International Journal of Engineering Research And Management (IJERM)
ISSN : 2349- 2058, Volume-02, Issue-11, November 2015

Deciphering the Entertaining Impact of Pokemon

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Abstract — **This paper investigates the setting in the gameplay of Pokemon, a very popular turn-based Role Playing Game (RPG) which attracts numerous players from all ages for over twenty years. For this purpose, game refinement theory, a unique theory that has been used as a reliable tool for measuring the attractiveness and sophistication of the games considered, is used as an essential tool for evaluating the enjoyment of Pokemon game. We propose a new model of game refinement theory called experience-based model and apply it to Pokemon Red, Pokemon Fire Red and Pokemon Soul Silver version. By analyzing many data, we conclude that the result supports the previous assumption which said that the balanced window of game refinement value is around 0.07-0.08.**

Index Terms—**game refinement theory, turn-based RPG game, Pokemon**

I. Introduction

John von Neumann first laid the first foundation for classical game theory [12], with the idea of the existence of a mixed-strategy equilibrium in two-person zero sum games. It was widely applied in many fields such as economics, political science and psychology. Another game theory is game refinement theory, which was proposed by Iida et al. [7], in which a metric of game refinement was proposed based on the concept of information on game outcome uncertainty. A mathematical model is constructed within the framework of game refinement theory and it is applied to many board games including chess variants and Mah Jong [8]. Recently, a general model of game refinement was proposed based on the game information progress model and applied to time-limited sport games such as soccer and basketball [14].

While game theory concerns a player's winning strategy, game refinement theory deals with the structure of a game, including the quality of gameplay and entertainment. The early works [19] [20] [21] focused on various games such as real time strategy games (RTS) and multiplayer online battle arena games (MOBA).

We now aim to investigate the attractiveness of one of the most popular turn-based RPG games, Pokemon. We consider about the effect of the setting of gameplay in Pokemon with two main research questions in our mind: "How does the environment in Pokemon affect to the game's entertainment?" and "What is the trend of the changing of setting of gameplay in Pokemon?". We consider a suitable model of the game information progress to derive the game refinement value of Pokemon. Then we apply our new game refinement model, an experience based-model, to three version of Pokemon games consist of Pokemon Red, Pokemon Fire Red and Pokemon Soul Silver. If the game refinement values are in the window, we can carefully deduce that this game is entertaining enough to attract many players and continue being played all over the world for twenty more years.

In this paper, we first provide some details on the Pokemon game in Section II. Then, in Section III we present the basic idea of game refinement theory which is used to analyze the related Pokemon game's attributes affecting gameplay. Finally, the results obtained are discussed in Section IV and concluding remarks are given in Section V.

II. Pokemon Game

In this section, we present a brief history of the Pokemon franchise and the versions we choose to perform our experiment.

A. Pokemon Franchise

Looking back at the history of video games, the first video game is "Tennis for Two" created by William Higinbotham in 1958 [10]. In 1972, the first commercial video game console that could be played at home is Odyssey, which was released by Magnavox and designed by Ralph Baer. From there, video games truly became popular, with many game consoles and much game software developed.

In order to see the influence of Pokemon, we cannot compare it with chess which has survived and evolved for 1500 years. However, in the video game world, a game franchise which has prospered for 20 years and continued being played globally must be not trivial. This game is a series developed by Game Freak and Creatures Inc., and published by Nintendo as part of the Pokemon media franchise. It was first released in 1996 in Japan for the Game Boy, and then, with each new game console of Nintendo, there have been new versions of, remakes of, or spinoff Pokemon games. Up to now, the game has 721 Pokemons and six generations. It is the second bestselling game franchise and as of April 2008, the series has reached more than 260 million copies.

Table 1 shows the history of Pokemon. From this success, many different series of manga and anime followed [13]. Even in the academic field, many papers have been written about the Pokemon game in different aspects: politics, mathematics, culture [5] [6], social science, media strategy [2] [9] [18] etc. All of them try to analyze and explain why this franchise is growing so fast and makes everyone know the cute yellow mouse Pikachu [1].

Manuscript received Nov 20, 2015

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Table 1: History of Pokemon

Generation	Number of Pokemon	Year	Version
1st	151	1996	Pokemon Red & Green
		1997	Pokemon Blue
		1998	Pokemon Yellow
2nd	251	1999	Pokemon Gold & Silver
		2000	Pokemon Crystal
3rd	386	2002	Pokemon Ruby & Sapphire
		2004	Pokemon Fire Red & Leaf Green
			Pokemon Emerald
4th	493	2006	Pokemon Diamond & Pearl
		2008	Pokemon Platinum
		2009	Pokemon Heart Gold & Soul Silver
5th	649	2010	Pokemon Black & White
		2012	Pokemon Black 2 & White 2
6th	721	2013	Pokemon X & Y
		2014	Pokemon Omega Ruby & Alpha Sapphire

All creatures living in the game world except Humans are Pokemons. They can be captured by a Pokeball. When Pokemon fights and defeats another Pokemon, it can level up so that its stats increase, like Speed, Attack, Defense and so on to make it stronger. One of the most interesting parts in Pokemon is that it can evolve, which makes it stronger, learn new skills, and sometimes change to new form. There are many different kinds of evolution. For example, player have to raise his Pokemon's happiness, trade Pokemon with another trainer or give special item to Pokemon.

In each version, there is a common format. Player begins as a boy or girl who wants to become a Pokemon master. Player will accept the request from the professor to fulfill the Pokedex, a portable device which provides information regarding the diversified species of Pokemon. To reach the goal, player starts by choosing one of three starters to begin the journey. In the adventure, player cannot finish the game without challenging other trainers in a battle. Gym Leaders, Elite Fours and the rival are the strongest trainers among them. Besides catching Pokemon as many as player can, player has to build his own team so that it becomes strong enough to win every single battle player engages in. If player wins, player will get not only the experience points but also the money to buy items to support his team.

B. Pokemon Red, Fire Red, Soul Silver

According to Table 1, Pokemon has six generations. This research focuses on three versions from different generations consists of Pokemon Red from the first generation, Pokemon Fire Red from the third generation and Pokemon Soul Silver from the fourth generation. The term 'generation' used here refers to the platform version in which the game is built.

In this study, we consider the entire game with hundreds of battles. This kind of battle occurs in every place in game between human and computer. Even if player is a newcomer, the chance to win against his opponent is still high. So in our experiments, we do not concern ourselves with the effect of battle type, under the assumption that one knows the basic battle type of computer AI.

We choose two main questions as our starting point to build our model: "How does the environment in Pokemon affect to the game's entertainment?" and "What is the trend of the changing of setting of gameplay in Pokemon?". Basically, each Pokemon has its unique characteristic. In combination with its level, it can change the outcome of the match massively. So if we meet a strong Pokemon too early, our team will dominate the opponent's team, which makes it not fun at all. With the same idea, if the setting of Pokemon in the opponent's team are too high, player will lose the game many times. Both of these situations lead to boringness and frustration in the player's mind, and then players will not want to play anymore. With these concerns, we collect data and propose our models.

III. ENTERTAINING IMPACT OF POKEMON

We give a short description of the basic idea of game refinement theory from [14]. The game progress is twofold. One factor is the game speed or scoring rate, while another is the game information progress focusing on the game outcome. In sports games such as soccer and basketball, the scoring rate is calculated using two factors: (1) the goal, i.e., total score, and (2) time or steps to achieve the goal. Thus, the game speed is given by the average number of successful shoots divided by the average number of shoot attempts. For other score-limited sport games such as Volleyball and Tennis in which the goal (i.e., score to win) is set in advance, the average number of total points per game may correspond to the steps to achieve the goal [11]. After that, we present formulas we use in our models, how we conduct experiments and results.

A. Game Refinement Theory

A general model of game refinement was proposed based on the concept of game progress and game information progress [14]. It bridges a gap between board games and sports.

Game information progress presents the degree of certainty of a game's results in time or in steps. Let G and T be the average number of successful shots and the average number of shots per game, respectively. Having full information of the game progress, i.e. after its conclusion, game progress $x(t)$ will be given as a linear function of time t with $0 \leq t \leq T$ and $0 \leq x(t) \leq G$, as shown in Equation (1).

$$x(t) = \frac{G}{T}t \quad (1)$$

However, the game information progress given by Equation (1) is unknown during the in-game period. The presence of uncertainty during the game, often until the final moments of a game, reasonably renders game progress exponential. Hence, a realistic model of game information progress is given by Equation (2).

$$x(t) = G\left(\frac{t}{T}\right)^n \quad (2)$$

Here *n* stands for a constant parameter which is given based on the perspective of an observer of the game that is considered. Then the acceleration of game information progress is obtained by deriving Equation (2) twice. Solving it at *t* = *T*, the equation becomes

$$x''(T) = \frac{Gn(n-1)}{T^n}t^{n-2} = \frac{G}{T^2}n(n-1) \quad (3)$$

It is assumed in the current model that game information progress in any type of game is encoded and transmitted into our brains. We do not know yet about the physics of information in the brain, but it is likely that the acceleration of information progress at the fundamental level is subject to the forces and laws of physics.

Therefore we expect that the larger the value $\frac{G}{T^2}$ is, the more the game becomes exciting, due to the uncertainty of the game outcome. Thus, we use its square root, $\frac{\sqrt{G}}{T}$, as a game refinement value for the game under consideration. We can call it the *R* value for short, as shown in Equation (4).

$$R = \frac{\sqrt{G}}{T} \quad (4)$$

B. Score-limited model

In the previous works, time-limited sport domains such as soccer and basketball [14]. We construct a game progress model with focus on the number of goals called *G* and the number of attacks or shot attempts called *T*. We then obtain $R = \frac{\sqrt{G}}{T}$. We have already applied this model in time-limited sports such as football and basketball and the results show in Table 2.

Table 2: Measures of game refinement for basketball and football

Sports	G	T	R
Basketball	36.38	82.01	0.073
Football	2.64	22	0.073

Next, we consider score-limited sport domains such as volleyball, badminton and table tennis [17] [21]. In these sports, the time not is limited but the score is limited. So, game refinement value *R* was calculated by $R = \frac{\sqrt{W}}{T}$ where *W* and *T* stand for the average winner's scores and the average total scores of entire game respectively. The values *W* and *T* correspond to *G* and *T* in Equation (4). We show the results from [11] in Table 3.

Table 3: Measures of game refinement for volleyball, badminton and table tennis

Sports	Version	W	T	R
Volleyball	Side-out system(15pts)	15	52.52	0.121
	Rally point system(30pts)	30	53	0.104
	Rally point system(25pts)	25	44	0.114
Badminton	Badminton Old scoring system	30.07	45.15	0.121
	New scoring system	46.34	79.34	0.086
Table Tennis	Pre-2000	57.87	101.53	0.075
	Post-2000	54.86	96.47	0.077

C. Formulas used in the game

The growth rate is a term used to determine how many experience points it takes to level up one Pokemon. A Pokemon that has a 'Fast' growth rate will need less experience points to get to level 100 than one that has a 'Medium' growth rate. According to few reliable website [3], Pokemons have six different growth rate functions, with *n* standing for the target level, and its maximum value is 100. The details can be described in Equation (5) to Equation (10).

$$ErasticExp\begin{cases} \frac{n^3(100-n)}{50} & n < 50 \\ \frac{n^3(150-n)}{100} & 50 \le n \le 68 \\ \frac{n^3(\frac{1911-10n}{3})}{100} & 68 \le n \le 98 \\ \frac{n^3(160-n)}{100} & 98 \le n \le 100 \end{cases} \quad (5)$$

$$FastExp = \frac{4n^3}{5} \quad (6)$$

$$MediumFastExp = n^3 \quad (7)$$

$$MeduimSlowExp = \frac{6n^3}{5} - 15n^2 + 100n - 140 \quad (8)$$

$$SlowExp = \frac{5n^3}{4} \quad (9)$$

$$FluctuatingEXP\begin{cases} n^3(\frac{\left(\frac{n+1}{3}\right)+24}{50}) & n \le 15 \\ n^3(\frac{n+14}{50}) & 15 \le n \le 36 \\ n^3(\frac{\left(\frac{n}{2}\right)+32}{50}) & 36 \le n \le 100 \end{cases} \quad (10)$$

With these equations, with the experience points player's Pokemon has, player can know which level it is. Ref [3] also let us know the number of Pokemons in each groups which is shown in Table 4. So, we can calculate the experience points that a Pokemon needs to level up for each growth rate group as shown in Table 5. From then, in order to keep generalization, we calculate the average experience shown in Table 6.

Table 4: Growth rate group

Growth Rate	Number of Pokemons
Erratic	22
Fast	53
Medium Fast	296
Medium Slow	189
Slow	147
Fluctuating	14

Table 5: Sample of experience in each level of each Growth rate group

LV	Experience					
	Erratic	Fast	MedFast	MedSlow	Slow	Fluc
1	0	0	0	0	0	0
5	237	100	125	135	156	65
10	1800	800	1000	560	1250	540
15	5737	2700	3375	2035	4218	1957
20	12800	6400	8000	5460	10000	5440
25	23437	12500	15625	11735	19531	12187
30	37800	21600	27000	21760	33750	23760
35	55737	34300	42875	36435	53593	42017
40	76800	51200	64000	56660	80000	66560
45	100237	72900	91125	83335	113906	98415
50	125000	100000	125000	117360	156250	142500
55	158056	133100	166375	159635	207968	196322
60	194400	172800	216000	211060	270000	267840
65	233431	219700	274625	272535	343281	351520
70	276458	274400	343000	344960	428750	459620
75	326531	337500	421875	429235	527343	582187
80	378880	409600	512000	526260	640000	737280
85	433572	491300	614125	636935	767656	908905
90	491346	583200	729000	762160	911250	1122660
95	548720	685900	857375	902835	1071718	1354652
100	600000	800000	1000000	1059860	1250000	1640000

Table 6: Average experience in each level

Level	Average Experience
1	0
5	132
10	958
15	3224
20	7750
25	15315
30	26711
35	42730
40	63736
45	90282
50	123518
55	164696
60	214816
65	273361
70	343098
75	423382
80	516936
85	621611
90	742302
95	874954
100	1024976

Ref [15] gives us the equation to calculate the experience points that player will get when defeating another trainer, which is shown in Equation (11).

$$EXP = \frac{a \times t \times b \times e \times L \times p \times f \times v}{7 \times s} \qquad (11)$$

In this experiment, player only concerns himself with a battle with trainers in the game, not a battle in the wild, and player are not allowed to hold or use support items. Therefore, we can simplify Equation (11) to Equation (12) shown below.

$$EXP = \frac{1.5 \times b \times L}{7 \times s} \qquad (12)$$

Where:

- b: base experience of the Pokemon that was defeated [3].
- L: the level of the Pokemon that was defeated.
- s: the number of Pokemons that participated in the battle that were not defeated.

D. Experience-based model

In this measurement, we concern about the balance of setting in the gameplay of Pokemon. If opponent is strong, player must be strong at least as strong as his opponent is so player can have a fair chance to defeat him. To apply this model, we ignore the battle strategy and many minor details in battle such as Pokemon's type, Pokemon's move and support item.

Because player can often knock out his opponent in one his so we do not have much information about the progress of battle. Therefore, score-limited model is suitable for this constraints. The following model is called experience-based model. The main idea of this model is that the experience points that player gets when player defeats opponent reflects how strong his opponent is. Equation (12) shows that experience points are based on the level of Pokemon and their base experience, together with the fact that a strong Pokemon has a high base experience, so *t* here is the number of experience points player obtain when player defeat his opponent and *x(t)* is the total number of experience points of both teams. Note that *t* is *G* and *x(t)* is *T* in Equation (1).

$$EXP = \frac{\sqrt{EXP\ of\ opponent\ team}}{EXP\ of\ opponent\ team + Exp\ of\ player\ team7 \times s} \quad (13)$$

According to Equation (13), the experience that player gets lies in a wide range so we have to scale this value to percentage. This means that the summation of player's experience points and his opponent's experience points is equal to 100%. It can be described by Equations (14) and Equations (15).

$$EXP = \frac{\sqrt{\%EXP\ of\ opponent\ team}}{\%EXP\ of\ opponent\ team + \%Exp\ of\ player\ team7 \times s} \quad (14)$$

$$EXP = \frac{\sqrt{\%EXP\ of\ opponent\ team}}{100} \quad (15)$$

Player can obtain data about the Pokemon team and the experience points of Gym Leaders, Elite Fours and the rival via walkthrough [16]. Unfortunately, the experience player acquire in the game [4] is a little bit different from the equation, so we check in both cases. In order to calculate the experience points player's opponent will obtain if he defeats player, we use the following assumptions:

- At the beginning, player has one Pokemon with level five in his team. After defeating the first Gym Leader, player will have one more Pokemon in his team. After defeating the second Gym Leader, player will have another one etc. However, the process will end when player defeats the sixth Gym Leader because player can only carry up to six Pokemons at the same time.
- All player's Pokemons will have his base experience equals to 136. It was calculated based on the average value from the base experience table in [3].
- The growth rate of all Pokemons is the same, which is the average of the six formulas shown in Table 6
- The level of the new Pokemon in player's team is the average level of the wild Pokemon in that catch zone [16].
- The experience player acquires when player challenges with normal trainer will be divided equally between all of the Pokemons in his team.
- From the experience points Pokemon has, we can find the level of that Pokemon by the average Growth rate.

Table 7: Example of player team's information with the first 4 Gym Leaders

	Number of Pokemons	Level of each Pokemons					
		1^{st}	2^{nd}	3^{rd}	4^{th}	5^{th}	6^{th}
Gym1	1	12	0	0	0	0	0
	1	12	0	0	0	0	0
Gym2	2	22	21	0	0	0	0
	2	22	21	0	0	0	0
Gym3	3	27	26	20	0	0	0
	3	27	22	20	0	0	0
Gym4	4	31	31	27	23	0	0
	4	31	31	27	23	0	0

Table 7 shows an example of player's team's information with the first four Gym Leaders by using the assumption mentioned above. In each Gym, there are 2 rows: the value player gets in Real Playing and in Equation (12). So, we can calculate the refinement value by using Equation (15). Then, Table 8 shows the result obtained by choosing Pokemon Fire Red version as an example.

Table 8: Refinement value when using the experience points measurement obtained in real playing and with the model of the score-limited equation

		ExpOp	ExpPly	%Op	%Ply	R
Gym1	RealPlay	544	349	60.92	39.08	0.0781
	Formula	385	349	52.45	47.55	0.0724
Gym2	RealPlay	1339	1253	51.66	48.34	0.0719
	Formula	1081	1253	46.32	53.68	0.0681
Gym3	RealPlay	1405	2125	39.8	60.2	0.0631
	Formula	1802	2125	45.89	54.11	0.0677
Gym4	RealPlay	3182	3262	47.18	52.82	0.0687
	Formula	3131	3262	48.98	51.02	0.07
Gym5	RealPlay	4710	4487	51.21	48.79	0.0716
	Formula	4124	4487	47.89	52.11	0.0692
Gym6	RealPlay	5093	6117	45.43	54.57	0.0674
	Formula	5738	6117	48.04	51.96	0.0693
Gym7	RealPlay	5994	6992	46.16	53.84	0.0679
	Formula	4860	6904	41.31	58.69	0.0643
Gym8	RealPlay	7830	7603	50.74	49.26	0.0712
	Formula	6934	7458	48.18	51.82	0.0694
Elite1	RealPlay	10122	8100	55.55	44.45	0.0745
	Formula	9777	7923	55.24	44.76	0.0743
Elite2	RealPlay	7912	8566	48.02	51.98	0.0693
	Formula	8066	8333	49.19	50.81	0.0701
Elite3	RealPlay	9731	8973	52.03	47.97	0.0721
	Formula	10686	8711	55.1	44.9	0.0742
Elite4	RealPlay	11209	9323	54.59	45.41	0.0739
	Formula	11378	9060	55.67	44.33	0.0746
Champ	RealPlay	15318	9644	61.81	38.19	0.0786
	Formula	15572	9293	62.63	37.37	0.0791

In Table 8, *ExpOp* indicates the experience points player obtains when the opponent is defeated, *ExpPly* indicates the experience points the opponent obtains when the player is defeated, *%Op* is the percentage of *ExpOp* and *%Ply* is the percentage of *ExpPly* in the total experience of both teams.

Finally, we apply our experience-based model to two versions remained, Pokemon Red and Pokemon Soul Silver. The results are shown in Table 9. *Rreal* indicates the average *R* value which was calculated with the data obtained from the real game [4] [16], while *Rformula* indicating the average of *R* value which is calculated by using the equation mentioned in Section III-C.

Table 9: Comparison of game refinement values

Version	Rreal	Rformula
Pokemon Red	0.072	0.0714
Pokemon Fire Red	0.0714	0.071
Pokemon Soul Silver	0.0691	0.0698

IV. Discussion

We conduct the experiment with data from reliable websites. Then, we apply game refinement theory, an experience-based model, to Pokemon Red, Pokemon Fire Red, and Pokemon Soul Silver. The results of the experiment are shown in Table 9.

However, despite the fact that the average refinement values lie in the window, from Table 8, the *R* value of individual battles with Gym Leaders is lower. The reason is that in the real game, a battle is not balanced, especially in the number of Pokemons. In the first Gym, player have only one Pokemon but player has to fight with two higher-level Pokemons (level 12 versus level 12 and level 14). At the end of the game, player's team is full with six Pokemons, but his opponent only has five, which gives player a lot of advantages.

We have two ways to explain why the result fits in the window. In the battle with the first Gym Leader and the Rival Champion, the *R* value is too high which makes the average *R* value fit in the window even though the values of other battles are below 0.07. So its true value should be below the window but greater than 0.06.

The other explanation can be found in the game of chess. In chess, although it is an interesting game, its *R* value is not high because it usually ends with a draw result. One possible solution is to use a round match tournament, so the player who wins more matches will be the winner of the whole game. We can explain it here in the same way. Each battle is usually not too exciting, because in most of the games, it is easy to predict who the winner is. But in a whole series of battles, there will be a higher chance that a player loses to another trainer, which makes the refinement value fit in the window.

In a real game, the player not only fights trainers, but also with wild Pokemon on grass to obtain experience points. This leads to the deduction that the Pokemon team of players will be stronger, thus the *R* value in the experience-based model will be decreased. This also means that this game will be easier than the experiment of the model, so it will be suitable for children to enjoy. Player does not have to spend too much time to struggle with a tough Gym leader, instead, player can enjoy the story line and doing the side quests too. Another factor is that we make an assumption that the base experience of all Pokemons is 136, which is usually higher than in the real play.

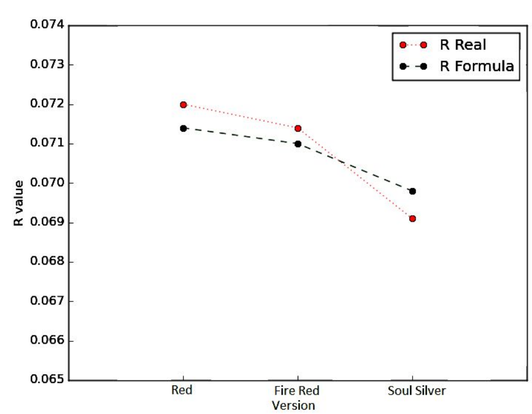
It is too early to say that normal battles are not interesting because the individual game's values lie under the window. However, if we want to raise the *R* value, there are several ways:

- Increase the number and the level of Pokemons in the Gym Leader team.
- Decrease the number of battles with trainers so player's Pokemon will have a lower level.
- Decrease the level of the wild Pokemon and the wild Pokemon should have a low base experience.
- The Pokemon that most people love to choose in their team should have a 'Slow' growth rate or a slower one.
- The Pokemon team of Players will not be filled soon in the first six Gyms. A strong Pokemon should only be found in the later stage.

Therefore, for the first research question, how does the environment in Pokemon affect to the game's entertainment?, we can conclude that there are so many factors which directly related to game's entertainment described above. We suggest that we can improve *R* value by adjusting environment's factor mentioned above.

For second research question, we start by comparing the result in Table 9 shown in Figure (1).

Fig. 1: Changes of game refinement values with three versions of Pokemon



According to Figure (1), we will see that the *R* value of the Pokemon which is applied by using the experience-based model is *0.069-0.072*, while previous studies confirm that sophisticated games will have an *R* value between *0.07-0.08*. So, we can say that Pokemon has an *R* value at the edge of the appropriate range.

Importantly, we can see in Figure (1) that the trend of the *R* value is decreasing. This may lead to a Pokemon's excitement is being lower from an old version to a new version. The slightly low *R* value indicates that it is suitable for children who are the main target of the Pokemon game.

Pokemon Red in general is the same setting as Pokemon Fire Red. There are just some minor differences such as in the summation of experience points player obtains if player defeat all trainers in the game: 608,098 Exp to 672,388 Exp of Fire Red. The main reason is that the level of trainers in the Red version is lower than in the Fire Red version which affects the *R* value and makes it higher. This is suitable with our suggestion above.

For Pokemon Soul Silver, the story takes place in two regions. In the first one, the setting of the Gym leader's team is quite low, while in the second one, it is really high with the *R* value of the last battle reaching 0.0819. However, when we calculate the average, it does not fit in the window. This can be explained as a trade-off when player has a longer story line with two regions compared to one region such as Pokemon Red or Pokemon Fire Red.

Therefore, for the second research question, what is the trend of the changing of setting of gameplay in Pokemon, we can answer that *R* value is being decreased and there are many reasons explained above.

These are our efforts to see the evolution in the gameplay and the change in the *R* value. In future work, we will conduct a survey with Pokemon players to see how they rank each version in a scale up to 10 with the best rank being 10. After that, we can look for a satisfactory explanation for the connection between the feeling and the gameplay in the human brain. Next, we can consider the *R* value so we can see the appropriate range of the *R* value and how the Pokemon game has evolved since the first version. Moreover, the later version comes with a new kind of competition such as beauty contest so we can also apply game refinement theory to this part of the game.

Game refinement also has another model named board-game model which concern about branching factor and the depths of the game. So, what will happen if we apply board-game model to Pokemon? We can build an automatic program for battle, with properties that are set as the real play of Gym Leaders, in order to apply board game model. However, this work will be very complicated, with a lot of strategies and many different ways of doing battle in Pokemon.

CONCLUSION

This work tries to investigate the setting in the gameplay of Pokemon, one of the most popular turn-based RPG video games in the world. We consider about effect of the setting of gameplay in Pokemon with two questions in mind: "How does the environment in Pokemon affect to the game's entertainment?" and "What is the trend of the changing of setting of gameplay in Pokemon?". For this purpose, we apply our new game refinement model, an experience-based model, to three version of Pokemon games consist of Pokemon Red, Pokemon Fire Red and Pokemon Soul Silver.

According to the results, we determined that Pokemon has a refinement value at the edge of the window as we expected. The trend of the *R* value of Pokemon is being decreased. This is because the target players of Pokemon are children. Moreover we suggest several ideas to increase the *R* value for the battle in the game.

In conclusion, it is obvious that game refinement theory can effectively be used in many type of games and sports, as long as we can find the appropriate mathematical model and the data is enough. It can be used as a helpful tool to measure the attractiveness of a game considered and it enables game designers to design a target game more sophisticated. With many observed experiments, we tentatively conclude that a suitable game refinement value is around 0.07-0.08.

Further research may include automatic real play, where the setting of the level and the number of Pokemons are the same as in the real game. From there, we can find the *B* and *D* values to apply the board game model to find the refinement value. However, the enjoyment of the Pokemon game is not only in Pokemon battle, it may come from other factors such as game's story or attractiveness of Pokemon's character. In further work, we plan to apply the theory to this perspective.

REFERENCES

[1] Allison, Anne. (2004). "Cuteness as Japan's Millennial Product." Pikachu's Global Adventure: The Rise and Fall of Pokemon. Ed. Joseph Tobin. Durham: Duke University Press, 2004. 34--49. Link: http://web.mit.edu/condry/Public/cooljapan/Feb23-2006/Allison-03-Postcol-Portble.pdf.

[2] H. Bromley (2004). Localizing Pokemon Through Narrative Play. Pikachu's Global Adventure: the Rise and Fall of Pokemon. Durham: Duke UP, 211-225.

[3] Bulbapedia, http://bulbapedia.bulbagarden.net/wiki/Experience, URL accessed, 2015.

[4] Gamefaqs, http://www.gamefaqs.com/gba/918915-pokemon-firered-version/faqs/28557, URL accessed, 2015.

[5] K. Hemmann (2013). Mythical Landscapes and Imaginary Creatures: Pokemon and Japanese Regionalism, Proceedings of the Association for Japanese Literary Studies, Vol. 13. Information about the publication can be found at: http://www.cla.purdue.edu/slc/ajls/.

[6] Horton, J. (2012) 'Got my shoes, got my Pokemon': spaces of children's popular culture. Geoforum. 43(1), pp. 4-13. 0016-7185.

[7] H. Iida, N. Takeshita, and J. Yoshimura. (2003). A metric for entertainment of boardgames: Its implication for evolution of chess variants. *Entertainment Computing Technologies and Applications*, 65--72.

[8] H. Iida, K. Takahara, J. Nagashima, Y. Kajihara and T. Hashimoto. (2004). An application of game-refinement theory to Mah Jong. *Entertainment Computing--ICEC2004*, 333--338. Springer.

[9] M. Ito. (2010). `Creating interest-driven content and programming that is easily shared, interactive and participatory is key to unlocking the power of networked media.' Nieman Reports: THE NIEMAN FOUNDATION FOR JOURNALISM AT HARVARD UNIVERSITY, page 18.

[10] Inventorss, http://inventors.about.com/library/inventors/blcomputer_videogames.htm, URL accessed, 2015.

[11] N. Nossal and H. Iida (2014). Game Refinement Theory and Its Application to Score Limit Games. *Proceedings of IEEE GEM 2014*. in press

[12] J. Neumann. (1928). Zur theorie der Gesellschaftsspiele. *Mathematische Annalen*, 100(1):295--320.

[13] OTAKU, MANGA: Pacific Affairs: Volume 83, No. 3, September 2010.

[14] Sutiono, A.P., Purwarianti, A., and Iida, H. (2014). A mathematical model of game refinement. In D. Reidsma et al. (Eds.): Intelligent Technologies for Interactive Entertainment 2014, LNICST Social Informatics and Telecommunications Engineering, 136, 148-151.
[15] Serebii, http://www.serebii.net/games/exp.shtml, URL accessed, 2015.
[16] Strategywiki, http://strategywiki.org/wiki/, URL accessed, 2015.
[17] J. Takeuchi, R. Ramadan, and H. Iida. (2014). Game refinement theory and its application to Volleyball, Research Report 2014-GI-31(3), Information Processing Society of Japan, 1--6.
[18] Joseph Tobin (2004). Pikachu's Global Adventure: The Rise and Fall of Pokemon, Publisher Duke University Press Durham, NC, USA.
[19] XIONG Shuo, ZUO Long and H. Iida (2014). Quantifying Engagement of Electronic Sports Game. *Advances in Social and Behavioral Sciences*}, 5, 37--42.
[20] XIONG Shuo and H.Iida (2014). Attractiveness of Real Time Strategy Games. *International Conference on Systems and Informatics (ICSAI 2014)*, 264--269.
[21] XIONG Shuo, ZUO Long, R. Chiewvanichakorn and H. Iida. Quantifying Engagement of Various Games. *The 19th Game Programming Workshop 2014*, 101--106.