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# Murder Mystery Game Setting Research using Game Refinement Measurement

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**Abstract.** This paper explores the game sophistication of a party game is called Murder Mystery Game (MMG), which is very popular in teenagers, recently it was boom developed in China and Japan. For players, they have to promote game story process by performing the role which was assigned to them, finally, players need to find out who is the "murderer", reversely murderer player has to try his best strategy to escape from the story. In this paper, our research focuses on the playing settings, MMG needs several players and cost a few hours, the game would become boring as the number of players becomes too large or too small, therefore we use the game refinement theory to analyze MMG setting to make the game process become more balanced and sophisticated. Computer natural and convergent simulations for a simple version of MMG are conducted to collect the data while game refinement measure is employed for the assessment. The results indicate several interesting observations, which can help game designers to create a better murder scenario.

**Keywords:** Murder Mystery Game · Game Refinement Theory · Game Design · Computer Simulation.

## 1 Introduction

Murder Mystery Game is a special type of Live-Action Role-Playing game (for short as LARP). The term LARP covers a wide variety of game variants, making them inherently difficult to define, however, it is LARP that is the commonly accepted term in the gaming community [8]. Generally to say, LARP is the party game, players do not need to use any electronic devices such as PlayStation 4 or computer, also players do not rely on the boards or pieces. From the rules, LARP seems like an improvisational theater or modern drama. A live role-playing game is a dramatic and narrative game form that takes place in a physical environment [6]. It is a story-telling system in which players assume character roles that they portray in person, through action and interaction. The game world is an agreed-upon environment located in both space and time, and

governed by a set of rules – some of which must be formal and quantifiable [2] [8].

Just like the film and novel, LARP also divided into several themes, like the relationship between literature and detective fiction, in this paper, we focus on the most popular subject– Murder Mystery Game (for short as MMG) [1]. Detective and murder puzzle is the core experience of Murder Mystery Game, also they are the most attractive point differ from other LARP. Similar to the Mafia game or Werewolf game, each player will be assigned identity in the MMG, one or a few players will be assigned the murderer or shady deal scenario. During the game, the detective has to find the murderer and shady deal; the innocent person need to clear themselves and accomplish their own mission, also they can try their best to help the detective to find who is the murderer player; of course for the murderer, they must scapegoat and attack the innocent. People can easily buy the Murder Mystery Game scenario or play the MMG in entity stores, recently the online scenario Murder Mystery Game is very popular in China between the young teenagers .

The origin of Murder Mystery Games came from the murder mystery fiction such as "Sherlock Holmes". In 1935, the first murder mystery box-packed game hit the market. One that era, the scenarios were simple, until now, due to the genius authors, more and more complicated scenarios were written, even you can enjoy the story as the audience.

## 2 Game Process of the MMG

According to the different scripts or scenarios, various rules existed. Generally, all the entire game can be described by a set of 6 parts: Preparing, Beginning, Search, Analysis, Voting, and Ending.

- Preparing: In the beginning, the players or game master have to choose the scenario, also players have to know the story theme and social background of the scenario. After that, each player will receive his/her own script (according to preferences or randomly assign), then prepare to read and act the role.
- Beginning: All players have to read their script carefully, confirm the storyline, confirm their task. For example, the murderer player should hide his identity and blame others, detectives and suspects need to find the real murderer, sometimes the suspects have to accomplish several branch tasks such as hide their scandals (although they did not "kill" anyone in the scenario). While all players finish the story reading and task confirming, the performance will begin.
- Rummage: After roles and story introduction, the murder happened, all players need to search the related pieces of evidence to prove who is the murderer. Of course, some evidence is interference options, and the murderer player has to hide the evidence which will work to him/her disadvantage.

- Analysis: The fourth step is case analysis, all necessary evidence was searched clearly and shown to every player(except the hide evidence by the murderer player). Then, around the case and puzzle, players would tell their timeline, alibi, relationships, murder motive, etc., exchange the evidence and script information, try to find who is the real murderer player. In contrast, the murderer player needs to establish a complete alibi, or use existing clues and logic to blame other suspects.
- Voting: According to the entire game time setting, while the final 15 minutes left, or everyone thinks the puzzle is solved and no space to discuss anymore, the host should announce that analysis and discussion finish. All players have to consider who is the real murderer then write the corresponding role name to vote anonymously.
- Ending: While all players finished the voting, the host announces the voting result, the player who gets the most votes will be considered as “murderer”, then the host has to tell everyone the voting result whether is correct or fault. If the “murderer candidate” is correct, the detective and suspects player win the game, otherwise murderer player wins. According to the winner, the host should tell the different story ending, and restore the truth of the scenario and the murderer’s technique process. Players thank each other then game finish.

To our best knowledge, few investigations have been made in the aspect of comfortable settings of the Murder Mystery Game. In order to tackle this challenge, computer simulations are performed to obtain statistical data such as the number of players, whereas game refinement measure is employed for the assessment. As a benchmark in this study, we have established a mathematical model of Murder Mystery Game, the setting can be represented as described in Notation 1.

**Notation 1**  $MMG(N, T, b, r, a, v)$  denotes a game of Murder Mystery Game which has totally  $N$  players and  $T$  full time, which consists of  $b$  beginning time and  $r$  rummaging time, also  $a$  means analysis period and  $v$  presents final inference and voting time.

### 3 Game Refinement Theory

We review the early work of game refinement theory from [3]. The decision space is the minimal search space without forecasting. It provides the common measures for almost all board games. The dynamics of decision options in the decision space have been investigated and it is observed that these dynamics are a key factor for game entertainment. Thus a measure of the refinement in games was proposed [4].

Later, the following works are sketched from [5],[7] that expands the model of game refinement which was cultivated in the domain of boardgames into continuous movement games such as sports games and video games.

The game progress is twofold. One is game speed, while another one is game information progress with a focus on the game outcome. Game information progress presents the degree of certainty of a game's result in time or steps. 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  $0 \leq t \leq t_k$  and  $0 \leq x(t) \leq x(t_k)$ , as shown in Eq. (1).

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

However, the game information progress given by Equation (1) is usually unknown during the in-game period. Hence, the game information progress is reasonably assumed to be exponential. This is because the game outcome is uncertain until the very end of game in many games. Hence, a realistic model of game information progress is given by Equation (2).

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

Here  $n$  stands for a constant parameter which is given based on the perspective of an observer in the game considered. If one knows the game outcome, for example after the game, or if one can exactly predict in advance the game outcome and its progress, then we have  $n = 1$ , where  $x(t)$  is a linear function of time  $t$ . During the in-game period, various values of the parameter  $n$  for different observers including players and supporters will be determined. For example, some observers might be optimistic with  $0 \leq t < 1$ . However, when one feels any difficulty to win or achieve the goal, the parameter would be  $n > 1$ . Meanwhile, we reasonable assume that the parameter would be  $n \geq 2$  in many cases like balanced or seesaw games. Thus, the acceleration of game information progress is obtained by deriving Equation (2) twice. Solving it at  $t = T$ , the equation becomes

$$x''(T) = \frac{\sqrt{x(t_k)}}{t_k} \sqrt{n(n-1)} \quad (3)$$

It is expected that the larger the value  $\frac{x(t_k)}{(t_k)^2}$  is, the more the game becomes exciting, due in part to the uncertainty of game outcome. Thus, we use its root square,  $\frac{\sqrt{x(t_k)}}{t_k}$ , as a game refinement measure for the game under consideration. We call it *GR* value for short as shown in Equation (4).

$$GR = \frac{\sqrt{x(t_k)}}{t_k} \quad (4)$$

We show, in Table 1, measures of game refinement for various games [9]. From the results, we conjecture the relation between the measure of game refinement and game sophistication, as stated in Remark 1.

*Remark 1.* Sophisticated games have a common factor (i.e., same degree of informational acceleration value, say 0.07-0.08) to feel engaged or excited regardless of different type of games.

Table 1: Measures of game refinement for various types of games

Game	$x(t_k)$	$t_k$	$GR$
Chess	35	80	0.074
Shogi	80	115	0.078
Go	250	208	0.076
Basketball	36.38	82.01	0.073
Soccer	2.64	22	0.073
Badminton	46.336	79.344	0.086
Table tennis	54.863	96.465	0.077
DotA ver 6.80	68.6	106.2	0.078

Therefore, we will use game refinement theory to analyze the Murder Mystery Game to control the game refinement value could be located in the zone area. Consider the game process, the speed can be described by two parameter: one is the full game time  $T$  as  $t_k$ , which are consisted by beginning period  $b$ , rummaging period  $r$ , analysis process  $A$  and voting inference segment  $v$ .

It needs to be explained that the analysis process  $A$  should be divided into small parts for each player. For example, there are 5 players then  $C_5^2$  role relationships need to be analyzed, for one sub-analysis time is marked as  $a$ . Based on above, the  $T$  equal to  $b + r + C_N^2 * a + v$ .

Another parameter is the effective outcome time  $x(t_k)$ , in this situation, the parameter could be described as the  $((N - 1) * (N - 1) + N) * v$ ,  $N$  is the total players number too. For  $N$  players, the murderer has to consider the  $N$  possibility, and other suspects have to consider the  $N - 1$  possibility (except themselves), therefore totally we have  $((N - 1) * (N - 1) + N)$  effective branching factors, then multiply the unit time  $v$  to get the outcome. Therefore, the refinement value in Murder Mystery Game as shown in Equation 5

$$GR \text{ value} = \frac{\sqrt{((N - 1)^2 + N)v}}{b + r + C_N^2 a + v} \quad (5)$$

## 4 Simulation

Different from Chess (certainty rules) or soccer (huge user and global organization), it is impossible to collect mega murder mystery game data from human players. Therefore, we would like to use the Python program to simulate game progress thousands of times, the simulation process as algorithm 1 shows.

The simulation principle is mentioned as below:

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**Algorithm 1** Murder Mystery Game Simulation Process

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**Require:**  $n$  is the quantifiable game round for natural simulation;

- 1: natural simulation random function setting for  $MMG(N, b, r, a, v)$
- 2:  $n = 0$
- 3: for  $i$  in range(10000):
- 4:  $GR\ value = \frac{\sqrt{B}}{D}$
- 5: if the  $0.07 < GR\ value < 0.08$  and  $120 < T < 300$ ,  $n = n + 1$
- 6: record average natural simulation  $NS(b, r, a, v)$ ;
- 7: else pass;

**Ensure:**  $m$  is the quantifiable game round for convergent simulation;

- 8: according to  $NS(b, r, a, v)$  to make convergent simulation random function setting for  $MMG'(N', b', r', a', v')$ ;
  - 9:  $m = 0$
  - 10: for  $i$  in range(10000):
  - 11:  $GR\ value = \frac{\sqrt{B}}{D}$
  - 12: if the  $0.07 < GR\ value < 0.08$ ,  $m = m + 1$
  - 13: record average natural simulation  $CS(b, r, a, v)$ ;
  - 14: else pass;
  - 15: **return**  $coincidencerate = n/10000$  and  $coincidencerate = m/10000$ ;
  - 16: **return**  $NS(N, T, b, r, a, v)$  and  $CS(N, T, b, r, a, v)$
- 

- For each setting, the simulation times equal to 10,000, which satisfy the requirement of mega statistic, and do not waste computer recourse.
- The unit of time in game refinement model is 1 minute, not second or hour. Because the basic and the shortest activity in MMG is role introduction, which just around 1 minute, therefore we use 1 minute as a basic unit.
- The simulation result should be located in zone value (0.07 – 0.08) will be considered valid and recorded. Also, the entire game time should between 120 minutes (2 hours) and 300 minutes (5 hours), because too short game period is no interesting, and too long will disturb normal daily life. For example, no one play game in the morning, so players get together at 13:00 pm, 5 hour later they have to have dinner, the evening is the same. Therefore,  $120 < T < 300$ .
- The First step is simulating the game process naturally as normal human experience setting, to get the coincidence rate as Table 2 shows, also the average setting  $NS(N, T, b, r, a, v)$  would be given.
- Second, according to the  $NS(N, T, b, r, a, v)$ , the convergent boundary are set within the unit range. For example in Table 2, while  $N = 4$  and  $b = 16.97$ , then the convergent boundary setting in simulation program was marked as  $random.uniform(16.47, 17, 47)$ , following the logic the convergent simulation result can be given as  $CS(N, T, b, r, a, v)$

According to the algorithm and principle, the complete simulation data was shown in Table 2.

Table 2: Murder Mystery Game simulation setting and result

Player number	b	r	a	v	A	Total time (T)	Coincidence rate
4-natural	16.97	17.41	16.43	8.90	98.58	141.90	4.43%
<i>4-convergent</i>	<i>16.99</i>	<i>17.40</i>	<i>17.40</i>	<i>9.00</i>	<i>104.40</i>	<i>147.82</i>	<b>99.84%</b>
5-natural	16.25	15.44	16.03	11.53	160.30	203.63	5.86%
<i>5-convergent</i>	<i>16.20</i>	<i>15.49</i>	<i>16.00</i>	<i>11.49</i>	<i>160.00</i>	<i>203.20</i>	<b>99.99%</b>
6-natural	15.32	15.29	13.57	11.31	203.55	245.62	4.51%
<i>6-convergent</i>	<i>15.30</i>	<i>15.30</i>	<i>13.50</i>	<i>11.29</i>	<i>202.50</i>	<i>244.45</i>	<b>98.83%</b>
7-natural	15.09	14.67	10.23	8.67	214.83	253.36	2.22%
<i>7-convergent</i>	<i>15.10</i>	<i>14.70</i>	<i>10.22</i>	<i>8.67</i>	<i>214.62</i>	<i>253.20</i>	<b>93.37%</b>
8-natural	14.92	14.79	7.93	6.70	222.04	258.62	0.93%
<i>8-convergent</i>	<i>14.90</i>	<i>14.81</i>	<i>7.93</i>	<i>6.67</i>	<i>222.04</i>	<i>258.68</i>	<b>90.63%</b>
9-natural	15.97	15.35	6.50	5.78	234.00	271.10	0.40%
<i>9-convergent</i>	<i>15.89</i>	<i>15.30</i>	<i>6.52</i>	<i>5.68</i>	<i>234.72</i>	<i>271.64</i>	<b>84.67%</b>
10-natural	14.26	14.13	5.60	5.27	252.00	285.67	0.15%
<i>10-convergent</i>	<i>14.30</i>	<i>14.10</i>	<i>5.61</i>	<i>5.21</i>	<i>252.45</i>	<i>286.12</i>	<b>56.61%</b>
11-natural	7.00	10.25	5.00	5.00	275.00	297.25	0.04%
<i>11-convergent</i>	<i>6.99</i>	<i>10.29</i>	<i>4.92</i>	<i>4.72</i>	<i>270.60</i>	<i>292.94</i>	<b>12.87%</b>

*Remark 2.* Total player number should larger than 3, while the player number  $N \leq 3$ , game setting should be “Player VS Environment”, In other word, “Player VS Player” at least need  $N \geq 4$ .

*Remark 3.* If we want control the game length in 5 hours with comfortable feeling, the maximum total player number must less than 11, because the program error will happen while  $N$  was inputted larger than 12. Despite all this, from Table 2 we notice that while  $N = 11$ , the convergent coincidence rate only equal to 12.87%, therefore the reasonable maximum  $N$  is 10, in special cases could be 11.

*Remark 4.* Both natural and convergent simulation, the highest coincidence rate setting is  $N = 5$ , which means 5-roles script is the easiest scenario for Murder Mystery Game authors, in addition 160 minutes is a suitable social entertainment duration in the afternoon and evening.

*Remark 5.* From 4 to 6 players setting, the comfortable time length increase obviously. However, from 6 to 10 players setting, the total time did not change too much. It means the average participating time for each player will decrease while number of players larger than 6. In other words, when  $N = 6$ , the average thinking and participation time of players can reach the maximum under the comfortable time setting.

*Remark 6.* Although the convergence coincidence rate of  $N = 9$  is still high, compare with other settings when  $N \leq 8$ , it is lower than 90%. This means high-quality script should consider the game rhythm. On the macro level, the data performance is still passable, but on the micro level, some players may not



have any participation in the script at all, they just play a role in the aggregate. When  $N = 10$ , the issue is more obvious.

## 5 Conclusion

In this paper, base on game refinement theory we analyzed the comfortable time setting in Murder Mystery Game. According to the computer natural and convergent simulation, some interesting result was found. The notion of game progress and game information progress model for Murder Mystery Games was introduced in the development of game refinement measure. It seemed to be a successful tool to analyze the Murder Mystery Games players and time setting. Whereas 0.07-0.08 should be a comfortable zone due to its good balance between skill and chance in game playing.

The setting of  $MMG(5, 203.2, 16.2, 15.5, 16, 11.5)$  is the most manageable scene for the author, and setting of  $MMG(6, 244.5, 15.3, 15.3, 13.5, 11.3)$  is the most most challenging script for the players. Moreover, in order to satisfy the comfortable setting, the total number setting should be  $4 \leq N \leq 8$ , sometime  $N$  could be 9 or 10. The maximum limit is  $N = 11$ , however it is not recommended in terms of comfort and script quality. Our suggestion is that if the script really needs more characters, we can add some pure detective roles, who are not regarded as suspects, so as to ensure that the game refinement analysis of the script can be controlled within the zone value. We believe this research achievement can help the Murder Mystery Game authors and players to gain the better experience.

Nevertheless, such field is still nascent and there is a pressing need for further exploration of a broader range of Murder Mystery Game domains. In the future, we may expand the Murder Mystery Game analysis area, update the game refinement theory model and simulation program to find the more interesting conclusion.

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