaged gaming behavior, where depression and anxiety tend to link with the former. At the same time, achievement and immersion are the latter's key elements. Blasi et al. [7] suggests that difficulty in emotional regulation relies on game experiences, while being deeply immersive, can promote emotionally focused and negative mood states, which increases the risk of addiction. Therefore, these studies showed that addiction and the sense of engagement are related to the mind's dynamic states.

The human mind was thought to be the last frontier of science. As mentioned by Herbert [32], ''mind is a fundamental process in its own right, as widespread and deeply embedded in nature as light or electricity.'' Recent scientific advances in brain science lead to a tremendous understanding of the organizational principles of information processing [74]. However, understanding our mind's fundamental functions, such as learning, intelligence, and consciousness, remains elusive, vague, and difficult to operationalize with precision. Since physics is the form of general laws that can be applied at all scales and sizes for obtaining the truth about the known universe, it is reasonable to associate such functions to physic phenomenons, both classical [65], [67], and quantum [21], [26].

Independent from previous works, this study uncovers the underlying physics of the mind by adopting games as the rich source of information for both objective and subjective ''motion'' hidden in our mind [35]. The gaming activities' behavioral and psychological aspects are analyzed to uncover its underlying mechanism based on such concept, specifically in the scopes of engagement and addiction. Such a concept bridges the gaps on the psychological studies by naturally defining elusive mechanisms of engagement and addiction by adopting its correspondence in physical phenomenon based on gaming activity.

From the perspective of the motion in mind concept [35], the fundamental quantities such as mass, momentum, and potential energy were analogically defined to investigate the games' underlying characteristics. An essential focus of this study emphasizes on analogically defined energy and the conservation of energy in games. In classical physics, the law of energy conservation states that an isolated system's total energy is unchanged and conserved over time. This situation means that energy can neither be created nor destroyed, while transformed or transferred from one form to another [72], [79]. In general, science considers that conservation of energy is related to conservation of mass via the perspective of Einstein's influential works on special relativity theory where the notion of mass-energy is conserved as a whole ($E = mc^2$). In theory, this situation implies that pure energy can be converted from any object with mass, and vice versa, only under the most extreme physical conditions.

In this study, the notion that energy is conserved over time in a game is conjectured, where a new measure of engagement was proposed, and the mechanisms of an intense engagement or addiction in popular games and public gambling were investigated (Section IV). In this study, the experiment was designed to triangulate the ethnographically-informed findings via conceptual model and computing data (board games) or statistics data (sports and public gambling games) analyzed by the formulated motion in mind approach. The computing data were collected via self-play AI agents, while the play statistics data for the sports and public gambling games were collected from public or official sports websites (see Section V for details). To this end, this study's objective involves exploring the extent to which the notion of energy is conserved over time in games can reliably estimate the mechanisms of engagement and addiction, both in the behavioral and psychological aspects of game-playing experiences, as well as identifying their possible implications (Section VI).

## II. MOTION IN MIND

### A. ESSENCE OF UNCERTAINTY

The basic notion of game playing depends on the rate of information representation, which constitutes the speed or "velocity" of a game, is generally defined as the success rate ($v$) [35]. In contrast, the challenge faced or difficulty of reaching such a success, which constitute the weight or "mass" of a game, is generally defined as the difficulty rate ($m = 1 - v$). Expanding on such analogies, the $m$ can be regarded as the "essence" of uncertainty. It represents the proportion of the amount of informational uncertainty that constitutes the component of play of a given game (i.e., the number of hidden nodes that unexplored or unable to be reached in the game tree during a move decision of a board game). On the contrary, the $v$ constitutes the proportion of the amount of informational certainty in a game (i.e., the number of explored nodes in the game tree during a move decision of a board game).

Based on the expanded analogy of $m$ and $v$, it correlates with Daniel Kahneman's theory of the duality of human's decision making "systems," where System 1 operates automatically and quickly, instinctively and emotionally. Meanwhile, System 2 operates slower, more logical, and deliberative [40]. System 1 was used 95% in decision making, while System 2 was used when a problem goes beyond a threshold of cognitive ease (i.e., complicated or difficult). However, given time and enough samples, some problem can be transferred and readily used by System 1. Such condition had provided the possibility of a loose parallel with machine learning (data-driven) and symbolic reasoning (knowledge-driven) in the artificial intelligence field [9].

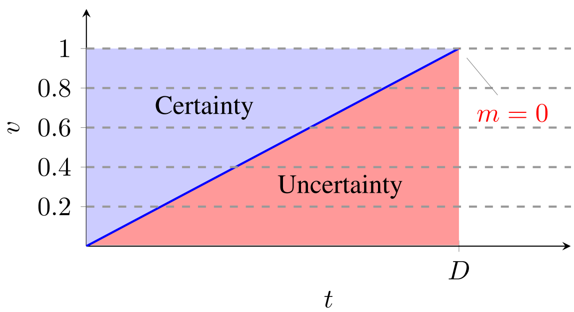


**FIGURE 1. The depiction of constitution of different amount of certainty ($v$) and uncertainty ($m$) of game over time.**

Therefore, in the context of games, given one part of $m$ and one part of $v$, the fundamental assumptions used throughout this study, relative to previous works [35], is defined as (1), which are based on the zero-sum assumption where gain or loss utility of one player is exactly balanced by the losses or gains of the utility of its opponent [54]. Figure 1 illustrates the essence of the uncertainty ($m$) relative to the game progression.

$$m + v = 1 \quad (1)$$

### B. RECOGNITION MODEL IN GAME

The phase of objective recognition is followed by subjective recognition and vice versa. In the context of game-playing experience, it can be translated into a position/move made in a game that is evaluated from the objective point of view first, such as score and point. Subsequently, other factors (i.e., past individual experience) would be incorporated into the subjective judge (i.e., win possibility prediction) for the final decision or real action. Such conditions had been observed in determining the game's level of difficulty [17] and play performance during competitive decision-making [24].

A significant difference was found between the objective and the subjective recognition in a player's evaluation of the game [17]. The author also points out that motivational aspects of the objective and the subjective recognition warrant further investigation. This finding was further solidified by objective experiences (System 2) and subjective beliefs (System 1) of a player's performance during a competition concerning the brain processing systems [24]. The study found that a negative outcome's expectation holds more significant weight in distinguishing between objective and subjective recognition.

Revisiting the game progress model [35], let $t$ be the game length, and $y(t)$ be the function of the game progress's solved uncertainty, then the ratio of solved uncertainty can be briefly described as $y = vt$. Considering the physic kinematic equation on motions ($y = v_0 t + \frac{1}{2}at^2$) where $v_0 = 0$ at $t = 0$, then $y = \frac{1}{2}at^2$ was obtained. Figure 2 showed that sophisticated board games (Chess, Shogi, and Go) were located on the same curve of $y = \frac{1}{2}at^2$.

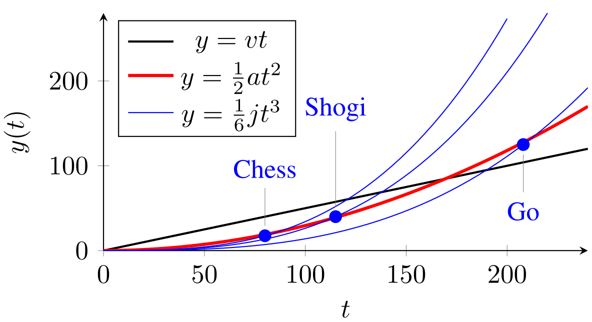


**FIGURE 2. Acceleration and jerk in games [35].**

Since $y = \frac{1}{2}at^2$ corresponds to the in-game acceleration, the figure depicted that sophisticated games have almost the same "gravity". This condition implies those games to be attractive to play. However, what makes the game different? Interestingly, the jerk (or vibration) of the game was observed to be different. Typically, vibration is, by its nature, a factor of noise or discomfort. However, once a player becomes familiar with such a vibration effect, it would be indispensable (greater engagement) or addictive like a drug while feeling stronger than comfort.

### C. ANALOGY OF MOTION

By analogically defined the winning (or success) rate and winning hardness (or difficulty) as the velocity ($v$) and mass ($m = 1 - v$), then various motions in mind quantities can be determined [35]. In the current context, the $v$ can be defined according to the rate of information change of the gaming environment. Relative to the previous works, $v = \frac{1}{2}\frac{B}{D}$ in board games and $v = \frac{G}{T}$ in sports games, were defined according to the candidate options and scoring ratios, respectively. Note that the definition of sports games was also applicable to general video games since its formalization was determined based on the target game's reward system. Table 1 provides the analogy of the related physics in mind notations and its in-game context.

TABLE 1. Analogical link between physics and game (adopted from [35]).

| Notation | Physics context | Game context |
|---|---|---|
| $y$ | displacement | solved uncertainty |
| $t$ | time | progress or length |
| $v$ | velocity | solving rate |
| $M$ | mass | solving hardness, $m$ |
| $g$ | acceleration (gravity) | acceleration, $a$ (Thrills) |
| $F$ | Newtonian force | force in mind |
| $\vec{p}$ | Momentum | momentum (Freedom magnitude) |
| $U$ | potential energy | potential energy, $E_p$ |

A brief sketch of motion in mind from Iida and Khalid [35] is given as follows. Momentum ($\vec{p}$) is given by (2). Meanwhile, potential energy ($E_p$) in game is determined by adopting the analogy of gravitational potential formula in physic as defined by $U = mgh$ in which $g = a$ and $h = y = \frac{1}{2}at^2$. Hence, $E_p = U$ can be defined as (3). Also, force ($F$) is determined by assuming a constant value of $a = 0.005$ according to previous studies [35], [87], given by (4). This condition is aligned with the sophistication zone of $GR \in [0.07, 0.08]$ in which the $GR = \sqrt{a}$, where $a = \frac{B}{D^2} = \frac{G}{T^2}$, determined by applying $y = \frac{1}{2}at^2$ and $y = vt$. Hence, the motion in mind with a focus on potential energy and momentum over various mass $m$ (where $0 \leq m \leq 1$) is illustrated as in Figure 3.

$$\vec{p} = mv = m(1-m) \tag{2}$$

$$E_p = ma(\frac{1}{2}at^2) = \frac{1}{2}ma^2t^2 = 2mv^2 = 2m(1-m)^2 \tag{3}$$

$$F = ma \;\; with \;\; a = 0.005 \tag{4}$$

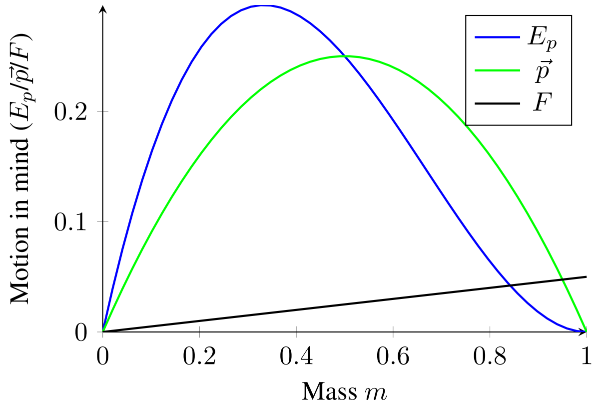


FIGURE 3. Motion in mind: potential energy, force, and momentum [35].

## III. USER EXPERIENCES AND BEHAVIORS

Ethnographic studies and game-related metrics had been the primary source of various methods and techniques for inferring behaviors and UX [58], [68], enabling a plethora of measuring tools proposed throughout the years. Such tools include the objective evaluation scales (i.e., questionnaires, surveys, in-game probes), analyzing in-game telemetry information (i.e., scores, game logs, keystrokes) using machine learning or data mining techniques, bridging psycho-physiological assessments (i.e., heart rate, respiration rate, muscle activation via electromyography), as well as the subjective evaluation (i.e., direct observation, focus groups, formal interviews). Each of these measures provided different dimensions and understanding that linked the UX and behaviors to its affective counterparts [39].

Initially, human-computer interaction relied on behavioral markers. With the advancement in recordings, interpretation, and analysis technology, research in affective computing provides access to other dimensions of a player's state. One such dimension is emotions, where it involves affective processes and states that describe non-specific physiological markers and changes (i.e., facial expressions, body posture) induced by perception, imagination, anticipation, or action triggers [58]. Typically, UX was contextualized based on physical cues triggered from physiological hardware. Such measure offered greater objectivity but generally costly (temporally and financially) and challenging to interpret [39]. Furthermore, psychophysiological measures are primarily independent of bias and can be measured continuously without breaking flow [27]. Meanwhile, UX's subjective assessment revolves around interviews, focus groups, in-game probes, and questionnaires, which are low-cost alternatives with fewer challenges around interpretation and offer variable insights both in depths and focus.

In this study, related works on user experiences (UX) in games were reviewed to substantiate the framework of recognizing objective and subjective game-playing tools from addiction and engagement perspectives and establishing the "human-side" of the proposed motion in mind measures. Such aspects were also discussed relative to gambling games, video games, board games, and game-playing activities, in general. Table 2 provides the summary of the related works reviewed for such a purpose relative to the ethnographically informed findings.

### A. ENGAGEMENT

In the development and research of games, the primary objective is to achieve high engagement [63], [85]. Games can induce high engagement levels, stimulate repetition and practice, and incentivize via challenges and rapid feedback [8]. Brown and Cairns [10] had defined engagement

**TABLE 2.** Related works on user experience and behaviors in games. It can be observed that psychological attributes related to addiction and engagement had many interactive and disparate effects relative to other relevant attributes depending on the study's context. This condition makes current studies on user experiences and behaviors related to addiction and engagement inconsistent for any specific target effect and requires unified views to understand addiction and engagement better.

| References | Psychological Attributes Findings of The Study | | | | | | | | | | | | | | Methods | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Immersion | Addiction | Engagement | Flow | Motivation | Challenge | Competence | Tension | Stress | Arousal | Negative Effect† | Positive Effect‡ | Affective Influence⋆ | Competitiveness | Questionnaires | Interviews | Observation | Psychophysiology | Others* |
| Nacke and Lindley [59] | ⊕ | | | • | | • | | • | | • | ⊕ | | | | ✓ | | | ✓ | |
| Drachen et al. [23] | • | | | • | | ⊕ | ⊕ | • | | | • | ⊕ | | | ✓ | | | ✓ | |
| Nacke et al. [60] | ⊕ | | | ⊕ | | ⊕ | ⊕ | | | | ⊗ | ⊕ | • | | ✓ | | | ✓ | |
| Nacke [57] | • | | | • | | ⊕ | ⊕ | ⊗ | | | ⊗ | | | | ✓ | | | ✓ | |
| Hoffman and Nadelson [33] | | | • | • | • | ⊕ | ⊕ | | | | | | ⊕ | | ✓ | ✓ | | | |
| Charlton and Danforth [16] | | ⊕ | ⊕ | | | | | | | | | | | | ✓ | | | | |
| Nacke et al. [61] | • | | | • | | ⊕ | ⊕ | ⊕ | | | ⊗ | | | | ✓ | | | ✓ | |
| Van Rooij et al. [84] | | • | | | | | | | | | • | | | | ✓ | | | ✓ | |
| Nacke [58] | ⊕ | | | ⊕ | | ⊕ | ⊕ | | | | ⊗ | ⊕ | • | | ✓ | | | ✓ | |
| Snodgrass et al. [77] | ⊕ | | • | | | | | | ⊕ | | • | | | | ✓ | ✓ | | | |
| Kardefelt-Winther [42] | | | | | • | | | | ⊕ | | • | | | | ✓ | | | | |
| Lehenbauer-Baum et al. [49] | • | • | • | | ⊕ | | | | | | | | | | ✓ | | | | |
| Hyun et al. [34] | | • | | | | | | | | | • | | | | ✓ | | | | |
| Brunborg et al. [11] | | ⊗ | ⊗ | | | | | | | | | | | | ✓ | | | | |
| Liu and Chang [52] | | • | | • | ⊕ | | | | | | | ⊕ | | | ✓ | | | | |
| Toker and Baturay [83] | | • | | | | | | | | | • | ⊗ | ⊕ | | ✓ | | | | |
| Arellano et al. [3] | | | ⊕ | | | | | | | • | | | | ⊕ | ✓ | | | ✓ | |
| Leiker et al. [50] | | | • | | • | | ⊕ | ⊕ | | ⊕ | | ⊕ | | | ✓ | | | | |
| Loton et al. [53] | | • | • | | | | | ⊕ | ⊕ | | ⊕ | | | | ✓ | | | | |
| Deleuze et al. [20] | • | • | • | | | | | | | | ⊕ | | | | ✓ | | | | |
| Carras et al. [14] | | • | ⊕ | | | | | | | | ⊕ | | | | | ✓ | | | |
| King et al. [44] | | • | | | • | | ⊕ | | | | | • | | | ✓ | | | | ✓ |
| Stockdale and Coyne [80] | | • | | | | | | | | | ⊕ | ⊕ | | | ✓ | | | | |
| Krossbakken et al. [46] | | • | • | | | | | | | | • | | | | ✓ | | | | ✓ |
| Johnson et al. [39] | • | | | • | | • | ⊕ | ⊗ | | | ⊗ | | | | ✓ | | | | |
| Ventura et al. [85] | | | • | ⊕ | | ⊕ | ⊕ | | | | | | | • | | | | ✓ | |
| Bodzin et al. [8] | • | | • | • | | | | | | | | ⊕ | | | ✓ | | | | |
| Sung et al. [81] | | • | | | | | | | ⊕ | | | | • | | ✓ | | | | |
| Rapp [68] | | | • | ⊕ | ⊕ | | | | | | ⊕ | | | | | ✓ | ✓ | | |

•: significant/target effect; ⊕: minor/interactive effect; ⊗: disparate/contrary effect;
†: Negative effects include problem gaming, coping, emotion dysregulation, social anxiety, loneliness, escapism, mental health;
‡: Positive effects include fun factors, learning, tolerance, usefulness;
⋆: Affective influence include socio-economic status, attachment, sonic effect;
*: Other methods include various data mining, analytics, and machine learning;

as phasic involvement, where the experience was not static but can be described as a scale of involvement with a game. Engagement was also related to experiential intensity and temporal involvements of immediate activities [8], [75]. Dorph et al. [22] discussed engagement based on behaviors, cognitive, and affective dimensions, where the combination of these three aspects of engagement supports the learning process. The concept of engagement also points to subjective experiences in the form of, for example, absorption, fulfillment, and enjoyment [68], which is typically correlated to the flow theory [18].

Flow and engagement come hand-in-hand, which involves intrinsic motivation and focus [63]. Flow requires continuous, long-term focus and loss of awareness of the surrounding environment [18]. Meanwhile, engagement involves affective involvement, motivation, control, and even learning. From the UX perspective, engaging experience demands being attentive without losing awareness while forming specific interactivity and goals that can provide a lasting impression. Hoffman and Nadelson [33] describe conscious awareness of motivation towards a particular activity as *motivational engagement*, where its strength partly influenced player perceived ability to control the game process and perceived winning possibility. The study also found that pre-gaming decisions (such as types of game and interest in the activity) and 'opposing interfering force towards positive targets' (such as conquering the game and overcoming obstacles) were important contextual engagement gaps between gaming and education domains.

An affective engagement was found to be unrelated to personality traits [16] but significantly associated with positive physical and psychological health, social relationships, and environment [3], [49]. However, some personality traits could lead to problematic gaming (i.e., form of coping [53] or stress response [77]) and other adverse effects when being highly engaged (i.e., due to difficult to form offline relationships) that could pathologically be headed towards addiction. Arellano et al. [3] showed that engagement was prominent when there are more significant social interactions, conversations, and mutual glances that warrant efforts (or arousal) when playing competitively and collaboratively. Moreover, autonomy had a significant influence on engagement due to the ability to control difficulty levels and increases intrinsic motivation for learning that likely to change over time [50].

Engagement and addiction were also two distinct but related constructs that distinguish from highly engaged and problematic engagement [20]. High engagement mainly involves peripheral addiction criteria such as salience, tolerance, and mood changes [11], [15], [46]. Meanwhile, problematic engagement involves conflict, withdrawal, and relapse, while satisfying some, but not all, core addiction criteria [11], [46]. Such conditions stipulated the need to distinguished healthy engagement and problematic engagement via other means and constructs that could lead to psychopathological conditions (i.e., video game addiction).

Research on UX also identified that competition and challenge were effective pathways to promote engagement [8], [85]. Competitiveness involves a situation where players maximize their success relative to the success of others. Meanwhile, challenge is a context-dependent activity that involves a degree of outcome uncertainty, variable progression, hidden information, or randomness. Competition and challenge shared mutual benefits on UX studies, where winning a competition that demands overcoming challenging hurdles influence the expected affective responses (such as engagement and curiosity) [8], [85]. Moreover, Rapp [68] assesses engagement from a systemic standpoint where linear, circular, and shared temporalities were weaved relative to the UX. A multifaceted conception of extreme engagement was introduced, composed of the interplay of social, desire, and mechanic engagement that lasts longer, sustaining the players' desire to play and the willingness to replay.

### B. ADDICTION

Studies on addiction in games have commonly been rooted in excessive Internet use, online gaming addiction, excessive video gaming, maladaptive gaming, and internet gaming disorder. While there had been various terms used, they uniquely refer to addiction that happened in the video game from a behavioral perspective, either in whole or in part. This study adopted *game addiction* as the term used throughout the study as representative of all those terms mentioned earlier. Game addiction can be defined as the inability to control excessive and persistent gaming habits despite awareness of social and emotional problems [11], response to life stress [77], coping strategy [42], [53], or attachment insecurity [81]. The DSM-5 had proposed nine criteria for assessing game addiction which had been mapped and associated with core (i.e., withdrawal, relapse, conflict, and problems) and peripheral criteria (salience, tolerance, and mood modification) [11], [15], [29]. Game addiction was also characterized by excessive or poorly controlled behaviors, preoccupations, and urges on available accessibility and usage [77].

Kardefelt-Winther [42] proposes a framework that characterizes psychological predictors of excessive internet use grounded on the notion of coping and motivation to identify the compulsive nature of an activity (i.e., addiction). Moreover, the study suggested that psychological characteristics need to be analyzed in a set of factors rather than isolated and explored as part of a chain of events rather than a focal point that may be informative and contribute to theory building. Also, it was previously found that gaming addiction is linked to a variety of comorbid psychopathological [80], personality differences [84], and attachment styles [81]. Looking from another perspective, relating addiction to the sense of substance use were associated with brain reward and related circuitry embedded within the environmental and socio-cultural contexts [77]. In this view, addiction is likely caused by complex, mutually reinforcing networks of mechanisms encompassing biological, psychological, and environmental mechanisms [43], [77].

Liu and Chang [52] had conducted a pilot study based on computer-mediated communication motives and their relation to flow that discovers the underlying links between flow and addiction. The significant relationship between flow experience and beliefs that drive behavioral addiction was confirmed, which reveals that flow has long-term effects that influence motivation, which can be used as a predictor of game addiction. Meanwhile, Loton et al. [53] examined the mediating effects of coping and mental health (such as stress, anxiety, depression) towards game addiction. The study found that coping dimensions (approach, resignation, withdrawal, diversion) correlate with depression and addiction, suggesting that mental decline has a more serious basis for sustaining game addiction. However, Deleuze et al. [20] argued that problematic behaviors (e.g., impulsivity or depressive) are not related to the engagement construct that constitutes peripheral criteria. In contrast, the addiction construct comprises core criteria that are potentially indicative of a disorder (e.g., conflicts or withdrawal), in which when co-occurring were associated with increased impulsivity and depressive symptoms.

Tolerance and withdrawal were essential concepts, mainly related to gaming, that help explains the addictive cycle of drug-like usage, repetitive behaviors, and as features of behavioral addictions [44]. Since tolerance and withdrawal are part of peripheral and core criteria, respectively, distinguishing them is far from trivial, as the peripheral criteria seem to indicate high engagement, whereas the core criteria seem to indicate game addiction [11]. Although addiction usually involves high engagement, it is possible to be highly engaged without being addicted, and vice versa. Formulating tolerance helps understand motivation in gaming, but a less agreed-upon characteristic for gaming addiction according to

UX studies [44], [78]. King et al. [44] identified inadequacy as the significant symptom associated with gaming addiction based on the three-factor model of tolerance in gaming. The study conceptualizes the possible disturbance of the player expectation (goal set by the player) and the actual outcomes (goal perceived by players and others) of game-playing experience, motivating increase in resource (either physical or temporal) investment.

### C. CONCEPTUAL MODEL OF ENGAGEMENT AND ADDICTION IN MOTION IN MIND

Engagement is a crucial affective component in gaming, strongly associated with motivation and flow while partly being influenced by challenge, competence, tension, and escapism. Simultaneously, engagement and addiction could be regarded as two sides of the same coin, which depends on the influx of other affective components in game-playing UX and behaviors. Moreover, addiction is significantly associated with the "negative side" of engagement, such as relapse, conflict, inadequacy, and withdrawal. However, as previous studies suggested, distinguishing engagement and addiction typically reports inconsistent findings and involved many overlapping affective components.

Motivation in game-playing is an essential affective component to retain player's engagement. If the play experience is dull, difficulty should be adjusted, which should be easier if it causes stress or frustration [3]. Understanding the game-playing motivation is a useful starting point that assisted in formulating tolerance and mitigate persistence of gaming disorder or harmful reward-seeking behaviors [44]. Motivation could also influence the game-playing experience in such a way; it could steer players towards positive, healthy engagement due to positive reinforcements (such as tolerance, salience); or steer players towards harmful, pathological addiction caused by negative reinforcements (such as persistence, withdrawal).

Additionally, players strive for relaxation, enjoyment, and social needs that were not achievable in the real world [52]. A game should be designed in such a way that the difficulty matches players' skills; basically, not too difficult or easy. In other words, this condition is related to the sense of control, making the game-playing experience engaging. When influenced by inadequacy, a rational gaming-related choice may cause the outcome to become sub-optimal [44]. Such a condition is related to the sense of focus that makes a game-playing experience more attractive to the players and potentially makes them invest more time in the game; thus, associated with player satisfaction that varies across gaming situations.

In essence, commonly shared sub-components between flow, engagement, and addiction were based on prioritization and intensity of control, motives, and focus. In the context of motion in mind, motivation is associated with the potential energy ($E_p$), which gives 'weight' to the play's progress and the player's expectation. Meanwhile, control and focus were associated with the velocity ($v$) and momentum ($\vec{p}$)

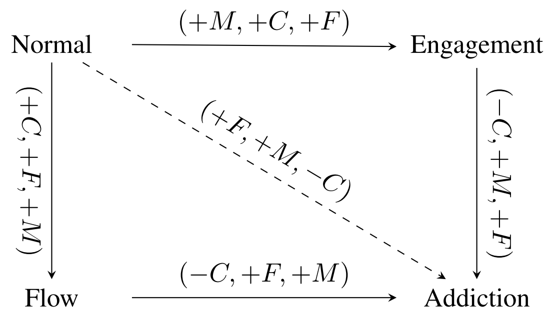


**FIGURE 4.** Conceptual model of engagement and addiction as a transition from baseline states (normal or flow states) in game-playing based on the prioritization (ordering, highest to lowest) and intensity (+ = high, − = low) of control, focus, and motives ($C$, $F$, $M$).

that describe the rate of player's progression and the rate of player's activity, respectively. Therefore, a conceptual model linking motion in mind to such psychological attributes based on previous studies on the UX and behavioral studies was proposed, depicted in Figure 4.

## IV. LAW OF CONSERVATION

In Special Theory of Relativity [25], energy and momentum are hyperbolic. Both momentum and mass can be considered as the manifestation of energy. Under certain circumstances, the mass of a substance can be derived from the energy of interactions between substances, and the mass of other substances can also provide the energy of a substance. Hence, energy, momentum, and mass should be considered as a whole.

In this study, the potential energy ($E_p$) is assumed to be conserved over time and transformed into the momentum of the game's motion and momentum of mind's motion, from which a new measurement of engagement is proposed. Analogous to the law of conservation of energy in classical physic, $E_p$ is expected to be conserved where the momentum of the game playing motions in the game contains both the objective (in-game) and subjective recognition (in mind), albeit different in levels. Table 3 provides a comparison between the game's motion and the mind's motion.

**TABLE 3.** Game's motion and mind's motion compared.

| Game's motion | Mind's motion |
|---|---|
| Change of scores during a game, i.e., the game will move as a score is taken | Change of winning prediction during a game, i.e., player's mind will move as the game progresses |

*Conjecture 1 (Momentum Conservation):* Potential energy ($E_p$) is transformed into Momentum of game's motion ($\vec{p_1}$) and Momentum of mind's motion ($\vec{p_2}$), i.e., $E_p = \vec{p_1} + \vec{p_2}$. Hence, it is expected for $\vec{p_2}$ to be a reliable measurement of engagement.

Applying (2) and (3), (5) is obtained. Then, the first derivative of (5) is given by (6). Solving $\vec{p_2}'(m) = 0$ would obtain the $m = \frac{3\pm\sqrt{3}}{6}$. This implies that $\vec{p_2}$ has two peaks in different

**TABLE 4. Peaks of momentum of mind's motion: mass in mind and typical examples.**

| $m$ and its nearby | Typical example | Remark |
|---|---|---|
| $m = \frac{3-\sqrt{3}}{6}$ (anticipating zone) | **Public gambling** Note that $m$ is given by $1 - r$ where $r$ stands for return rate. | Super engaged due to its high win-expectation. Easy to repeatedly join due to its low $F$, i.e., becoming *addictive*. |
| $m = 0.5$ (neutral zone) | **Go** and score-limit sports such as **table tennis** and **badminton**. | Momentum of game's motion ($\vec{p_1}$) is maximized while Momentum of mind's motion ($\vec{p_2}$) is zero. |
| $m = \frac{3+\sqrt{3}}{6}$ (hair-trigger zone) | **Chess** and low-score sports like **soccer**. | Greater tension would occur since any error must be avoided. Higher force $F$ (i.e., ability or skill) is needed to move the game. |

directions where the play engagement is maximized.

$$\vec{p_2}(m) = E_p - \vec{p_1} = 2m^3 - 3m^2 + m \quad (5)$$
$$\vec{p_2}'(m) = 6m^2 - 6m + 1 \quad (6)$$

Table 4 provides the possible observations of the peaks of momentum of mind's motion ($\vec{p_2}$) based on their respective mass in mind ($m$), which can be related to some typical example games. Thus, based on such observation, Conjecture 2 was made.

*Conjecture 2:* $m = \frac{3+\sqrt{3}}{6} \simeq 0.79$ and its nearby is the zone for competitive play mode (i.e., high excitement in the competitive context), whereas $m = \frac{3-\sqrt{3}}{6} \simeq 0.21$ and its nearby is the zone for easy-win play mode (i.e., strongly engaged or addictive in the speculative context).

Meanwhile, the potential energy in the game ($E_p$) is defined as the amount of information required to finish a game [35], [87]. Such a condition also relates to the magnitude of information perceived by the game's player due to the sheer amount of possibilities and magnitude of initial expectation (i.e., a game perceived to be simple and easy to play may encourage people to play, but a game that perceived to be difficult may discourage them to play instead[1]). In this paper's context, $E_p$ is further expanded concerning the new recognition model in games, which is then defined $E_p$ as the objective measures of game motivation. Then, the difference between the momentum of game's motion ($\vec{p_1}$) and momentum of mind's motion ($\vec{p_2}$) would define the subjective measures of the motivation in mind ($E_q$). An illustration of the various motion in mind measures, relative to the original concept of the motion in mind [35], is given in Figure 5. Table 5 provides a comparison between a game's motivational potential and the mind's motivational potential.

By solving (2) and (5), then $E_q$ is given by (7). Then, the first derivative of (7) is given by (8). Solving $E_q'(m) = 0$,

[1]It is important to note that the other way around also true; nevertheless, this study interested to point out the general case.

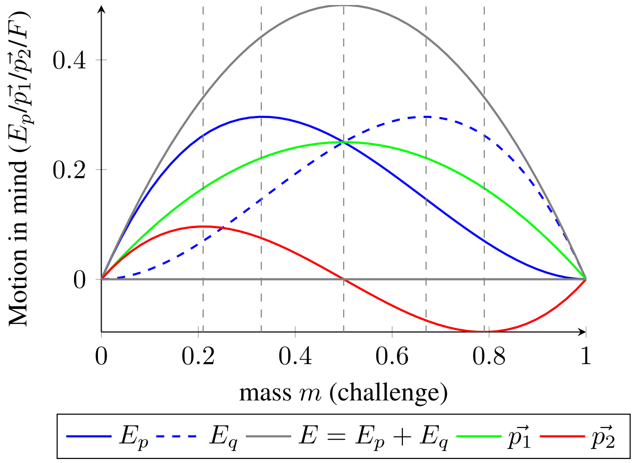


**FIGURE 5. The difference between Potential Energy and Momentum is given by $\vec{p_2}$. When $\vec{p_2}$ has a positive peak at $m < 0.5$, the game would be highly engaged or addictive since the desire to win is so strong (profit-winning engagement). Meanwhile, $\vec{p_2}$ has a negative peak at $m > 0.5$, implying that the game would be fascinating (risk-taking engagement). The difference between momentum in games $\vec{p_1}$ and momentum in mind $\vec{p_2}$, given by the $\Delta E = E_q$, peaked at $m = \frac{2}{3}$, implying that motivational potential in mind is the strongest. Then, the total energy $E$ which peaked at $m = \frac{1}{2}$ implies greatest attractiveness.**

**TABLE 5. Game's motivation potential and mind's motivational potential compared.**

| Game's motivation potential | Mind's motivation potential |
|---|---|
| Amount of information perceived in games , i.e., the information of the game as a the game move is made or the score is taken | Amount of information expected in games, i.e., the branch and depth of a game tree's move or the number of possibilities of obtaining the score |

then $m = \frac{2}{3}$ which has the peak of $E_q = \frac{8}{27}$, which is symmetrical to $E_p$. The peak of $E_p$ and $E_q$ are $m = \frac{1}{3}$ and $m = \frac{2}{3}$, respectively, implying the potential magnitude of 'gravity' felt in play and in mind.

$$\Delta E = E_q = \vec{p_1} - \vec{p_2} = 2m^2 - 2m^3 = 2m^2v \quad (7)$$
$$E_q'(m) = 4m - 6m^2 \quad (8)$$

*Conjecture 3 (Energy Conservation):* Energy conservation involves the summation of objective energy ($E_p$) and subjective energy ($E_q$), which transformed and changes to indicate the sense of "gravity" felt by the player in the game. In such a context, the 'energy' refers to the notion of 'motivational' potential, analogous to the gravitational potential, where the speed of the effort given for every challenge faced is equal to the motivation 'stored' by the player. Hence, it is expected for $E_p$ and $E_q$ to be a reliable measure of motivational potential while $E$ is the measure of freedom expected from a game. Then, the total energy of a game system is given by (9).

$$E = E_p + E_q = 2mv \quad (9)$$

Interestingly, $\vec{p_2} = 0$ when $m = \frac{1}{2}$, which is equivalent with the cross point of $\vec{p_1} = E_p = E_q$. In the current context, such a situation reflects the moment where the game's motion is the greatest. Meanwhile, the mind's motion is non-existence since $E_p$ and $E_q$ reflects momentum and energy conservation, respectively, of objective and subjective motion in mind. In other words, the game reaches its 'natural' state of motivational play without any engagement experience influence (highest $E$).

*Conjecture 4 (Game's Natural Equilibrium State):* The point where $\vec{p_1} = E_p = E_q, \vec{p_2} = 0$, and highest $E$ reflects natural state of motivational game-playing where the play experience tends to become continuous and in a constant state of frequent seesaw [87]; implying greatest attractiveness to play.

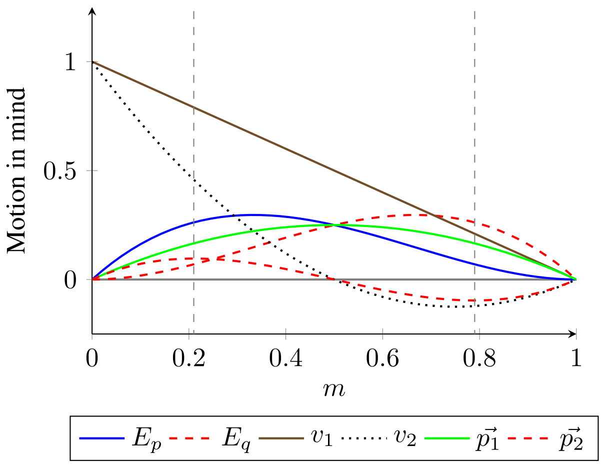


**FIGURE 6. Motion in games (objective) and motion in mind (subjective) from the perspective of velocity ($v_1$ and $v_2$) and momentum in mind ($\vec{p_1}$ and $\vec{p_2}$), relative to potential energy in mind ($E_p$). The gray dashed line is the peak points of $\vec{p_2}$.**

### A. GAMBLING PSYCHOLOGY AND COMFORT IN MIND

Considering the objective momentum $\vec{p_1}$ and subjective momentum $\vec{p_2}$ from the gambling perspective, then $v_1$ and $v_2$ are the win rate (or velocity) for the objective and the subjective motions, respectively. Given by a function of mass $m$, then $v_1$ and $v_2$ are given by (10) and (11) (illustrated in Figure 6). Then, acceleration of the objective motion $a_1$ and subjective motion $a_2$ are given by (12) and (13), respectively. Moreover, the jerk of the subjective motion $j$ is given by (14).

$$v_1(m) = 1 - m \quad (10)$$

$$v_2(m) = 2m^2 - 3m + 1 \quad (11)$$

$$a_1(m) = -1 \quad (12)$$

$$a_2(m) = 4m - 3 \quad (13)$$

$$j(m) = 4 \quad (14)$$

It can be observed that the objective win rate $v_1$ is given by $v_1 = \frac{1}{2}$ when $m = \frac{1}{2}$. However, the subjective win rate $v_2 = 0$ when $m = \frac{1}{2}$. This implies that from subjective point of view no one would have interest in a gambling with $m = \frac{1}{2}$. To have $v_2 = \frac{1}{2}$, substituting $v_2 = \frac{1}{2}$ in (11), then we obtain $m = \frac{3-\sqrt{5}}{4} \approx 0.19$. This implies that people might have interest in gambling when $m \leq \frac{3-\sqrt{5}}{4}$.

*Remark 1:* The objective motion denoted by $\vec{p_1}$ is a motion with constant acceleration which relates the sense of thrilling. Meanwhile, the subjective motion denoted by $\vec{p_2}$ is a motion with constant jerk which relates to the sense of thrill and engagement.

*Conjecture 5:* Addictive event like gambling postulates a condition where the subjective win rate satisfies $v_2 \geq \frac{1}{2}$, which is equivalent with $m \leq \frac{3-\sqrt{5}}{4}$.

The subjective win rate ($v_2$) is aligned with the Prospect theory [19], which defines utility of losses that was distorted and regarded as higher utility compared to gains of equivalent value (known as "loss-chasing" by gamblers). In the context of motion in mind, $m \geq 0.5$ implies a greater emphasis on losing where the minimum win rate in mind should be offset by about 12% ($v_2 \in [0, -0.125]$); thus, relates with high-tension events. Meanwhile, $m < 0.5$ corresponds to the win rate that considers as 'standard' in mind ($v_2 \in [0, 1]$); thus, relates to high-expectant events. This condition is more prominent when $v_2 \geq 0.5\,(m \leq 0.19)$. This situation demonstrates the acceptable "comfort" people willing to accept in mind when facing risks or adverse loss [86].

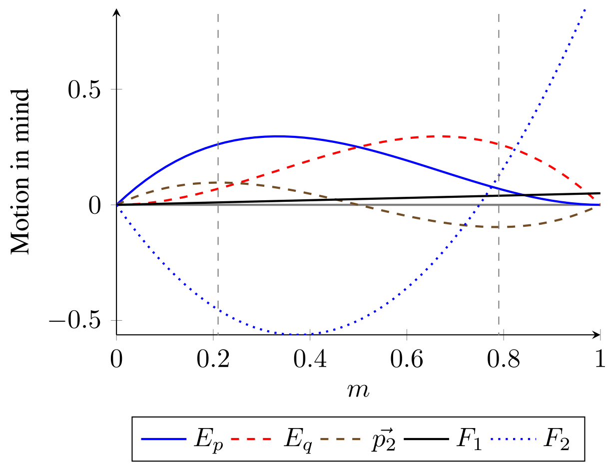


**FIGURE 7. Subjective force and motion in minds relative to potential energy in mind ($E_p$). The gray dashed line is the peak points of $\vec{p_2}$. The gray dashed line is the peak points of $\vec{p_2}$.**

### B. FORCE IN MIND AND PLAYER PERCEPTION

As previously defined by Iida and Khalid [35], force in mind indicates the player's ability to move in the game or relative to the player's strength in general. This situation was due to the relationships between large candidate options directly proportional to the magnitude of force retained over time, observed from the game progression. In other words, games with a high number of options require the attainment of force; thus, associated with the ability to play. Based on the acceleration of the subjective motion $a_2$, the game's subjective force can be determined, given by (15) and illustrated as Figure 7. Solving $F_2' = 8m - 3$, $m = \frac{3}{8} \simeq 0.38$ is obtained as the lowest point of $F_2$ (negative peak). Such a peak implies that the game "pushes" the players to acquire the necessary ability instead of requiring the player's ability to move the game ($F_1$), making it a good condition for a novice or educational purposes.

$$F_2 = m \cdot a_2 = m(4m - 3) \quad (15)$$

*Conjecture 6 (Game's Inertial Force):* The game's inertia will be perceived as an appropriate challenge for novice (or educational activity) when the subjective player's ability to move the game satisfies $F_2 < 0$. This condition is equivalent to a win difficulty rate of $m = \frac{3}{8} \simeq 0.38$. Also, this situation reflects the game's inertial force acting on the player, making the game more accessible and possessing the appropriate motivational potential to continue or repeat the game (compelling to play).

A cross point at $\vec{p_2} = E_q$ can be obtained by solving (5) and (7), where $\vec{p_2} - E_q = 2m^2 - 3m^2 + m - 2m^2 - 2m^3 = 0$ which obtained at $m = 0.25$. Such a cross point implies low mind's motivational potential that was equal to positive subjective momentum, while being close to the peak $E_p$. Thus, such a condition is equivalent to the concept called "pleasure in uncertainty" [47], where in the game-playing context, relates to the sense of motivation to prolong play (winning engagement) due to uncertainty of a positive event ($E_p > E_q$).

In addition, the cross point of $F_2 = \vec{p_2}$ is obtained by solving (15) and (5), where $m = \frac{7 \pm \sqrt{17}}{4} \simeq 0.72$. This situation corresponds with the player satisfaction model [87], relative to the domain of $m$, where fascination (of play) in mind ($\vec{p_2}$) meets dedication (of work) in mind ($F_2$). Such notion is related with blurring the boundary between work and play.

It can be observed that the $F_2 \simeq 0$ when $m \simeq \frac{3}{4}$ or $m \simeq 0.75$, which, interestingly, also the negative peak of $v_2 \simeq -0.125$. Such a condition postulates when the game challenge is equal to the player's ability to overcome it. It relates to the activity that borders between brute-force and knowledge-based requirement and acts as the turning point in the player's game-playing ability in a subjective sense. In addition, $F_2 \geq F_1$ when $m \geq \frac{a_1+3}{4}$ which is obtained by solving (15) and (4). This condition implies an increasing magnitude of the "gravity of play" in mind related to the sense of excitement or thrills.

To this end, the proposed law of conservation and its derivatives were conjectured as psychometric measures of game-playing experience, which is summarized in Table 6.

## V. ANALYZING GAMES USING NEW MEASUREMENT

### A. FIXED ABILITY OVER VARIOUS DIFFICULTY

Consider the case where the player's performance level ($v$) is fixed in a given game over various difficulty levels ($m$). This category includes many popular games such as Mind Sweeper, where the difficulty level will be chosen depending on the player's ability. A minesweeper artificial intelligent (AI) agent was developed to automatically play the game

**TABLE 6.** Summary of conjectures of the study.

| Conjecture | Label | Description |
|---|---|---|
| 1 | Momentum Conservation | $E_p = \vec{p_1} + \vec{p_2}$ is a reliable measure of engagement |
| 2 | Engagement Zones | $m = \frac{3 \pm \sqrt{3}}{6}$ is the peak engagement zones |
| 3 | Energy Conservation | $E = E_p + E_q$ is a reliable measure of freedom |
| 4 | Natural Equilibrium | $\vec{p_1} = E_p = E_q$ is a natural state of play with greatest attractiveness |
| 5 | Addictive Zone | $v_2 \geq \frac{1}{2}$ is a condition for addictive event |
| 6 | Inertial Force | $F_2 < 0$ is a condition for compelling play |

up to the size of 16 × 30 board for data collection. The AI agent randomly guesses possible squares and picks the best possible squares. The general process of the minesweeper AI agent can be found in [82]. Note that the game's mine distribution is populated on the board after the first move was made, and data were collected using an AI agent for this experiment (data would be changed when using another AI due to level differences). The experiment design involves applying the AI agent to play the game with varying numbers of mines, inclusive of the three standard minesweeper board sizes (9 × 9, 16 × 16, and 16 × 30), where the total mines were increased for the first two boards and decreased for the 16 × 30. An AI agent played the game 10000 times, where the success rate and its motion in mind measures were collected.

There are three standard settings of Mind Sweeper: (1) 10 mines on 10 × 10 board size, (2) 40 mines on 16 × 16 board size, and (3) 99 mines on 16 × 32 board size. It is expected that the player would play in the first standard-setting, which will be followed by the second and third ones. It is then assumed that the rate of successful solving ($v$) will decrease as the difficulty level ($m$) becomes higher.

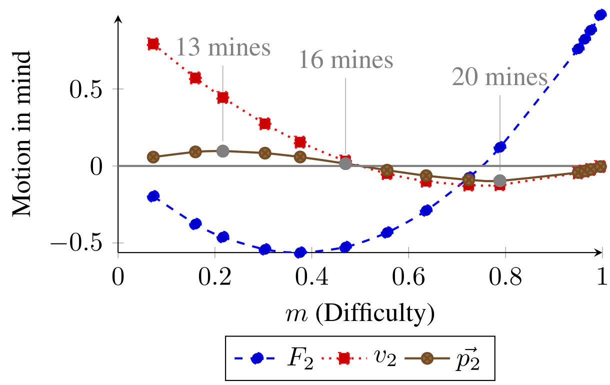


**FIGURE 8.** The motion in mind measures for minesweeper of 9 × 9 board. Interplay of $\vec{p_2}$ and $F_2$ implies different engagement mechanism suited for novice ($b = 13$), fair ($b = 16$), and competitive ($b = 20$) play.

Figure 8 depicted the engagement measures ($\vec{p_2}$), force in mind ($F_2$), and comfort in mind ($v_2$) for 9 × 9 minesweeper board sizes with different mine numbers ($b$). The standard setting with 10 mines on $9 \times 9$ board size takes the smallest challenge ($m = 0.0727$) and low impact of engagement ($\vec{p_2} = 0.0572$). It implies that the setting is inadequate for the novice. Instead, more number of mines ($b = 13$, for example) would be better in this case. If people want a competitive event on $9 \times 9$ board size, the setting with 20 mines would be reasonably played. Furthermore, if people want to feel fairer while playing using $9 \times 9$ boars size, the setting with 16 mines would be reasonable.

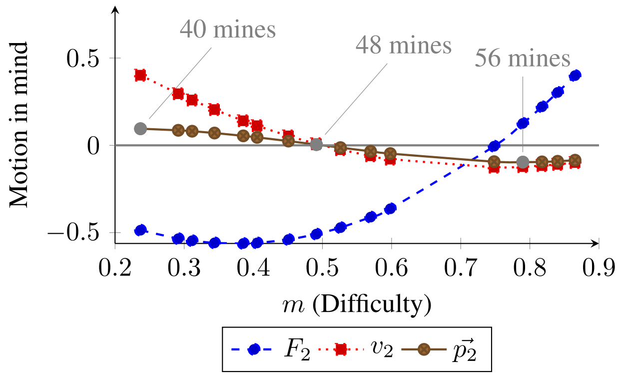


**FIGURE 9. The motion in mind measures for minesweeper of 16 × 16 board. Interplay of $\vec{p_2}$ and $F_2$ implies different engagement mechanism suited for novice ($b = 40$), fair ($b = 48$), and competitive ($b = 56$) play.**

Figure 9 depicted the engagement measures ($\vec{p_2}$), force in mind ($F_2$), and comfort in mind ($v_2$) for $16 \times 16$ minesweeper board sizes with different mine numbers ($b$). The standard setting with 40 mines on $16 \times 16$ board size takes the smallest challenge ($m = 0.2368$) but highest impact of engagement ($\vec{p_2} = 0.0952$). If people want a competitive mode using $16 \times 16$ board size, 56 mines setting with $\vec{p_2} = -0.0962$ (lowest) would be reasonably played. Furthermore, if people want to feel fairer while playing using $16 \times 16$ board size, 48 mines setting would be reasonable ($m = 0.4912$, $\vec{p_2} = 0.0044$).

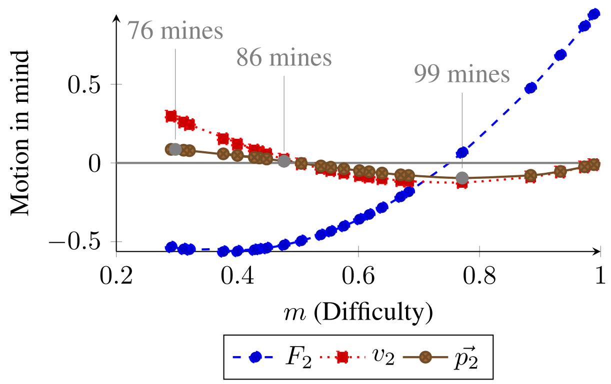


**FIGURE 10. The motion in mind measures for minesweeper of 16 × 30 board. Interplay of $\vec{p_2}$ and $F_2$ implies different engagement mechanism suited for novice ($b = 76$), fair ($b = 86$), and competitive ($b = 99$) play.**

Figure 10 depicted the engagement measures ($\vec{p_2}$), force in mind ($F_2$), and comfort in mind ($v_2$) for $16 \times 30$ minesweeper board sizes with different mine numbers ($b$). The setting with 76 mines on $16 \times 16$ board size takes the smallest challenge ($m = 0.2976$) but highest impact of winning engagement ($\vec{p_2} = 0.0863$). The standard setting with 99 mines on $16 \times 30$ board size takes $m = 0.7713$ and $\vec{p_2} = -0.0957$ which corresponds to the most engaged zone in the sense of competitive engagement. If people want to feel fairer while playing using $16 \times 30$ board size, 86 mines setting would be reasonable ($m = 0.4771$, $\vec{p_2} = 0.0114$).

*Remark 2:* The standard setting of $16 \times 30$ board size with 99 mines provides the play experience that corresponds to the given board size's expected player levels. However, the standard setting for $9 \times 9$ and $16 \times 16$ board sizes with 10 and 40 mines, respectively, were observed to be less than ideal ($9 \times 9$ board were too easy and $16 \times 16$ suited for the novice) for the expected board sizes. In addition, although the novice setting for all of the board sizes is considered highly engaged (high $\vec{p_2}$), they do not exhibit enough criteria to be addictive ($v_2 < 0.5$).

### B. FIXED DIFFICULTY OVER VARIOUS ABILITY

Consider the case where the task's difficulty level ($m$) is fixed for players with various levels ($v$). This category includes Jump & Jump game, where its difficulty is fixed. It is supposed that the success rate of $v$ will increase when a player's ability becomes higher. Figure 11 showed the search popularity of Jump & Jump game. Since the game was released in December 2017, the number of game players exploded quickly. However, after just three months, it loses its attractiveness, where only a few users remain in this game. Perhaps because some expert players have repeatedly played this game, the game becomes effortless and possibly dull. With the adoption of motion in mind measures, the downward trend demonstrated in Figure 11 may be reasonably explained for the reduction of popularity of the Jump & Jump game.

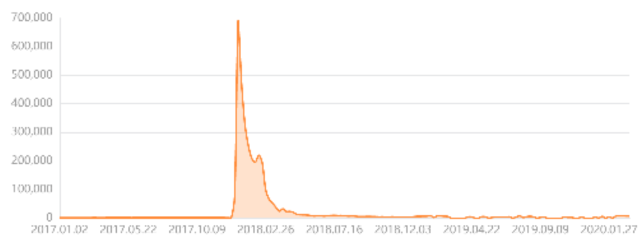


**FIGURE 11. Screenshot of search popularity of Jump & Jump game.**

A program to simulate the Jump & Jump game progress can be found in [70], where a Binomial distribution is utilized to simulate the successful probability of the different state of the players' performance. A cyclic Binomial distribution for simulating jump in the game is utilized with $\sigma = 0.2$ (standard deviations). The simulation is conducted 1000 times, and the process repeats for every player level. Since each jump of players is a random independent experiment, another Binomial distribution is used to generate random probability to represent a realistic simulation of risk rate ($m$) and success probability ($v$).

**TABLE 7.** Jump & Jump: motion in mind measures over various levels.

| Level | $G$ | $T$ | $v$ | $m$ | $\vec{p_1}$ | $E_p$ | $\vec{p_2}$ |
|---|---|---|---|---|---|---|---|
| Lv 9 | 117.37 | 120 | 0.98 | 0.02 | 0.0196 | 0.0384 | 0.0188 |
| Lv 8 | 79.14 | 85 | 0.93 | 0.07 | 0.0651 | 0.1211 | 0.0560 |
| Lv 7 | 54.66 | 65 | 0.84 | 0.26 | 0.2184 | 0.3669 | **0.1485** |
| Lv 6 | 34.42 | 50 | 0.69 | 0.31 | 0.2139 | 0.2952 | 0.0813 |
| Lv 5 | 17.55 | 35 | 0.50 | 0.50 | 0.2500 | 0.2500 | **0** |
| Lv 4 | 7.83 | 25 | 0.31 | 0.69 | 0.2139 | 0.1326 | -0.0813 |
| Lv 3 | 2.45 | 15 | 0.16 | 0.84 | 0.1344 | 0.0430 | **-0.0914** |
| Lv 2 | 0.72 | 10 | 0.07 | 0.93 | 0.0651 | 0.0091 | -0.0560 |
| Lv 1 | 0.11 | 5 | 0.02 | 0.98 | 0.0196 | 0.0008 | -0.0188 |

$G$: average number of safe jump;
$T$: average steps per game;

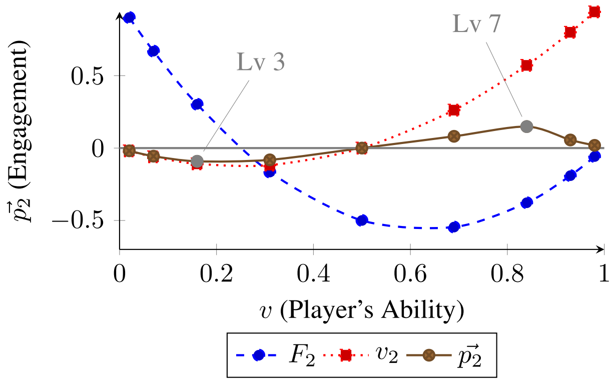


**FIGURE 12.** The motion in mind measures for Jump & Jump game of 9 levels of player's ability. Interplay of $\vec{p_2}$ and $F_2$ implies different engagement mechanism impacted the game enjoyment and continuity differently on Lv 3 (high-tension engagement) and Lv 7 (high-expectant engagement).

Nine levels of the player were set, denoted as $Lv \in [1, 9]$, where 1 and 9 stand for a novice and expert player in the game, respectively. Table 7 showed the success rate ($v$) and other motion in mind measures. Based on the table, Figure 12 illustrates the proposed measure of engagement ($\vec{p_2}$) over various player's ability levels according to their success rate ($v$).

Theoretically, the two peak points of $\vec{p_2}$ in Figure 12 can be observed. Lv 3 takes the strong impact of engagement ($v = 0.16$; high-tension engagement). It implies that people would feel highly engaged in the sense of competitiveness if they successfully arrive at this level from the very novice Lv 1. Additionally, the game is challenging (negative $\vec{p_2}$) and requires the player's ability to overcome it (positive $F_2$). Reaching Lv 3 also indicates the moment that was close to the moment that borders the play satisfaction and work dedication ($\vec{p_2} = F_2$; player satisfaction model). This condition means that Lv 3 is the "turning point" from frustrating (work-like) to fascinating (more play-like) play experience.

If people reach the Lv 7 after some practice, they feel strong engagement ($v = 0.84$; win-expectant engagement). Such a situation implies that the game becomes easy to win (positive $v_2$) and potentially becomes effortless (negative $F_2$). The example from Jump & Jump game suggests that the game becomes effortless and possibly dull if people can achieve a high level (say beyond Lv 7) too quickly. In addition, the $v_2 = 0.5712$ at Lv 7 which implies that the game becomes fair in a subjective sense, which suggests that prolonged play at such level could potentially cause addiction.

### C. PUBLIC GAMBLING

In general, gambling can be defined as any risk-taking activity (i.e., placing bets) that balances chances against the outcome's uncertainty. In much narrow sense, gambling refers to risk-taking activities typically placed in a differentiated ritual setting and revolve around monetary wager staking with the ultimate goal of gaining more in value than that staked [36], [56].

Japan is typically described as a "heaven for gamblers", where individuals can enjoy several types of gambling, including horse races, boat races, and lotteries [2], [37], [56]. Although gambling is prohibited by law in most countries due to the adverse effects that often accompany it [37], publicly managed gaming has been given official approval on condition that the harmful effects are removed, while the event remains within the scope of wholesome entertainment or a specific goal. In Japan, publicly managed gaming has been operated by local governments, the profits from these events contributing to local government finances [37].

In this section, several public gambling games were considered for evaluation where the notion of motion in mind is applied to evaluate mechanisms that make them engaging and potential addictive. These include online casino, Pachinko, public races, and lottery.

#### 1) ONLINE CASINO AND LOTTERY

The risk of addiction associated with casino and lottery players varied based on the time lapse between betting and outcome certainty [69]. However, with the accessibility of the internet, the online casino becomes more attractive and familiar due to unique aspects, such as anonymity, proximity, conveniences, loose regulations, and a greater sense of control [48], [69]. Besides, the psychological value of using "electronic" cash compared to actual money may drive online gamblers to stake more (large bets) and to make riskier bets (on positions with lower probability of winning) than their offline counterparts [69]. Depending on the business provider, the payout rate of the online casino falls between 90.25% to 98.77%. However, for the case in Japan, the average was found about 96%.[2]

Meanwhile, Lottery (Takarakuji) accounts for up to 39.5% gambling participation among the public gambling games [76]. Lottery composed of three main types: unique number lotteries, selected number lotteries, and scratch cards. The lottery tickets typically sold at 100 to 500 yen and available at takarakuji booth, stores, popular outlets, where it were held throughout the country on a regular basis for the top

[2]https://www.scams.info/online-casino/japan/ (Accessed on: October 27, 2020)

cash prizes that are usually 100 million yen or as law permits, up to 400 million yen.[3]

Typically, lotteries return rate was around 50% to 70%. However, to address concerns on problem gambling behavior, takarakuji law stipulates that the total prize pool for any given lottery is to be less than 50% of total sales. Currently, 40% goes to local government organizations and charities, 14% for design, printing, promotion, and sales of the lotteries, while 46% is paid out in prizes.

#### 2) PACHINKO AND PACHISLOT

Among the publicly managed games, Pachinko and Pachislot (pachisuro) was found among the highest severity as problem gambling with the highest rate of spending [36] and almost exclusively found in Japan and some other places abroad like Taiwan, the USA, and the UK [56]. Although considered to be among the most popular gambling games, Pachinko and Pachislot do not defined as gambling activity since the winning prize is in the form of materials goods or monetary values was gained indirectly (by converting them) [2], [36].

Pachinko machine looks like a vertical pinball machine with numerous pins and gates arranged in the form of a maze and a digital display featured at the center, resembling a slot machine [2]. Player borrow balls via money or integrated circuit card, turn the knob on the machine to shoot the balls into it. Additional balls are received via a triggered spin of a slot, or a payout gate opens to return a large number of balls if the slot pictures (or number) match up. While Pachinko players borrow balls to play, Pachislot players borrow medals to play. In Pachislot, players pull down the lever to spin the slot, stopping the spin by pressing a button while trying to match the pictures. The payout volume depends on the type of picture.

Many players employed unique strategies to increase their probability of winning even though the national standard guideline imposed several restrictions. In Japan, the payout rate can range from 90% to 200%, due to the payout and post-payout modes via *kakuhen* (improved winning probability) and *jitan* (decrease slots spin time). However, as Pachinko and Pachislot is considered as an electronic gaming machine (EGM), the true return rate to the player was considered as 85% according to previous study [5], [30].

#### 3) PUBLIC SPORTS

Public sports are public races that were allowed for legal gambling, where special laws and regulations set by the local governments [37]. In this study context, four types of public races were considered[4]: horse racing, bicycle racing, speedboat racing, and auto racing (motorcycle).

Bicycle racing (Keirin), is an Olympics event since 2000, was created in Japan in 1948, that takes place on a cycling track in a velodrome with a lap length of between 333 to 500 meters. Usually, nine cyclists compete in laps for a distance of 2,000 to 3,000 meters, and the bicycles used must conform to Keirin standards [37]. Meanwhile, auto race (or motorcycle race) is a racing event, using a unique motorcycle specification unique to auto race (small, no brakes, two-speed transmission, and custom-made suspension system), take place on an oval circuit of 500 meters in length and width of 30 meters with a small incline [37]. In each race competition, eight motorcycles race for 6 or 8 laps following two racing types (handicap and open racing).

Speedboat or motorboat racing (Kyotei) occurs in a boat racing stadium with a lap length of 600 meters where the motorboats used conform to Kyotei standards [37]. In every competition, six boats race anti-clockwise three times around the racecourse, where they speed up (up to 80 km/h) on the final straight lap to reach the finish line. Meanwhile, a horse race is a popular equestrian sport in Japan, with more than 21,000 horse races held each year, consisting of three types of races: flat racing, jump racing, and draft racing. The horse race is organized by the Japan Racing Association (JRA) and the National Association of Racing (NAR), where JRA is responsible for horse race events at ten major racecourses in metropolitan areas. At the same time, NAR is responsible for various local horse race events (unique to Japan).

All these public sports typically have a payout rate of about 75% from the ticket sales as outlined by the National Association of Racing and Japan Racing Association races. The remaining 25% was used as prize money and operating costs. Since the horse racing reforms, race organizers were allowed to set the payout rate at their discretion, typically lowered to 70% (i.e., Auto race) or raised to 80% (i.e., Horse race).

#### 4) ANALYSIS OF PUBLIC GAMBLING GAMES

Based on the posted payout percentage of various public gambling games, the average is collected for the online casino while the rest were determined based on such games' available regulations. As such, the payout percentage and the return rate is used interchangeably throughout this paper.

*Definition 1:* For a gambling with its return rate $r$, velocity $v$ is determined as $v = r$ and hence $m = 1 - r$.

Based on definition 1, the motion in mind measures for the major public gambling activities can be observed in Table 8. In the context of the public gambling games, the player is equivalent to a gambler. It is found that the Auto race has a relative peak value of $E_p$, with the lowest value of $F_2$. Meanwhile, lottery possesses highest value of $\vec{p_1}$ and $E_q$, but with $\vec{p_2}$ of close to zero (negative). Horse race has the highest positive $\vec{p_2}$, while the online casino has the highest $v_2$.

Based on the auto race game observation, the peak value of $E_p$ implies that motivational potential is most significant. This condition is caused by the amount of information accessible beforehand, which allowed for objective judgment by the player. It also had the lowest $F_2$ implying the game's inertial force was acting upon the player and the motivational

[3] https://www.japantimes.co.jp/community/2003/08/31/general/when-your-numbers-up/ (Accessed on: October 27, 2020)

[4] http://factsanddetails.com/japan/cat21/sub144/item793.html (Accessed on: October 27, 2020)

**TABLE 8.** Motion in mind measures for major public gambling.

| Games | $v$ | $m$ | Objective | | Subjective | | | |
|---|---|---|---|---|---|---|---|---|
| | | | $E_p$ | $\vec{p_1}$ | $E_q$ | $\vec{p_2}$ | $v_2$ | $F_2$ |
| Online casino | 0.96 | 0.04 | 0.0737 | 0.0384 | 0.0031 | 0.0353 | 0.8832 | -0.1136 |
| Pachinko/Pachislot | 0.85 | 0.15 | 0.2168 | 0.1275 | 0.0383 | 0.0893 | 0.5950 | -0.3600 |
| Horse race | 0.80 | 0.20 | 0.2560 | 0.1600 | 0.0640 | 0.0960 | 0.4800 | -0.4400 |
| Speedboat race | 0.75 | 0.25 | 0.2813 | 0.1875 | 0.0938 | 0.0938 | 0.3750 | -0.5000 |
| Bicycle race | 0.75 | 0.25 | 0.2813 | 0.1875 | 0.0938 | 0.0938 | 0.3750 | -0.5000 |
| Auto race | 0.70 | 0.30 | 0.2940 | 0.2100 | 0.1260 | 0.0840 | 0.2800 | -0.5400 |
| Lottery | 0.46 | 0.54 | 0.2285 | 0.2484 | 0.2683 | -0.0199 | -0.0368 | -0.4536 |

**TABLE 9.** Motion in mind measures: board games and sports.

| Games | $v$ | $m$ | Objective | | Subjective | | | |
|---|---|---|---|---|---|---|---|---|
| | | | $E_p$ | $\vec{p_1}$ | $E_q$ | $\vec{p_2}$ | $v_2$ | $F_2$ |
| Chess | 0.22 | 0.78 | 0.0748 | 0.1709 | 0.2670 | -0.0961 | -0.1230 | 0.0977 |
| Shogi | 0.35 | 0.65 | 0.1578 | 0.2268 | 0.2959 | -0.0690 | -0.1059 | -0.2552 |
| Go | 0.60 | 0.40 | 0.2882 | 0.2398 | 0.1914 | 0.0484 | 0.1213 | -0.5602 |
| Soccer | 0.11 | 0.89 | 0.0217 | 0.0983 | 0.1749 | -0.0766 | -0.0861 | 0.4962 |
| Badminton | 0.58 | 0.42 | 0.2838 | 0.2429 | 0.2021 | 0.0408 | 0.0982 | -0.5558 |
| Basketball | 0.27 | 0.73 | 0.1085 | 0.1985 | 0.2886 | -0.0901 | -0.1239 | -0.0673 |
| Table tennis | 0.50 | 0.50 | 0.2500 | 0.2500 | 0.2500 | 0.0000 | 0.0000 | -0.5000 |

potential may lead to continued or repeated play. Highest $\vec{p_1}$ and $E_q$ in lottery implies that such a game requires some balance of skill and chance while having motivational potential in assessing hidden information. However, $\vec{p_2}$ showed that lottery possesses a small amount of engagement where the player's mind does not move; In a sense, the player remains in a constant state of curiosity.

Moreover, the horse race game was observed with the highest positive $\vec{p_2}$, which implies that such a game is highly engaging with high winning expectation. Similar to auto race, the inertial force (negative $F_2$) of the horse race is sufficient to cause continuous play, having the appropriate motivational potential of playing the game (high $E_p$), and perceived as a fair win ($v_2$ approaching $\frac{1}{2}$). Finally, online casino possesses the highest $v_2$, which implied that the game has the most significant winning rate, both objectively and subjectively; thus, perceived to be the least risky and some potential for continuous play (low $F_2$).

### D. ANALYSIS OF POPULAR GAMES

Data from previous studies [35], [87], were collected from several popular board games (e.g., Chess, Shogi, and Go), as well as some sports games (i.e., Soccer, Badminton, Basketball, Table tennis) for comparison. The velocity for board games were defined as $v = \frac{1}{2}\frac{B}{D}$, while the sports games were defined as $v = \frac{G}{T}$ [35]. Based on the data of popular board games and sports games, then the results of various motion in mind is given in Table 9.

Based on the results, it can be observed that Go, Badminton, and Table tennis were situated at $m \leq 0.5$. These games possess high $E_p$, $v_2$ close to zero, and lowest $F_2$ (negative). This condition implies that such games are generally easy to play (i.e., simple rules) and do not move the player's mind (compels to prolong the play); thus, they tend to be highly attractive. These games' motivational potential have approximately equivalent to the mind's motivational potential ($E_p \simeq E_q$). This condition implies the amount of information perceived in the game is similar to the one 'abstracted' in the player's mind.

Meanwhile, board games like Shogi and Chess, and sports (like Basketball and Soccer), were situated at $m > 0.5$, where all of them have a low $v_2$ (negative). This situation implies that these games were high-tension games (fascinating to play), which is vulnerable to loss aversion. However, Shogi and Basketball have negative $F_2$ approaching zero and high $E_q$. This situation implies that the game rules require some skills and moderate planning because of the high motivational potential of the mind. Besides, the games' engagement involves dealing with the risk-taking situation (negative $\vec{p_2}$). Moreover, Chess and Soccer have highest $F_2$, low $E_p$ and $\vec{p_1}$, and lowest $\vec{p_2}$ (negative). Both games were considered high-tension games with great skill requirements to move the game. Also, the mind's motivational potential is greater than the motivational potential of the game ($E_q > E_p$), implying tactical to strategic planning based on little information available.

## VI. DISCUSSION

The overall depiction of all types of games considered in this study is given in Figure 13. Based on the figure, it was found that addictive event was situated on large $\vec{p_2}$ at $m \leq \frac{1}{2}$ and small $\vec{p_2}$ at $m \geq \frac{1}{2}$. Namely, the larger the difference between $E_p$ and $\vec{p_1}$, the greater the engagement becomes. It implies that large difference makes people addicted in

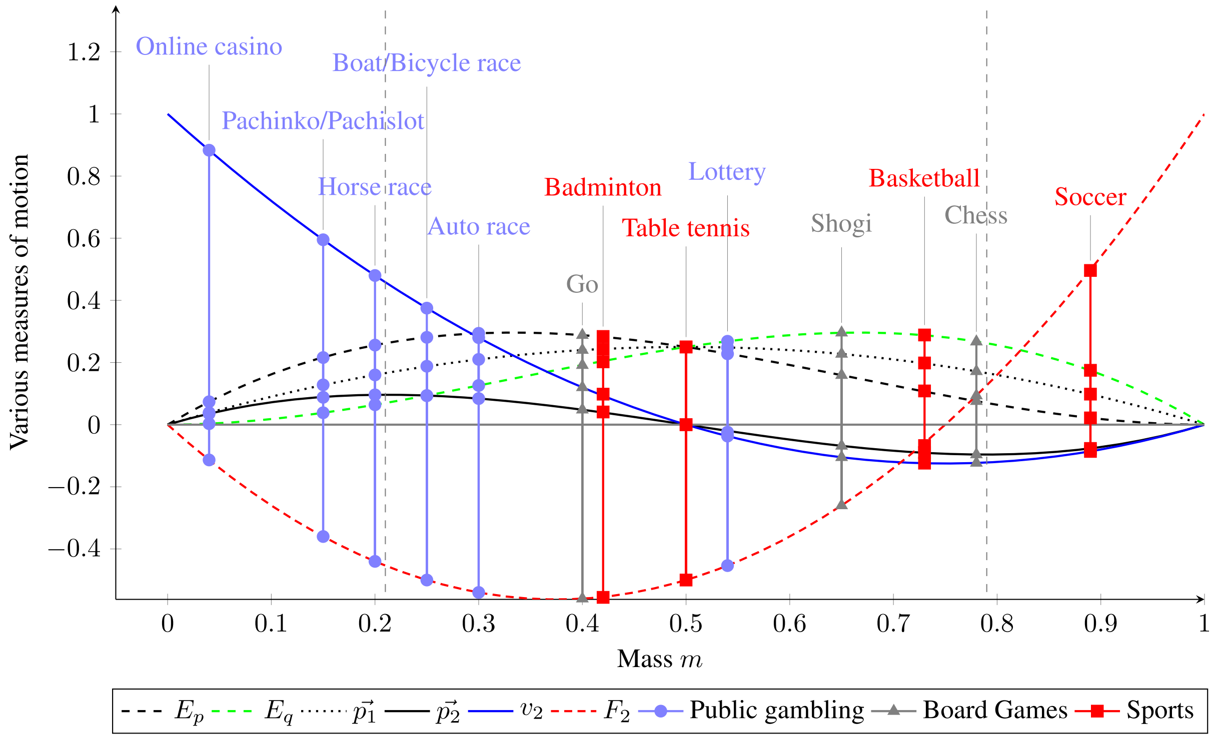


**FIGURE 13.** Illustration of motion in mind of the engagement zones, $\vec{p_2}$, demonstrating the winning (positive peak) and playing (negative peak) engagements of various games. It can be observed that highly addictive public gambling games (i.e., Online casino and Pachinko) were located in the addictive zone ($v_2 \geq 0.5 \simeq m \leq 0.19$). Also, beginner accessible games were located at about the peak of the negative $F_2$, such as Go and Badminton. It was also found that most public gambling games (such as Horse race, Boat/bicycle race, and auto race) possess high game's motivational potential ($E_p$) while competitive games (such as Basketball, Soccer, and Chess) possess high mind's motivational potential ($E_q$).

two directions: profit-winning (e.g., public gambling) and risk-taking (e.g., popular sports like soccer) events. Such a condition satisfies Conjecture 1 and Conjecture 2. Besides, popular public gambling games such as Pachinko, and online casino was found to be located at $m \leq 0.19$, which indicates that the game was perceived to be fair in the gambler's mind (satisfying Conjecture 5) and possess enough game's inertial force to be played by both novice and experienced players; thus, encourage continuity and prolonged play (satisfying Conjecture 6).

By considering addiction from the perspective of the motivational potential, it was found that the majority of the public gambling games typically considered having $E_p > E_q$, where gamblers tend to be highly motivated due to positive outlook of the game's payout (which also aligned with the 'pleasure of uncertainty' theory [47]). This situation represented energy conservation where the motivational potential was shifted from the information expected in mind mainly to the game's perceived information (satisfies Conjecture 3). However, for the case of Lottery, it takes advantage of the natural state of the game (satisfies Conjecture 4) by being close to $m = 0.5$ where the amount of information expected and information perceived is similar (no intuitive possibility). The game's momentum is maximized (momentum of the mind is nonexistence), implying that gamblers will be continuously attracted and curious about it and potentially be addicted.

Although addiction mechanisms can be represented via the subjective motion in mind measures, the critical components in any of those measures involve the interplay of uncertainty via $v$ and $m$. Based on the current results, it was found that an addictive event relies mostly on the perceived or certainty of information. At the same time, having a little amount of uncertainty present to invoke a degree of confidence towards repeating the event and making the event attractive yet stochastic. Such a situation similar to the principle of game design, characterized as "easy to learn but difficult to master" [55] (i.e., Go board game). Also, an addictive event does not go over the threshold of cognitive ease in correspondence with System 1 of Kahneman's duality theory, making it easy for gamblers to familiarize themselves and turn impulsive towards such an event.

Additionally, this study expanded the claims made by [49] where there was a clear distinction between addiction and engagement. While both relate to the mind's dynamic state, the mechanisms leading to either one are different but interdependent. Depending on the amount of uncertainty posed by a game, an addictive event requires players to be both engaged and highly motivated to continue play. This condition may be due to the illusion of pleasure expected during and after the event (desire to prolong or continuous or repeated play); thus, being related to pathological gaming behaviors [12], [45]. However, engagement can be a one-time event that players experience due to high win-expectancy (or high-risk) characteristics. The critical difference is the ability to overcome the tendency of addiction, where engaging events were perceived to be the least fair in mind (low $v_2$) and the least compelling to be dependent (positive $F_2$).

While some studies argued that addiction should be differentiated from gambling in games where the former involves behaviors while the latter involves psychological states [31], [38], the current study found that both situations can be overlapped. For example, public gambling games were found to have high motivational potential ($E_p$ and very low $F_2$) and high winning engaging (high $\vec{p_2}$). In essence, addictive activity is initially started because it was perceived as fair and easy to play. This condition demonstrated that such games involve the tendency of repetition or prolonged play (behavior) and are considered subjectively fair and perceptively comfortable (psychological) in game-playing aspects. By considering the probability of an actual winning, an addictive event would be very close to $m = 1$. Such situation may needs to happen once in a lifetime; thus, causing pathological gaming and become addictive.

From the perspective of popular board and sports games, some located at $m \geq 0.4$ while the rest located at $m > 0.5$. Such a condition relates to being mind sports [87]. Such situation relates to the mind's motivational potential tends to be high or greater, and uncertainty becomes relatively important for determining the game's outcome. Besides, such games require strategic to tactical planning that typically requires considering selective knowledge (human) or exhaustive resources (computer) to achieve a strong feat in game-playing; thus, going over the threshold of cognitive ease and could triggers System 2 [24], [40]. In a sense, these types of games demand more than just skill and knowledge. Such situation implies high amount of uncertainty, abstraction of information, and potentially risky event. Hence, overcoming the challenge posed by such games is fascinating and elicits the element of achievement.

Furthermore, most of the popular board and sports games were considered high-tension games where the play engagement was induced from the experience of risky events (high levels of uncertainty). Compared to public gambling games, losing in competitive games carries more weight in the playing experience (negative $v_2$ and $\vec{p_2}$) where players tend to be resilient by avoiding error as much as possible by careful planning ahead. As such, it is consistent with the Prospect theory [19], [86], where the tendency of losing is highly regarded compared to winning, especially when it was expected (or previously experienced). However, Go and Badminton presents a special case where both relatively compelling to play ($m < 0.4$ and $v_2 > 0$) compared to being risky in a competitive setting.

An unexpected trend was found for the $F_2$ and $v_2$, where the lowest $F_2$ would occur about $m = 0.38$ and lowest $v_2$ at $m = 0.75$. These two points seem to be co-dependent, where the lowest $F_2$ also aligned with $v_2 = E_q$, whereas lowest $v_2$ aligned with $F_2 = 0$. Based on current findings, the lowest $F_2$ indicates events that compelling to play since the game's inertial force is the greatest to motivate players. At the same time, the amount of information expected of the player's mind is conforming with the pace of the player's ability to play the game; thus, suited for encouraging learning and education. In contrast, the lowest $v_2$ indicates events related to perceptive turnover where it involves high-tension situation (risky) and possesses a challenge equivalent to the player's ability. In a sense, such a point emphasizes the expertise threshold that a player needs to acquire for a better play or improve in-game advantages (i.e., intuition, knowledge, planning, etc.). Beyond such a point would regard the play to be highly skillful, knowledge-based, or resourceful. In summary, various motion in mind measures with its related events were given in Table 10.

**TABLE 10.** Summary of various motions in mind from objective and subjective perspectives.

| $m$ | Indication | Associated Events |
|---|---|---|
| 0.19 | $v_2 = 0.5$ | Subjective Fairness |
| 0.21 | Peak $\vec{p_2}$ | High Win-Expectant |
| 0.25 | $E_q = \vec{p_2}$ | Pleasure in Uncertainty |
| 0.33 | Peak $E_p$ | Objective Motivation |
| 0.38 | Peak* $F_2, v_2 \simeq E_q$ | Compelling Play |
| 0.50 | Peak $E, \vec{p_1} = E_p = E_q, \vec{p_2} = 0$ | Game's Natural Equilibrium |
| 0.67 | Peak $E_q$ | Subjective Motivation |
| 0.72 | $F_2 = \vec{p_2}$ | Player Satisfaction |
| 0.75 | Peak* $v_2, F_2 \geq 0$ | Perceptive Turnover |
| 0.79 | Peak* $\vec{p_2}$ | High Tension |

*negative;

Nevertheless, it is essential to notes the caveats of the study can be summarized threefold. Firstly, the findings from the study were derived from mixtures of human players and AI players. For example, some conditions necessitate the need to use AI players to conduct self-play (play against a copy of itself). Such a condition satisfies the zero-sum assumption of game-playing where the AI players' ability is perfectly matched. Additionally, the study's feasibility was also preserved, which enabled timely data collection and efficient computing resource usage. Meanwhile, some games (e.g., sports and public gambling games) were collected from publicly available or reported game-playing statistics (such as scores, rounds, trials) of human players composed of offline or online environments. The findings' average value was reported to represent the general case for each game type, and conditions considered that conform to varying errors.

Secondly, the study's findings assumed that every game considered for this study was accessed and interfaced via standard interfaces (computer peripherals) under the best possible game-playing environment. Although there were no significant impacts on enjoyment was found when interfaces of the game change [28], the advent of high-performance and efficient feedback fusions (audio, visual, haptic) [51], head-mounted displays (HMDs) [71], biometrics [41] have been pervasive human-computer interfaces that enrich UX and behaviors. Investigating the impacts of such pervasive interfaces in games and non-game contexts would open up a new height in UX and behaviors that warrant further endeavors.

Third and finally, the study is conducted primarily based on perceived UX and behaviors, which involves some levels of behavioral and experience implications. Such a condition was derived from the interpretation and findings of ethnographically informed studies and the psychosocial influences of game-playing, leading or associated to addiction and engagement. In essence, further evidence and support from the neurological aspects of game-playing is needed, which is a potential area for future studies.

## VII. CONCLUDING REMARKS

This study had investigated the mechanisms of addiction and engagement in games from both objective and subjective perspectives. Inclusive of the conservation law in games, several conjectures were made relative to gambling psychology and perceptive force in the game-playing experience. Such conjectures were addressed by the presented evidence from various public gambling games, popular board games, and popular sports games.

Moreover, several related theories were compared and discussed relative to the proposed analogy of motion in mind that bridges the understanding of the possible behaviors and close interpretation of the mind's psychological states. In all instances, uncertainty played a significant role in determining engagement and addiction mechanisms in the game-playing context. Such findings are valuable in understanding the dynamic of information in different games, impacting the player's state of mind.

Although the current findings provided an interesting interpretation of various games, public gambling games were measured based on the payout rate, which may not represent the said games' actual essence. Since the payout rate is the standard measure of public gambling attractiveness, its winning odds may provide a different understanding of the game-playing experience. For example, a lottery winning odds were based on probability distribution and highly combinatorics in nature, which theoretically always be very close to $m \to 1$. Further model development of the public gambling measures using the motion in mind needs to be considered, where potential solutions to better manage addiction and elicits engagement in various contexts could be a fruitful endeavor.

To this end, a new measure of engagement was established, where addiction mechanisms were identified from objective and subjective experiences. Nevertheless, further works may be necessary to identify the discussed motion in this study on the game process itself and differentiating the impacts of data collected from human and artificial intelligence players. Potential future works may include expanding such motion in mind in the field of education, creative design, risk management, and medical rehabilitation. Another exciting direction includes integrating brain-computer interface technology, extending the study on virtual reality games and interactive media technology, and considering games with a purpose to explore greater granularity and refine the continuum of the game-playing experiences via the motion in mind measures.

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