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Ludonotation: A Visualization System of Recording and Analyzing Interactive Strategic Gaming Behaviors

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Abstract: Interactive strategic games (ISG) are dynamic and involve complex gaming behaviors and oftentimes intrinsic interrelated gaming strategies. Students' interactions would influence group dynamics, and players with different personality traits would behave differently in the game, and vice versa. This study develops a visualization tool: Ludonotation, a notation system of ludology, to record and analyze interactive gaming behaviors. The presentation of Ludonotation@ISG and its functions are accompanied by the example of the analysis of the house-made strategic game <Fragrance Channel v2.0>; the conceptual model is adaptive to other game genres. The paper shows how the gaming strategies of the players with different personality traits were modelled, and to understand the relationships between interactive gaming behaviors and gaming strategies.

Keywords: Ludonotation, Interactive Strategic Games, Gaming Behaviors, Gaming Strategies

1. Introduction

Interactive strategic games (ISG) are dynamic, and involve complex gaming behaviors and often times intrinsic interrelated gaming strategies. In most game analyses, players' single behaviors are identified individually and independently. Behavior features are extracted and the procedural data are analyzed only to predict their outcomes. Nevertheless, depicting their processes and defining their behavior patterns in social interactions, especially those interrelated, interactive, and intrinsic behaviors across players, become important to understand what people would do in the game, especially when people are with distinct personality traits and goals.

In order to do that, a visualization tool: Ludonotation, a notation system of ludology, is introduced to record and analyze interactive gaming behaviors both physical and conceptual. Ludology is game studies which rooted in anthropology and examining aspects such as game designs, player interactions, and social roles of games. Ludonotation is to visualize players' gaming strategies hidden from the interactive gaming behaviors that assist us to understand, respect, communicate, and work with others, either in or outside of the game.

This paper presents Ludonotation@ISG and its functions with the example of the analysis of the house-made strategic game <Fragrance Channel v2.0>.

2. Literature review

2.1 Interactive Strategic Games

Strategies can be defined in various ways depending on the genres of games. To avoid being distracted to the long list of game genres, this paper places its focus on the interactive strategic games (ISG) that has fundamental features in varying degree: a) Players progress based on strategic decisions, not luck; b) Players have equal knowledge to play; c) Play is based on multiple decisions a person could make on each turn with possible advantages and disadvantages each time; d) Players can plan strategies that will take multiple turns to complete fully; e) Players can replay the game many times and have a different experience each time; f) Winning and losing is specific and achievable.

The ISG designed in this study, <Fragrance Channel v2.0>, has a couple more features that defines it as a scenario-based ISG (e.g. Covaci, Ghinea, Lin, Huang, & Shih, 2018; Shih, Huang, Lin, & Tseng, 2017): a) A thematic scenario and narrative that encompass certain degree of conflicts. The scenario often comes along with narratives and conflicts so that players are engaged in the game environment. Conflicts are the source of competition in which players compete over limited options, choices, and resources. b) Multiplayers that take unequal roles in the game. The inequality motivates players to use strategies to win the game. c) The round-based game with certain degrees of free-talk game sections. This free-talk section is designed to encourage social interactions that allow players to negotiate for reaching common goals or achieving mutual agreements. d) Interactions that are generated from the free-talk section for negotiation or so forth. The negotiation also affects players' strategic planning and decision-making. e) Open ending, in which the victory is defined by principles instead of the achievement of any single player. Game outcome answers the objective of game that fit the theme and solve conflicts of the triggering events. Games can end in a variety of ways by achieving a stated condition described by the designer. These features bring ISG its complexity and adhesiveness.

In ISG, players use strategies as their decisions and choices in the game where the outcome depends not only on their own actions but on the actions of others (Kugler, Kausel, & Kocher, 2012). ISG are often dynamic that do not rely on luck but decision-making skills in determining the course and outcome of the game. These decisions do not occur by accident as game designers create games purportedly to generate specific actions, behaviors, and strategies.

2.2 Behavior Analysis

Game-based learning (GBL) involves two types of behaviors: learning behaviors and gaming behaviors. Whereas learning behaviors are those actions outside of the game but using game as learning medium, gaming behaviors are those actions happen inside of the game according to the mechanisms. Learning behaviors are done for the learning goals, and gaming behaviors are for gaming tasks. Learning is for improvement and gaming is for winning. Since the goals and behaviors are different between learning and gaming, researchers should make clearer definitions to the two.

Most GBL behavior analysis are about individual behaviors in the whole process with or without peers (e.g. Huang, Cheng, Huang, & Teng, 2018; Prada, & Paiva, 2009; Worth, & Book, 2014); seeing group behaviors as a whole in terms of learning styles, personalities, learning achievements, etc. (e.g. Buckley, & Doyle, 2017). So far, there is no study that looks into individual player's interactive behaviors in the group, nor generate identifiable social interactive behavior patterns of individuals. Also, most studies in GBL focus on analyzing learning behaviors with the game but not gaming behaviors in the game (e.g. Yang, Chang, Hwang, & Zou, 2020); and some studies mix learning and gaming behaviors in their coding system (e.g. Hou & Keng, 2021).

Other than looking at probabilities, frequencies, ratios, factors, we are looking for behavior patterns. Behavior documentation should be done in multimodal forms, such as text, audio, video, as well as system logs. Multimodal analytics would also involve facial expression recognition, body gesture recognition, social distance and space movements, and so forth (e.g. Spikol, 2017).

It also requires a visualization tool so that the complex interrelationship of player interactions can be seen and transmitted. To understand the relationships between individual behaviors, Lag Sequential Analysis (LSA) can be used (e.g. Hou, 2012); yet only an extended version of Time Sequence Analysis (TSA) can show a series of intersected actions done by several players, and the chain of every individual's actions in every round of the game. The major difference is that the later shows the real-time stamps of every event instead of a mined data calculation. There is only one study mentioning game behavior strategies (e.g. Azhar, Mclennan, & Reif, 2005).

3. Research Methods

3.1 Game Design

This research develops strategic complex board game <Fragrance Channel v2.0> in which the players role-play European countries, namely England, Netherland, Spain, and Portugal, each completes respective spice trade missions in the Great Voyage time. The players have to obtain spices from not

only their own colonies but also others which cause cooperation (trades) and competition (battles) to happen. Smart phone is integrated in the physical board game which extends the functions of the game mechanisms including documenting and exchanging gaming parameters and values. The database documented every player's gaming behaviors which can be used for consecutive time sequence behavior analysis. In this dynamic game, players have a lot of interpersonal interactions and strategic planning. Other than moving their ships to designated locations, they manage to find out the best approach to complete their missions faster than other players and win the game.

3.2 Research Design

This research documented 8 games for about two hours each with four players in a game. Students were identified with the personality trait using PDF personality scale. In order to more clearly describe the following discussion, animal nicknames are used to refer to the personality traits. Nevertheless, students were too young to possess dominance (Tiger) trait. Therefore, Tiger trait is neither included in the analysis nor the discussion in this study.

Document codes were inscribed as below for narrative purposes and served as evidences for analysis. For example, 814-M-01 refers to game session of "date -time (morning/afternoon)-session number"; and P1-B-Peacock refers to "player number-gender(boy/girl)-personality".

After every game, 20-minute focus group was conducted with every gaming group to review the gaming process together. All gaming behaviors and dialogues were transcribed and coded for analysis. Two categories of codes were used. Gaming Behavior codes (GB) are to document the players' extrinsic gaming movements that are observable. Gaming movements in <Fragrance Channel v2.0> were transcribed into ten codes. Movements with higher code values mean more aggressive game behaviors, such as: 10-attack, 9-upgrade weapon; reversely, lower code values mean more conservative game behaviors, such as: 5-inbound without spices, 2-trade, 1-maintanence, etc. Code 6-move placed in the middle of the chart is simply neutral in terms of gaming attitudes.

Simultaneously, and Human Interaction codes (HI) are to document players' dialogues between each other to identify their intrinsic gaming strategies that are not evident from observations. Focus groups are performed with the players to review the process together to avoid over-speculation of the researchers. Since the scenario of <Fragrance Channel v2.0> embeds conflict-resolution and problem-solving process, this research adopts Spivack and Shure's (1974) Preschool Interpersonal Problem-Solving Test (PIPS) about social problem-solving strategies to generate the human interaction data. Interactions that would happen in the games were listed and categorized into six interactive strategies including lie, prosocial strategies, neutral, controversial strategies, affective, and change goals. Higher code values are more pro-social to other players, such as 12-temptation, 11-lie, 10-ask for consent, 9-share and give advice; lower code values are more anti-social, such as 6-self-centered, 5-threaten, 4-criticize, 3-plead for pity. In the middle is 7-neutral communication.

4. Ludonotation

The game research analysis representations that are known today mostly exhibit only a piece of the information, a variable that influences the whole study, or a route that one has taken. It hardly takes a comprehensive view of a gaming scene, especially when the subject of the study is complex, dynamic, and interconnected. There is a need to generate a new tool for this specific purpose which can more perfectly capture the milieu.

Just like Labanotation as a dance equivalent to music notation, Ludonotation is a notation system meant to serve the recording and analysis in game studies. In order to allow researchers to visualize the whole detailed game process, just like the music notes shown in Grand Staff that goes on and on until the end of the music, Ludonotation is also an incessant representation that documents and shows the complete game process for the total game time (also see Figure 1)

In the notation, it is suggested to comply around 13 codes to connote notes like those in the Grand Staff, which can be topped up to two coding systems like the upper and lower staff. With needs to present several parties or groups working in parallel, a symphony score can be useful just as several music instruments play together in a piece of music. The coordination of the four players becomes an

ensemble and the interactions would be composed into distinct music. It is supposed that certain behavior patterns can be read as particular melodies that can be quickly inferred in Ludonotation.

Ludonotation needs several elements in the notation system to document sufficient information identified by respective symbols (also see Figure 1). The five fundamental requirements include: players, player features, player behaviors in codes, player behavior direction to its target player, and flow sequence of behaviors in regard of time. Players' actions and interactions are documented on and between the lines according to the values of the codes. The frequencies of each action can be noted with the time signatures. Players are identified by colors, and personality traits, or any other players' features, are identified by geometric shapes. Black lines pointing to four directions identified by quadrants symbolizing the target players each behavior aiming to. It opens up the possibilities to illustrate the social space created in the game. For adaptation of Ludonotation for other game genres, maybe different symbols would be used to suffice its nature and needs.

Lag Sequential Analysis is often used to identify behavior patterns according to the frequencies between any two behavioral movements. However, in the strategic game, behavior patterns appear in a time span normally involve two movements and up of one player or between players across rounds (Shih, Chiu, & Lin, 2022). The string of single player's movements composes gaming strategies that might dynamically change in accordance to the movements of other players that occur in between the plotted string. In other words, streaming linkage between single players' cross-round behaviors and causal-effect relationships between players' behaviors are beyond what sequential analysis can capture. Other than asking the probability between behaviors, it is more important to recognize the dynamic matrix across time.

Therefore, an example of the use of Ludonotation@ISG was presented with <Fragrance Channel v2.0> that gives a comprehensive view of the game that strengthens the need of displaying in parallel the gaming behavior chart and the human interaction chart to see the flow of games over time.

5. Research Results

The research analysis results will be presented with the excerpts from games in the experiment to showcase what players with different personality traits do, how they influence each other, and what their gaming strategies are by observing and analyzing their gaming behaviors and human interactions. The two coding results were displayed in a Ludonotation which is a lengthy time sequence chart so the researchers can visualize the game process. The following section chooses one game excerpt to illustrate: a) the gaming behavior patterns of the players with different personality traits; b) the gaming stratagems used in the strategic game; c) the use of Ludonotation and its functions. Various stratagems were found in the excerpts (Table 1).

Table 1. *Stratagems used by players in <Fragrance Channel v2.0> Game 815-A-02*

Players	Chapter	Stratagems
P1-B-Chameleon (P1)	I-1 II-4 III-5 VI-4	Deceive the heavens to cross the sea. Hide a knife behind a smile. Tossing out a brick to get a jade gem. Inflict injury on oneself to win the enemy's trust.
P2-B-Chameleon (P2)	I-3	Kill with a borrowed knife.
P3-B-Owl (P3)	I-4 VI-6	Wait at leisure while the enemy labors. If all else fails, retreat.
P4-B-Koala (P4)	I-3 III-5	Kill with a borrowed knife. Tossing out a brick to get a jade gem.

Figure 1 is the excerpt of 815-A-02. In the beginning of this game, P1, P2, P4 made coalition in the beginning and use attack to exchange spices. P1 and P4 has a lot of conversations on lending (HI8), sharing and giving advice (HI9), and asking for consent (HI10) about exchange spices as a gesture of "tossing out a brick to get a jade gem" (Stratagem III-5) and "hiding a knife behind a smile" (Stratagem II-4). Since P3 played as an independent country, that he "Wait at leisure while the enemy labors" (Stratagem I-4). He made sure he ended in the port (GB5, GB7) in every round to avoid being attacked by using "if all else fails, retreat" (Stratagem VI-6) even though these behaviors cost him action points.

However, in Round 13, P1 broke his contract with others and move (GB6) to start point after he obtained his spices. It is the act of "deceiving the heavens to cross the sea" (Stratagem I-1) by lying to others to achieve his own goal. P2 criticized (HI4) him, and agitatedly reminded P4 of P1's betrayal; this is when he used "kill with a borrowed knife" (Stratagem I-3). Then P4 moved (GB6) to attack (GB10) P1 by "tossing out a brick to get a jade gem" (Stratagem III-5). P1 was good at communication and altered his strategies for his own benefits according to the conditions due to his personality traits.

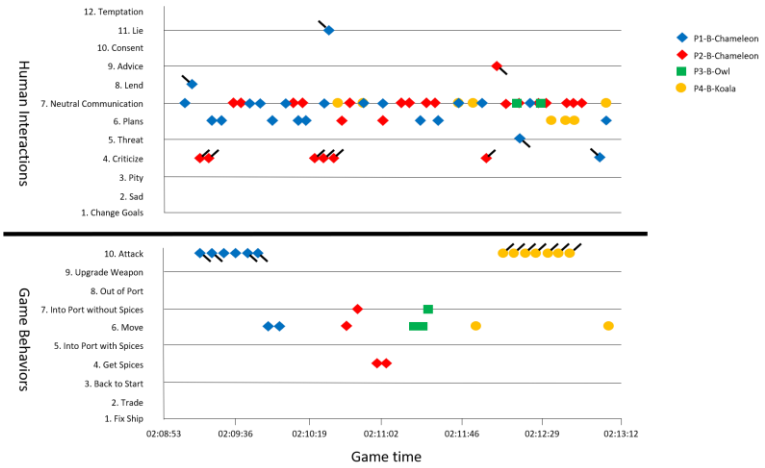

Figure 1. Ludonotation stave for strategic game excerpt 815-A-02 Round 13

After the analysis, preliminary conclusions are made to identify some behavior chains to be possible gaming stratagems (Table 2).

Table 2. *Behavior chains of possible stratagems used in the game*

Stratagems	Behavior chains	Behavior codes
I-1	Pro-social — Lie/temptation — Anti-social	HI8/9/10 — HI11/12 — HI4/5
I-3	Pro-social — (others) attack	HI9/10/11/12 — HI4/I5; GB10
I-4	No anti-social interactions.	No HI2/3/4/5
I-6	Talk to A — Attack B	HI4/5 (to A) — GB10 (to B)
II-3	(Others attack each other) — (No pro-social or anti-social actions)	(others) GB10 — (no) HI4/5/8/9/10
II-4	Lie/temptation — Anti-social	HI11/12 — HI4/5
III-5	Pro-social/lure — (others) Pro-social	HI8/9/10/11/12 — (others) HI8/9/10
VI-4	(others) Anti-social — Sad/Pity	(others) HI4/5; GB10 — HI2/3
VI-6	(others) Anti-social — Avoid/Hide	(others) HI4/5 — HI1; GB3/5/6/7

In order to be able to visualize the possible pattern of the behaviors, they are noted in Ludonotation. Figure 2 are the nine stratagems that are found in <Fragrance Channel v2.0>. One can see that behaviors done by one player, though with other behaviors in between the stratagem-oriented behaviors, can be identified as using the stratagem. It is to certain degree that the stratagems might be overlapped, abandoned, ignored, or with variants, that have to be acknowledged and identified by players. What's tricky and difficult to note is those stratagems that specify the absence of behaviors, such as "no lying", "no attacking", "no trading", etc.

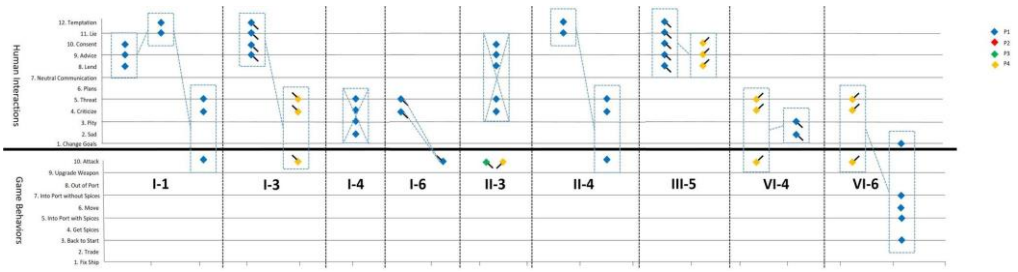

Figure 2. Behavior Chains of Stratagems on Ludonotation

6. Conclusion

Ludonotation is a means for the documentation of a game, an adjunct to video, and as a tool for game analysis. The analysis of the gaming process can help to diagnose the behavior patterns of specific personality traits; providing possible advices can be valuable and major contribution of this study.

The prospective development of Ludonotation shall continue to grow into a more sophisticated version that can serve more variation of strategy games, or even other genres of games. Such a notation system shall have flexibility for users to add, select, or modify for specific purposes. With the assistance of computer, digitized notation system using automated detection function with encoding module, annotation and visualization functions as well as big data mining ability will all contribute to the enhancement of the elicitation of behavior patterns.

Using Ludonotation is to conduct game analysis with anthropological perspective. The understanding to the complete gaming process, including the players, objects, mechanisms, and intentions, is the comprehension to the small world. Such system can be beneficial for education, and future studies of games and human behaviors.

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