A Key Factor to Maintain Engagement: Case Study Using 'Login System'

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Abstract

The game refinement (GR) theory has been applied to many different games for quantifying their entertaining impacts. It is assumed that when playing any type of game, the game information progress is encoded and transported in our mind, and it is likely that the acceleration of that information is subject to the forces and laws of physics; thus, GR-value focuses on the "force" that the player feel. This paper focuses on not only the "force" that the player's felt, but also the change of that "force". A login system is a typical monotonously-repeated action whereas such system may easily lose their attractiveness from the user standpoint. The designers of the login system always try to improve its entertaining elements to motivate the users to make the boring process more uncertain and exciting. The "attractiveness decrease" process is investigated, under the premise of GR value being a constant at the end of the login process and the tendency of GR value to affects the users. To prove this concept, the instantaneous attraction during the total progress is investigated and the reward rule in different time stage is adjusted in order to maximize users' attractiveness. In addition, an example related to real-world phenomenon in accordance with the rate of change of the GR value is also discussed.

Keywords: engagement, entertainment, game refinement theory, login system

Introduction

A 'login system' is widely used and relevant in many fields, especially in the domain of online learning games such as DouDizhu† , BaiCizhan‡ and Duolingo§ . A login system is a typical monotonous repetitive action. As such, the system designers are expected to set some rewards to motivate the users to log in more often. From user point-of-view, such reward in the login system can be regarded as some form of entertainment. However, maintaining engagement in games is not an easy feat, especially with the rise of free-to-play marketing model of online game that rapidly become the norm [1].

Quantifying entertainment impacts in games have been previously conducted through the game refinement (GR) theory [2]. According to the GR theory, it is assumed that when we play any type of games, every game progress is encoded and transported in our minds. Although we do not know about the physics of information in the brain, it is likely that the acceleration of information progress is subject to the forces and laws of physics. The abstraction of the game elements to describe the game process had provided the derivation of the GR value in order to measure the attractiveness and sophistication of such process [2] [3]. As such, using similar methods to analyze the reward structure of the login system would provide insights on improving its entertainment impact.

In every game progress, either fun or serious game, all players would have the possibility to give up. The second derivative of GR theory indicates that most fun games located in "zone" value (GR $\in$ [0.07,0.08]) which established the measures of attractiveness of the game process[2]. If the components of the login system is regarded as the game elements, its GR value can be determined. Under the premise that the GR value stays constant until the game ends, the instantaneous and the rate of change of the GR values in the total process are explored. The goal of this paper is to determine the key factor of maintaining engagement by analyzing the login systems using the GR value and its derivative. The findings of such factor is also discussed based on an example from a real-world application.

Login system with game elements

Game has existed since 2600 BC and has been the primary conditions of human culture and cultivated various complex activities of the human society such organization, languages, philosophies, war, and art [4]. In the beginning, the game was just for relaxation after a busy work or making a simple and certain decision. With the development of society, the game process becomes more meaningful; thus, making us look forward to improve ourselves in the game process. Such improvement was reflected by the system designers that always try to make the login system more attractive by using some game elements [5]. This would be achieved by careful attention to the relations between the attractiveness or the loyalty of the users and the game elements [6].

If the components of the login system are regarded as the game elements, then the login days and their respective rewards are regarded as "game length" and "game outcome", respectively. Some example had been applied to the language learning system (i.e. Duolingo) where some game elements (such as "badge" and "winning streak") were introduced in order to prevent the users from feeling bored and enhances the game's attractiveness [7] [8] [9] . In addition, the value and the trend of the GR value differ based on the language users in different milestone.

According to the GR theory, the game information progress x(tk) will be given as a linear function of time t with $0 \leq t \leq t_k$ and $0 \leq x(t) \leq x (tk)$. Since the game outcome is uncertain, the information progress is not linear but exponential, which is given as in (1). Meanwhile, the second derivative of (1) has been used to measure the attractiveness and sophistication of the game process, as shown in (2).

$$x(t) = x(t_k).\left(\frac{t}{t_k}\right)^n \tag{1}$$

$$x''(t) = \frac{x(t_k)}{t_k^n}.n(n-1)t^{n-2}| t = t_k$$
$$= \frac{x(t_k)}{(t_k)^2}.n(n-1) \tag{2}$$

According to the previous research in the fun game domains [10] [11] [12], $GR = \left(\frac{\sqrt{x(t_k)}}{t_k}\right)$ is located in the "zone" value where the value of GR $\in [0.07, 0.08]$ (see Table 1). Interesting correspondences were also found, where if the GR value is high, the game process is more uncertain yet exciting; otherwise, the game process is more deterministic and challenging [8].

Table 1. Measures of game refinement for various types of games [10] [11] [12]

Games	$x(t_k)$	t_k	GR value
Chess	35.00	80.00	0.074
Shogi	80.00	115.00	0.078
Go	250.00	208.00	0.076
Basketball	36.38	82.01	0.073
Soccer	2.64	22.00	0.073
Badminton	46.34	79.34	0.086
Table Tennis	54.86	96.47	0.077
DotA ver 6.80	68.60	106.20	0.078
StarCraft II Terran	1.64	16.00	0.081

So far, the game situation only considered the GR value as a constant at the end of the process. This means that both the reward and the total process are constant, where the attractiveness of the process is the same. However, if setting different reward rules along the process, how can the measure of attractiveness be determined in any time node? This study focuses on the change of the GR value that measures its tendency, similar to the tendency of attractiveness the users can obtain. As such, the relations of the tendency of GR value using (3) can be explored. The process of getting more attractiveness represents an addictive-like situation or strong engagement which defined as the AD value ($AD = \frac{\sqrt{x(t_k)}}{t_k\sqrt{t_k}}$).

$$x'''(t) = \frac{x(t_k)}{(t_k)^n}.n(n-1)t^{n-2}$$
$$= \frac{x(t_k)}{(t_k)^n}.n(n-1)(n-2)t^{n-3}| t = t_k$$
$$= \frac{x(t_k)}{(t_k)^3}.n(n-1)(n-2) \tag{3}$$

In addition, the login system can be further divided into several tiers and different reward rules which are applied to timely motivate the users. This process simulates the "force" in the human mind, where the "inertia" makes it a little difficult to persist the total process. In other word, a timely reward change is an appropriate stimulation to help

users continue to overcome the difficult (potentially caused by boredom) uphill process. A relationship between the bio-mechanical effects and psychological attractiveness can also be established. For example, when we take the roller coaster, not only we can feel the gravity, but also we can feel the "attraction" in our mind. In the previous works, the attractiveness is focused on the game length and uncertainty. However, this study investigates the relationship between the change of gravity (phenomenon known as "weightlessness") and the change of attractiveness (in this context, called "addiction").

VISUALIZING THE LOGIN SYSTEM PROGRESS

With the rise of free-to-play business model of games [1] and rising popularity of e-learning as an educational medium [13], some game elements had been adopted to increase motivation and improve retention of the users on such system through the login application's rewards. Based on this aspects, a popular application in China named "we are primary school students" were studied and adopted for this study.

The regulation of the login application is as follows. The user can get one reward per day through application login and the main process can be described by two factors: the number of reward obtained from "continuous login days" and the number of "login days" which corresponds to the R and D, respectively. It can be hypothesized that different time periods have different reward rule. As such, how can

we make the process of losing the user's attractiveness more gentle and smoothly? To observe this behavior, 5 different reward rules are defined as in Table 2 which represents an incremental reward system.

According to the GR theory, the GR value for the user is given by (4). As the GR value measures the attractiveness of the users, it can be assumed that the first derivative of

GR value also affects users in some way. For example, the users may get high attractiveness in a short time which makes the GR value increases suddenly, just like addiction. Thus, the first derivative of GR value is defined as the AD value as (5). Applying the five rules in Table 2, the curves of the GR value and AD value are depicted in Figure 1 and Figure 2, respectively.

Table 2. Five different reward schedules and rules.

Rule#	Period	Rewards Distribution
1	A year divided into a single part (365 days)	1.00
2	A year divided into 2 equal parts (365 days)	0.50, 1.50
3	A year divided into 3 equal parts (365 days)	0.50, 1.00, 1.50
4	A year divided into 4 equal parts (365 days)	0.25, 0.75, 1.25, 1.75
5	A year divided into 5 equal parts (365 days)	0.25, 0.75, 1.00, 1.25, 1.75

Since the login application is a repeated action process, losing attractiveness from the users quickly is typical and should be avoided. Figure 1 shows the change of GR value over time based on the regular reward rule which rapidly declining at the beginning. This implies that the users will lose their attractiveness and feel boring in a short time. However, the decrease of GR values is the least for Rule 5, which indicates a smoother "attractiveness decrease" process. Although Rule 1, Rule 2, and Rule 3 provide better GR value in the beginning, the rapid decrease of the GR value over time would cause the inability of the user to retain engagement.

In addition, the change of AD values over time (see Figure 2) also showed similar tendency of reducing smoothly, especially on Rule 5 which implies gentle losses on users' attractiveness. Imagine the "weightlessness" of the roller coaster, the change of the AD values corresponds to the degree of "attractiveness-less" where it is more acceptable to be experienced by the users little by little. In other words, although "attractiveness-less" can be viewed as a negative experience, it still retains user's sense of enjoyment, which reduces smoothly over a long period of time. As such, "attractiveness-less" barely noticeable to the user can make their engagement to be retained longer.

$$GR_{r1} = \frac{\sqrt{R}}{D} \quad (4)$$

$$AD_{r1} = \frac{\sqrt{R}}{D\sqrt{D}} \quad (5)$$

Another popular example of reward system that benefits users the more they login is the "tiers system" and the "points system" on the hotel loyalty systems [14] [15]. The previous study had provided evidence that the "tiers system" is better than the "equal reward" per day because the process provides a smoother decrease of user attractiveness throughout a longer time span (months to years). An example of the popular application, War poetry, have adopted similar reward rules and schedules (see Table 3). This enables the player to obtain login rewards that grows over time, rather than remain constant every day. To justify this claim, the login system of the War poetry is evaluated using "equal system" and "tier system". If the number of rewards and the login days in War poetry is regarded as the R and D, respectively, the changes of the GR values (Figure 3) and the AD values (Figure 4) can be obtained.

Table 3. Different reward schedules of "War poetry" from first day to the seventh day.

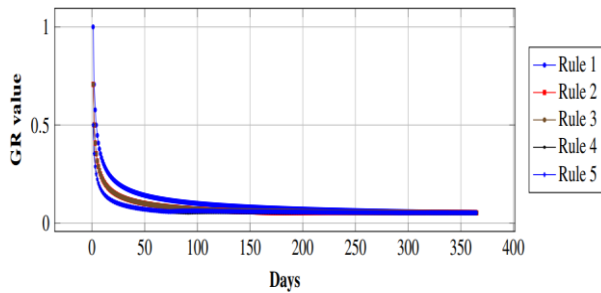| Reward Rule | War Poetry Rewards | |
	Equal System	Tier System
Day 1	1.77	1.00
Day 2	1.77	1.10
Day 3	1.77	1.30
Day 4	1.77	1.50
Day 5	1.77	2.00
Day 6	1.77	2.50
Day 7	1.77	3.00
Total	12.40	12.40

Figure 1. The change of GR values over time: five different reward rules compared
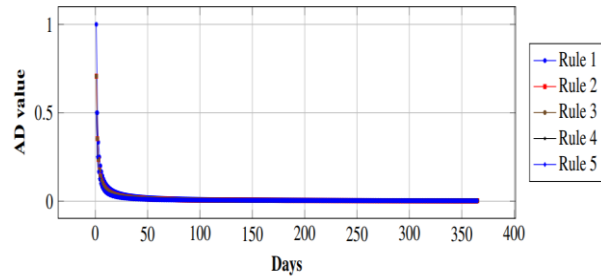

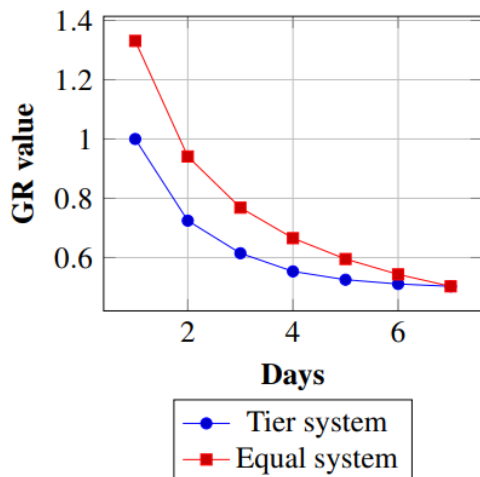Figure 2. The change of AD values over time: five different reward rules compared

Figure 3. The change of GR values over time: different reward rules of "War poetry" compared
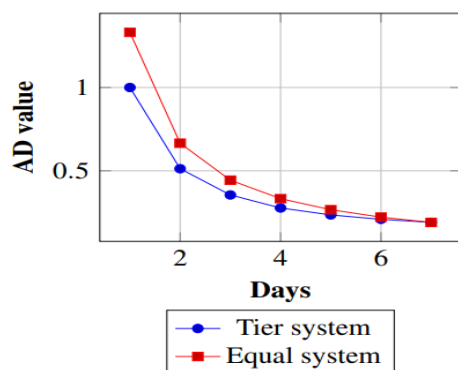

Figure 4. The change of AD values over time: different reward rules of "War poetry" compared

The differences of the GR values and AD values, at the beginning and the ending of the time period for each login systems, in this study is summarized in Table 4. According to the table, the value of "ΔGR × ΔAD" become less when reward system is smoother towards losing user's "attractiveness". This shows that both changes in GR values and AD values are important factors to retain the engagement of the users. As such, it is important for the system designers to set different reward rules in different time stages. Based on the value of "ΔGR × ΔAD", both the incremental reward and tier system is the most effective in gently reduces the "attractiveness" and prolonging the engagement of the user.

DISCUSSION

The rate of change of the GR value had demonstrated some successful cases, such as "we are primary school student" and "War poetry", where the designers set different reward rules in different stages, although the total reward is a constant. By dividing the process to many stages, the reward rule can be optimized to maximize the users attractiveness and make them more loyal [15].

It can also be observed that the change rate of GR value on regular reward rule (Rule 1) would be reduced sharply which implies that the users may experience boredom in a short period of time. While the reward rule provides a good indication of attractiveness at the beginning (high GR value), abrupt reduction of the GR value would imply a sudden reduction of attractiveness (bio-mechanical equivalents of "jerk"). This would likely cause the feeling of frustration (receiving constant reward) and at the same time excitement (due to increase in cumulative reward) to the users; thus, associated with the phenomenon known as "addiction". On the other hand, incremental reward rule (Rule 5) demonstrates the rate of change of the GR value that gently reduced; thus, gently reduced the attractiveness. This implies that the user feels boring but still willingly engaged for a longer period of time (the feeling of motivation).

In addition, the successful examples of the rate of change of the GR values and AD values can be interpreted with respect to the bio-mechanical processes of the roller coaster [16]. ΔGR means the interval of the attractiveness of users in the total process, which implies the range of maximum and minimum "attraction", just like the height of the roller coaster. The AD value is similar with the feeling of "weightlessness" (or related to the force of gravity) where ΔAD implies the interval of the degree of "weightlessness" (changing rate of the GR value). By making both ΔGR and ΔAD smaller would also make the "attractiveness" to decline smoothly. Similarly, the tier system which corresponds to the value of ΔGR×ΔAD, also indicates smooth and progressive reduction of the GR value. As such, the relationship between bio-mechanical effects and psychological attractiveness are established as in Table 5.

Table 4. Different reward schedules of "War poetry" from first day to the seventh day.

Login System	GR-begin	GR-end	AD-begin	AD-end	$\Delta GR \times \Delta AD$
Login system rule1	1.0000	0.0523	1.0000	0.0027	0.94514
Login system rule2	0.7071	0.0523	0.7071	0.0027	0.46124
Login system rule3	0.7071	0.0523	0.7071	0.0027	0.46124
Login system rule4	0.5000	0.0523	0.5000	0.0027	0.22264
Login system rule5	0.5000	0.0523	0.5000	0.0027	0.22264
War poetry equal system	1.3310	0.5031	1.3310	0.1901	0.94455
War poetry tiers system	1.0000	0.5031	1.0000	0.1901	0.40244

DISCUSSION

According to previous studies on GR theory, game progress had been the cornerstone of evaluating the attractiveness of the games (GR value). However, the login system involves processes that correspond to the game progress, which can be either monotonous or boring. Since users tend to readily give up on such a system, including some game elements (such as reward system) would improve their engagement and their motivation in general.

Table 5. Possible link between bio-mechanical effects and psychological attractiveness.

Bio-mechanical effects	Psychological Attractiveness
Gravity or other force	Force-in-mind
Acceleration	Attractiveness
Jerk	Addication
Height of the roller coaster	Interval of attractiveness
Degree of weightlessness interval	Degree of attractiveness-less interval
Smooth train tracks & road (safe)	Smooth "attractiveness" (acceptance)
Clothoid	Reward system based on "tiers system"

In the login system process, adjusting the game elements with respect to the quantity and time provides a new perspective on the tendency of attractiveness (AD value) that relevant in retaining the engagement of the users. Although findings in this study is a work-in-progress, the key factors highlighted here demonstrated that the proper quantification method on some specific game elements on a monotonic system such as the login system can also be engaging. While GR value involves balancing the game length and game outcome that optimizes the "attractiveness" of the game, the AD value takes one step further where it involves balancing the game length and the game attractiveness which theoretically optimizes the "engagement" of the game.

Current findings on the login system showed that a lower value of ΔGR × ΔAD would improve the game process and increase the acceptability of the users; thus, the retention of the user's engagement can be improved. Possible future works may involve the combination of the GR value and AD value in order to optimize every process that maximizes the attractiveness of the user.

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