Open Problems in Simulation and Story Analysis

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Abstract. The game designer is charged with an aesthetic imperative. The design is partitioned into four channels: simulation, user interface, story, and look and feel. Of these, the simulation and story channels are considered. In a game, the aesthetics of a simulation and of a dramatic story are suspected to be deeply coupled in conflict, choice, and change. Using the mechanics-dynamics-aesthetics framework, the simulation and story channels are isolated to survey *practical problems* encountered when designing a game, including dramatic elements of the player's choice, conflict, and change.

1 INTRODUCTION

x	x	o
o	o	
x	o	x

Table 1. A game board of Tic-tac-toe on the turn of X

In the game board of Tic-tac-toe, how many moves does the user have? The player of X has only one move, but the user has at least one more option. She can quit playing. In fact, on every turn the user always has the option to quit playing. While game theory usually has no need to consider this alternative, quitting play is the ultimate problem that game designers face. In non-interactive entertainment, such as a dramatic movie, the audience, too, has the option to physically leave or mentally excurse on a daydream. Along the lines of decision theory, the user is trying to satisfy an aesthetic preference for entertainment (over boredom). The user not only has a choice of moves to make in the game, but may also choose, when none of the moves promise to be entertaining, to quit playing and seek entertainment elsewhere. If the system requirements and the user requirements have been met, then the game has failed to entertain. Out of all the options available to the user, the game has ceased to be the most engaging. Perhaps the game session engendered frustration or, as in the Tic-tac-toe example, boredom.

Hereafter, I shall *italicize phrases that indicate problems designers face*, for which formal techniques would be a boon. As a designer in need, I cannot claim competence for their solution. Instead this survey is intended to promote collaboration between designers and theorists.

The Tic-tac-toe user's boredom is derived from having solved the problem posed by the simulation dynamics. In the Tic-tac-toe example above, it does not matter whether the pieces of the user interface are ergonomic or whether the endgame cinematic has an epic look and feel. To facilitate this distinction when analyzing the design of a game, over the past few years I have found it helpful to partition the game design into four channels: simulation, user interface, story, and look and feel.

	gameplay	**style**
inferred	simulation	story
perceived	user interface	look and feel

Table 2. Four channels of game design

Here is a brief definition and example of each channel, using the ancient Chinese boardgame, Go.

- ***simulation***: The abstract rules governing play. In Go's simulation, a new stone's *position* may not be in an occupied *cell*.
- ***user interface***: The input controls and the output representation to the human players, abstracted from any fine art. In Go's user interface, there is an orthogonal *grid*, and several black and white *markers* intended to be placed on the intersections.
- ***story***: The premise, characters, and plot that the user is internally narrating. In Go's story, a group is *alive* or *dead* and may be *attacked* or *defended*.
- ***look and feel***: The sensorial style and artistry, such as stylistic qualities of visual, aural, and tactile senses. In the look and feel of a fine Go set, the board is thick and made of golden *kaya* wood, the black stones are *slate* and the white are *clamshell* with faint wavy lines on one side.

In a manner somewhat similar to Jesse James Garrett's dual representation of interface and information [1], all four channels contribute to the user's experience. Analyzing a game into these channels isolates phenomena under discussion and invites a multidisciplinary analysis of games, which leverages the decades to centuries of expertise in discrete mathematics, ergonomics, dramatic writing, and the sensorial arts. Design discovers a consonance among the channels.

In this article, only the channels of simulation and story will be discussed, because of the wealth of prior theoretical work. By a dual analysis of the simulation and story channels, we will see that channel consonance is a corequisite to entertainment.

Here is an example of simulation and story consonance. At DigiPen, a team of students created their senior project, Narbacular Drop. In the premise of its story, Princess No-knees escapes a devious dungeon. In the salient feature of its simulation, the avatar maps space on arbitrarily placed portals to advance through puzzles. The simulation and story compatibility is slightly dissonant; the user's belief is stretched to accept a princess that shoots teleporters. In the follow-up, Portal, the salient feature of the simulation is the same, but Portal's premise of its story is: A human test subject completes a robotic lab's training. The story's premise of a science fiction laboratory fits better with the simulation mechanics of space-warp puzzles. So

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the simulation and story channels are interdependent, and in the case of Portal, they are consonant.

Designers, who must combine simulation and story, would benefit from *a model that unifies the aesthetics of a game's simulation and story* [2, 3].

2 AESTHETIC REQUIREMENTS

In 2005, Gregor Benedetti had evoked a fearful look and feel in HeroCard Nightmare. But the simulation and story channels of the game were not evoking a consonant sense of tension and fear. So the project was cancelled. Hating to see the evocative art and components go to waste, I proposed a redesign of the simulation and story channels, while preserving the user interface and look and feel channels. Benedetti's horrific look and feel set an aesthetic requirement of fear and suspense. I faced the practical problem: What simulation and story dynamics heighten tension and induce an entertaining form of fear?

Because the general problem of *correlating a user's emotional response to a game's simulation mechanics* is germane to game design, Marc LeBlanc proposed partitioning the design into: mechanics, dynamics, and aesthetics [4]. Following each definition is an example in the simulation channel and story channel of Go.

- ***mechanics***: the rules and assets of the game, as an artifact of development. In Go's simulation mechanics, if a *contiguous set* of stones has no *empty* neighbors, then that set of stones is *eliminated*. In Go's story mechanics, if a *group* loses all its *liberties* the group is *killed*.
- ***dynamics***: the game session created from the execution of the mechanics and its interaction with users. In Go's simulation dynamics, suppose that during play a *maximally connected* set of stones only has one empty neighbor, and so might be eliminated during the next move. In Go's story dynamics, her *dumpling* is about to be *eaten.*
- ***aesthetics***: the emotional experience by the users. In Go's simulation aesthetics, suppose a player is *worried* about diminishing their *points* by the *count* of stones eliminated. In Go's story aesthetics, suppose a player is *indignant* at having *her* dumpling eaten.

The overview suggests *a functional relationship: mechanics influence dynamics, which influence aesthetics.* The users have unique beliefs and preferences. For that reason, designers empathize with the user, and aim to understand the user's aesthetic preferences, even when the user does not understand them [5].

Aesthetics has long been a domain of interest among dramatists. Egri restates a classic model of aesthetic requirements as a drama's subjective experience, which consists of a rising action, climax, and conclusion [6]. In a dramatic story, Egri posits that the aesthetics correlate to the dynamics of the story. Let us look at the story dynamics and consider their possible confluences with simulation dynamics.

3 DYNAMICS OF SIMULATION AND STORY

Egri explains the dynamics of drama by fundamentals often referred to as character, conflict, choice, and change. Due to a broad scope of media and attention to the psychology of motivation, I will adapt Egri's concepts to games.

Personality and objective makes a character more interesting. In God of War, the bloodlust of Kratos elicits an emotional response, albeit immature and for a juvenile aesthetic profile.

The characters in a drama are pitted in conflict. In Half-Life, Gordon's lab is invaded by aliens. In Ico, Ico and Yorda are trapped in a castle and pursued by shadows.

The choices made by the characters drive their story. Gordon Freeman explores an alien-infested laboratory. Ico escapes a demonic castle.

The result of the choice that the character makes changes the values and beliefs of the character, in narratives and games. The psychology of Macbeth changes from loyal to murderous. The isolation of Ico from Yorda reveals his, and the target user's, need for companionship.

To elevate tension, writers sometimes employ dynamics of risk to craft the character's options into a dilemma. The greatest such dilemma in a story is the crisis. In the season one finale of the television drama, Heroes, Peter and Nathan Petrelli face the crisis of destroying New York or committing seeming suicide.

Let us apply these dramatic terms to the simulation.

3.1 Representing a simulation session as a dramatic story

Sid Meier's most popular game, Civilization, emphasizes the aesthetics of the simulation channel. In the management of an empire, the user is often considering the dynamics of the simulation as a "series of interesting choices."

Part of the interest in a choice is due to the "risk and return" [7]. The user risks his or her resources or chances of winning in exchange for the prospect of greater resources. Here is a modified example from Super Mario Bros. At the beginning of World 5-1, the user may take a low-risk option of destroying a Koopa Troopa (turtle) by fireball, or perform the higher risk maneuver of jumping onto and then kicking the turtle shell to hit several enemies in a combo. If the user's timing or trajectory is mistaken, then the avatar might lose a life to the Koopa Troopa. To compensate for the higher risk, expert execution yields an extra life. So with sufficient skill, the risk of loss is offset by the gain. For another example in Reiner Knizia's two-player card game Lost Cities, before pursuing an expedition a player may play an investment card. The investment card multiplies the points of the expedition, which may turn out to be negative or positive. *Correlating the simulation dynamics of risk and return to the aesthetic experience of play*, such as excitement, would refine the design of simulation mechanics.

Part of the interest in a choice is due to the drama. Marc LeBlanc applies the aesthetics of a dramatic arc to the card game Magic: The Gathering. During the opening game, players have few resources, so the intensity of conflict is relatively low. The players draw resources for attacking and defending through mechanics that conform to a producer-consumer pattern [8]. Thereby the uncertainty and inevitability increase until it is obvious which player will win. Then tension diminishes [4]. Likewise, in Go, Poker, StarCraft, and Civilization, resources are produced over time, through producer-consumer mechanics. For the target users of these kinds of games, the dynamics of risk emerging from such mechanics often induce an aesthetic experience that adheres to a dramatic arc [4].

3.2 Modeling a dramatic story as a simulation session

The requirement of rational agents with perfect knowledge is incompatible with storytelling. From Shakespeare to soap opera, drama is about characters with imperfect intellects [6]. Addressing this, Lowe and Pacuit formally model mistaken beliefs and preferences in a dramatic story [9]. In their analysis of an example story, they represent the characters as players in a formal game, who make choices that lead to conflict and whose conclusion changes the beliefs of at least one of the characters. This model elucidates a fundamental connection between the channels of story and simulation. If their techniques could be adapted to *model the aesthetic consequences of changes in belief*, then it might help integrate the design of a game's simulation and story.

Although a game's drama cannot be reduced to a narrative [2], and the emotions of videogames differ from those of cinema [10], the simulation and story share similar characters, conflict, choice, and change. Egri analyzes dramatic conflict as opponents attacking and counterattacking. Lowe and Pacuit analyze a story as tactical scheming. Modeling the player of a game in Egri's dramatic terms and Lowe and Pacuit's terms of beliefs, it is reasonable to conjecture: *The player, facing a conflict, makes the main character's choices and through the conclusion of the most difficult choice, the crisis, experiences a change in values or beliefs.* To develop this hypothesis, let us discuss some special cases.

4 DRAMA: CORRELATING DYNAMICS TO AESTHETICS

Conflict is crafted by balancing player skill and scenario challenge [11, 12]. By design the difficulty and risk of problems with a similar solution, which Inoue and Ushijima call a gimmick, is ramped. In Super Mario Bros, the gimmick of a cliff is iterated in four stages so the user may: remember, practice, apply, and master that gimmick. In their example, a cliff is leapt from four times: first, with ground below, second without, third with a performance evaluation at the flagpole, and fourth with a moving platform [13]. Designers sequence the difficulty and risk to teach an essential skill of play while developing a dramatic arc, derived from challenging the player. This design task would benefit from *a theoretical relationship between challenge construction, skill acquisition, and the aesthetics of drama.*

One special case of the dramatic conflict has been formalized in deterministic turn-based games of perfect information. In combinatorial game theory, the heat of a game state correlates the simulation's dynamics to the urgency of making a choice [14]. In Go, this is often a situation when one or both players can claim initiative, such as during a ko fight. It would be interesting to investigate *whether the combinatorial game theoretic heat of a simulation state correlates to the aesthetic experience of its users.*

In the dynamics of the simulation channel, there have been several mathematical analyses, some of which could be suspected to have correlations to the aesthetic quality of the game's users. For instance, Chess has too many draws at the championship level [15]. An extremal case of this trend is Tic-tac-toe, or any other game that a player has solved. The result of every session is predictable, and therefore changes no beliefs.

A videogame can induce a sudden change in belief that results in surprise [16]. Emiliano Lorini and Cristiano Castelfranchi have formally modeled surprise as an epistemic change [17]. While their model is beyond my comprehension, if it is compatible with the simulation dynamics of a game that modifies player belief, this epistemic model of surprise would offer a special case solution to the problem of correlating simulation dynamics to aesthetics.

For some classes of game simulations, some parts of the dynamics have been formalized. To give HeroCard Nightmare a simulation dynamics-induced sense of suspense and fear, I inverted the salient simulation mechanics of Clue. In Nightmare's simulation channel, you begin with a deal of cards that when discovered, eliminates you from the game. In the story channel, you are shown a photograph of where you will die (your dealt scene card), and who will kill you (your dealt killer card). Together, these *simulation and story mechanics induce dynamics of bluffing correlating to aesthetics of fear*. Probability of discovery increases during play, increasing fear, while disseminating disinformation may mislead players, incentivizing bluffing. Moving someone else's killer pawn away might deceive other players into misidentifying your actual killer. I have an intuitively derived and empirically tested correlation of Nightmare's simulation dynamics to the aesthetics of its user experience. What I did not have was a theory of knowledge games. Hans P. van Ditmarsch modeled the salient mechanics of Clue (or Cluedo) as a knowledge game, in which players are dealt cards, and winning consists of knowing the deal of the cards [18]. In doing so, there is a formal model of the dynamics of play. If the theory of *knowledge games could be extended to model correlations to a user's aesthetic experience*, then the aesthetics of a game like Clue could be discussed analytically.

In both the dynamics of a simulation channel and a story channel of some dramatic games, choice reveals character and advances the conflict toward a conclusion. In a model like Lowe and Pacuit's, a choice reveals information of a player's preferences, and therefore adjusts the beliefs of observers. The actions of a player in Clue, Poker, or Go reveals the aspects of the strategy and beliefs of the active player. This applies to many genres of games.

It is hard to imagine a satisfying simulation channel in which the enthusiastic player does not have some belief about the simulation dynamics or about another player altered through the course of play. Seeing a newly dealt card in Seven-card Stud Poker or Lost Cities changes belief on the strength of one's hand. This change in belief may alter tactics. Discovering a weakness in one's wall of stones in Go may stimulate the player to protect the weakness before it is exploited. Such cases of play often induce excitement among users. It would be a boon to designers if the dynamics of belief change, such as the work of Ditsmartch, Lorini and Castelfranchi, could be adapted to model a user's emotional state.

5 CONCLUSIONS

A player (in the simulation channel) and a character (in the story channel) changes or reveals preferences. The player-character can be jointly analyzed as a simulation-story. For instance, Ico's, and the user's, preferences for companionship, are revealed when Yorda is lost. Lowe and Pacuit have taken steps to model the revelation of preferences in a simulation-story.

This article has not formalized techniques, which are beyond the author's competence. Instead, I have *italicized practical problems* that designers face without theoretical tools. Centuries ago, Cardano, Pascal, and Fermat formalized the analysis of simulation mechanics in games of chance, clarifying the design of countless dice and card game mechanisms to follow. Even if the simulation and story problems are not solvable, partial solutions would advance the art of crafting games that satisfy our aesthetic requirements.

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