

AI-Based Game Design: Enabling New Playable Experiences

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ABSTRACT

With the current set of design tools and methods available to game designers, vast portions of the space of possible games are not currently reachable. In the past, technological advances such as improved graphics and new controllers have driven the creation of new forms of gameplay, but games have still not made great strides into new gameplay experiences. We argue that the development of innovative artificial intelligence (AI) systems plays a crucial role in the exploration of currently unreachable spaces. To aid in exploration, we suggest a practice called AI-based game design, an iterative design process that deeply integrates the affordances of an AI system within the context of game design. We have applied this process in our own projects, and in this paper we present how it has pushed the boundaries of current game genres and experiences, as well as discuss the future AI-based game design.

KEYWORDS

game design, artificial intelligence, AI-based game design, design methodologies, expressive AI, experimental prototypes

INTRODUCTION

Throughout the history of digital games, technological improvements have driven new forms of gameplay. Advances in computer graphics have provided games with more realistic and immersive environments, while new controller technologies such as the *Wii* and *Kinect* have enabled physical movement games. If we imagine the vast space of all potential digital games, however, there is still a great amount to explore. Artificial Intelligence (AI) has been suggested as a mechanism for pushing forward technological advances in games (Mateas 2003, Tozour 2002, Fairclough et al. 2001), however, many games create the illusion of intelligence with “smoke and mirrors.” This is prone to the *Eliza effect* (Wardrip-Fruin 2009), in which the player reads more intelligence into a system than it really supports, and it breaks down upon closer inspection. Since it is a form of merely “faking it”, it cannot stand up to the demands of new forms of gameplay.

While there are times when smoke and mirrors is appropriate, exploring new forms of play experiences and experimenting with new game genres based on AI innovation

requires more than the illusion of complexity. AI must be robust enough to support player experimentation and exploration, and games must be designed to take full advantage of it.

We argue that to make real progress in innovation for game AI and new forms of gameplay, the AI needs to play a more central role in game development. This paper presents AI-based game design as a practice that makes inroads into the vast space of potential games through the co-formation of new AI technology and games that are heavily dependent on the AI system. By operating in this design space, rather than relying on “smoke and mirrors”, we have the opportunity to take steps towards creating real magic.

The Role of AI in Games

Systems that are completely predictable to the player feel mechanical and “dead” (Mateas 2003). For instance, an object that has been dropped will act appropriately for the physics of the environment it is in, but it will always drop the same way and it will always bounce the same way when it hits a surface. The player does not assign meaning to the actions of the ball, does not need to try to understand the psychological goals of the ball, but instead understands that there is a physical system that is operating on the ball. While modeling this behavior is important for believability of the world, it does not add life to the system.

Contrast this with human behavior, which is so complex that it cannot be fully predicted. Instead we can rationalize and reason about why someone acted the way they did, but their exact actions cannot be predicted. While there is some debate about whether humans truly have free will, or if they are ruled by chemical reactions in the brain (Nutt 2011), the human mind is so complex that it can be neither fully modelled nor predicted. Dennett (1987) argues that when interacting with a complex system, humans will abstract away the complexity and instead reason about the intentions and goals of that system.

Likewise, when players encounter an AI system in a game, they assign intentionality to that system, “using words whose meanings go beyond the mathematical structures” (Agre 1997). They create narratives that rationalize the AI’s actions and reasoning about the AI’s goals (Sengers 2000). This intentionality can be observed both through the actions of an explicit AI-controlled character in a game, such as an enemy NPC in *Halo 3* (Bungie 2008), or through the results of actions taken by an invisible agent that responds to a player or designs part of the world, such as the the level generator in *Rogue* (Toy et al. 1980) or the drawing analyzer in *Crayon Physics Deluxe* (Purho 2009).

When an AI system does not have sufficient complexity to support the intentionality the player reads into it, the illusion breaks down and the life-like impression that has been built up by the AI is immediately lost. This happens because the player now understands the system enough that there is no longer a need for the player to abstract to an intentional level. On the other hand, robust modeling of behavior, be it believable social interaction or the creative design of a level, leads to complex area of exploration from which to draw new game experiences. It is through AI and the exploration of AI systems that we will find the most new ground in the space of possible games.

Focusing on AI in Game Design

Although AI systems can help us explore the expressive range of game design, we cannot merely write a new AI system and expect that this alone will create a new experience. An

AI system must have an environment to work within to be able to choose an appropriate action. In a game, this context is provided by the design of the game world in which the AI must operate, subject to constraints chosen by the game designer. If the AI makes choices independently of the environment it is situated in, the actions will lack context or meaning, and will make the system feel autonomous (if overly predictable) or schizophrenic (if lacking an overall structure) (Sengers 2001). The design of the game therefore should have an impact on the space within which the AI operates, and give context to the actions made by the AI. By allowing the game to inform the design of the AI, the AI can be contextualized to maximize the amount of intentionality the player can read into the system.

It is not sufficient for the AI to be informed by the game design. If the game design is not shaped by the AI design, it is possible for the system to suffer from the *Tale-Spin effect* (Wardrip-Fruin 2009, p. 419): the player is unable to see or understand the operation of the underlying AI system, losing the effect of the complexity of the AI. Alternatively, the *SimCity effect* (ibid, p. 420) leads to players being able understand the operation of the system, which can only be found if the game design is informed by the affordances of the underlying system--in our case the AI. The game must be designed in a way that allows players to reason about the actions of the AI such that they can read meaning into the AI's choices.

The AI system typically influences the mechanics and aesthetics, and indirectly the dynamics, of the game. A rich AI system underlying the mechanics, that understands the player's actions and responds intelligently, leads to emergent gameplay: a player can attempt many different strategies in the game and find them equally supported by the system. Genres are defined in part by commonalities in mechanics and aesthetics of their constituent games; by allowing the AI to influence the direction of these two aspects of the game design, new game genres can emerge from the AI-based game design process. Additionally, an AI system has affordances for shaping the narrative of the game, providing an opportunity to explore new territory in the space of stories.

For the reasons outlined above, the AI and game should not be designed in isolation, but instead in tandem, informing each other. We describe this method of iterative co-formation of AI and game design as AI-based game design. In the remainder of the paper we will discuss the practice of AI-based game design through analyzing five AI-based games that are currently in various stages of development. We conclude with a discussion of challenges that arise when designing AI-based games.

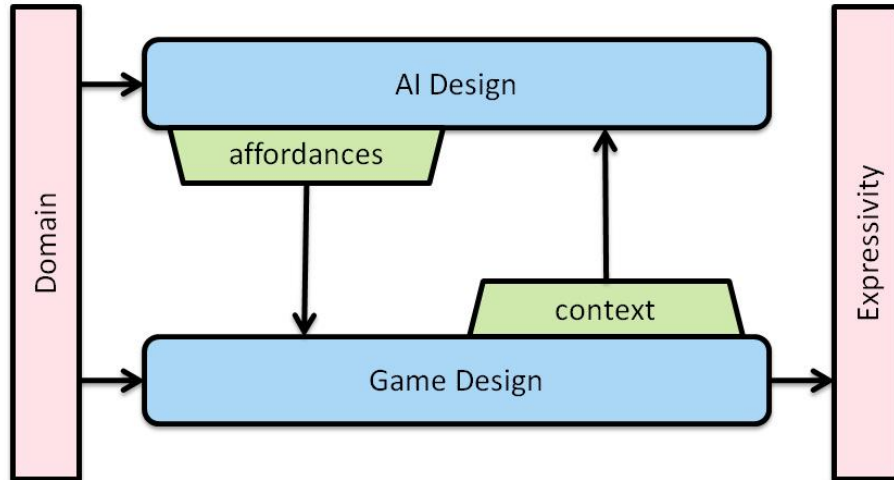


Figure 1. This diagram illustrates the process of AI-based game design. The AI system affords certain mechanics and aesthetics for the game design, while the game design provides the context in which the AI operates. Domain information, such as theories.

THE PROCESS OF AI-BASED GAME DESIGN

Here we describe the process of AI-based game design (see Figure 1) within the context of five AI-based games and their associated AI systems, each of which is under development by one of the authors.

1. *Pataphysic Institute* is a multiplayer game in which the AI architecture, known as the *Mind Module*, gives both avatars and non-player characters personalities, moods and emotions (Eladhari 2010). Players need to defeat manifestations of negative mental states by cooperating—the spells they can cast depend on their personalities and states of mind.
2. *Mind Music* is a small experimental game in adaptive music which also uses the *Mind Module*. In the game, state of mind is expressed by variations in harmony, groove and melodies (Eladhari et al. 2006).
3. *Rathenn*¹ is a 2D platformer game in which the player influences the creation of a procedurally generated level while they are exploring it. The player influences the game by climbing ladders that push the level towards particular extremes of the generative space. *Rathenn* uses the *Launchpad* rhythm-based procedural level generator to choose small segments of a level, called rhythm groups, as players continue exploring (Smith et al. 2011).
4. *Prom Week* is a social simulation game about the dramatic week leading up to a high school prom, in which players sculpt the social landscape by having characters engage in social exchanges with each other. *Comme il Faut* (CiF) is the supporting AI system that enables an interactive, authorable model of social interaction for autonomous agents (McCoy et al. 2010).
5. *Mismanor* is a role-playing game in which the core mechanic is social interaction instead of combat, with a focus on supporting player-driven story. It uses both a modified version of the *CiF* framework (mentioned above) to handle game-level social interactions, and *GrailGM* to manage the story structure and quest system (Sullivan et al. 2011).

When discussing AI-based game design, it is useful to use the Mechanics, Dynamics, and Aesthetics (MDA) framework as described by Hunicke et al. (2004). Mechanics are the system framework, describing the laws and rules of the game, and the specification for how entities within the system behave. Dynamics emerge when the game is played: they are the runtime behavior of mechanics acting upon player inputs. Aesthetics signify how players experience the game and why they find it fun or meaningful.

Affordances and Context

An AI-based game is one that has an AI system closely integrated into its core mechanics and aesthetics, and also into the setting and story. For example, *Prom Week*'s core mechanic involves manipulating characters in the world by choosing social games for them to play; this mechanic could not exist without *CiF*'s formal representation of social games and how characters play them. Additionally, *CiF* explicitly reasons over stories by leveraging an episodic memory of plot events. *Launchpad*'s ability to generate small sections of a platformer level according to designer parameters afforded an aesthetic of exploration when designing *Rathenn*; the fact that levels are generated at runtime informed the decision to make the game be set in a dreamscape, to explain the constantly morphing geometry. In turn, this setting informed the game's theme of overcoming fears that are represented by different types of generated challenges.

A game also naturally informs the design of its AI system by providing a context in which the AI should operate. For example, *Mismanor*'s design calls for robust interactions between the player and different NPCs, which drove the decision to use the *CiF* AI system to handle these social interactions. However, *CiF* was not designed to act within the role-playing game genre, so support for quests, items, and knowledge was added to the system through the creation of new rules and microtheories (encoded domain models of specific cultural interactions) which provides context for the AI system. Likewise, the addition of *sentiments* (emotional connections to an objects in the game world) in the *Mind Module* was motivated by the game design goal to create individual emotional ties to types of objects for players in the same world. This allows different characters to have different play experiences in the same environment depending on their nature and their play history.

Entering the Iterative Design Loop

At the core of the AI-based game design process is this iterative loop involving the AI design and game design informing each other in an iterative manner. As it is a loop, there is not one entrance point, rather it is possible to enter this loop from either the game design or the AI design side.

The motivation for *Mismanor* and *GrailGM* came from the game design side: there was a desire for modeling more meaningful interactions in role-playing games (RPGs) and making quests as playable as combat (Sullivan 2011). Similarly, the game design idea that became the *Pataphysic Institute* motivated the creation of the *Mind Module*; the goal was to find ways to approach how to create stories in massively multi-player games that would be meaningful for individual players. During the development of the *Mind Module*, a desire to explore different design spaces and how the system could apply to different domains motivated the creation of *Mind Music*. The creation of *Mind Music* motivated further development of the *Mind Module* as it was used in *The Pataphysic Institute*.

From the other side of the loop, *Prom Week* was conceived as a way to experimentally validate the efficacy of *CiF* and the abstraction of social games through authoring a playable experience. This work entered the iterative loop from the point of AI system design and had the primary goal of using game design as a critical tool. Similarly, *Launchpad* was a mature AI system when the *Rathenn* project began. The goal of *Rathenn* was to study how procedural content generation (PCG) can lead to new playable experiences, and learn more about the properties of the *Launchpad* level generator to better inform newer PCG-driven design tools. During the course of designing *Rathenn*, a number of substantial changes have been made to the *Launchpad* level generator to support the game design, including introducing a concept of challenge progression and further refining player control over the output of the system.

It is important to note that in each author's experience, it was crucial to iterate on the game design and AI design early in the design process, regardless of the entry point to the AI-based game design loop. Without a rough design of the AI system, it is impossible to flesh out the mechanics of the game; without a rough design of the game system, it is impossible to know what should be modeled in the AI system.

The Influence of Domains

The game and AI designs are each also informed by the domain of the project. There are typically at least three types of domains used during AI-based game design: AI architectures, game design conventions, and knowledge domains.

The *Mind Module* is inspired by spreading-activation theory (Anderson 1983) as an AI architecture, while the knowledge domains used are personality psychology (Allport 1961), affect theory (Tomkins 1962) and that of basic emotions (Ekman 1994). The nature of activity and decay of the nodes in spreading-activation networks has had a profound effect on the game mechanics within *Pataphysic Institute* and *Mind Music*, both built upon the *Mind Module*. Quick and intense emotion node activity depends on weightings of each character's slow and permanent personality trait nodes, and the emotion node activity determines the character's mood. This functionality is at the heart of the AI system, affecting the mechanics of the game prototypes. In *Pataphysic Institute* mood determines what spells can be cast, and in *Mind Music* it determines groove and harmony. Between these two games, nodes have differed in number, type, naming, decay rate, and prerequisites, but the basic architecture has always been used in its original form.

There are a number of game design conventions that influence the development of an AI-based game. For example, *Rathenn*'s design is heavily influenced by the genre conventions of 2D platformers. The level representation used by *Launchpad* is derived from an analysis (Smith et al. 2008) of rhythm and level structure in the popular 2D platformers *Super Mario World* (Nintendo 1990), *Sonic the Hedgehog 2* (Sonic Team 1991), and *Donkey Kong Country 2* (Rareware 1995). A particularly important aspect of this representation is the notion of rhythm groups, small linear level segments that encapsulate challenge. This aspect drove the decision to have *Rathenn* be made up of connected rhythm groups, and have the player be able to explore new rhythm groups by climbing ladders, which are frequently seen in exploration-based 2D platformers.

The knowledge domains of dramaturgical analysis (Goffman 1959) and high school hallway politics were used to create *CiF* and *Prom Week*. The patterns of interaction that

the characters in *Prom Week* perform are encoded using the dramaturgical metaphor as a basis for knowledge representation method. Using this encoding method, the patterns appropriate for the game's high school setting were authored. In this way, the knowledge domain of a sociological encoding of interactions is used in conjunction with the knowledge domain of stereotyped high school interpersonal relations as a basis for *Prom Week's* game mechanics.

Reusing AI Systems

Although AI-based game design dictates that the AI system be designed within the context of a game, and that the game be designed for the affordances of the AI system, it is possible to reuse some or all of an AI system with a new game. This occurs when the AI system is general enough to afford the different game mechanics, and/or when the context of the game is similar enough to place no new requirements on the AI system.

Though *Pataphysic Institute* and *Mind Music* both use the *Mind Module*, the implementations take inspiration from different domains. In terms of the *Mind Module*, both implementations use knowledge from the areas of affect theory, personality trait theory and that of basic emotion. But while the *Pataphysic Institute* draws upon design conventions from massively multi-player RPGs, the *Mind Music* system drew its conventions from early arcade style games. While the *Pataphysic Institute* relies on conventions from social interactions between people for its design, *Mind Music* draws upon knowledge from musical theory and from artistic skills of a composer. The expressive results are quite different in nature despite being based on the same AI system.

Prom Week and *Mismanor* are an example where the affordances of the AI did not meet the requirements of game design. *Mismanor's* game design required many of the same domain elements used by *CiF*, but with the addition of conventions from the RPG genre, such as inventory and quest structure. Part of the iterative refinement of the *GrailGM* AI system was to add support for affordances beyond those provided by *CiF*. The addition of these new features to the AI system allowed the iterative refinement process to move from AI system design to game design and allowed for further work on *Mismanor*.

DISCUSSION

In creating the games previously mentioned, we have distilled two major discussion points: the importance of maintaining an appropriate level of transparency of the AI system through the game design, and the challenges of designing for emergent gameplay.

Transparency of the AI System

In *Expressive Processing*, Wardrip-Fruin discusses a problem called the *Tale-Spin effect*, where a player fails to read intentionality into a complex AI system. This occurs when there is no "means for interaction that would allow audiences to come to understand the more complex processes at work within the system" (p. 419, 2009). However, from a gameplay perspective, it is also important not to overwhelm the player with too much information about the AI system. Finding the appropriate level of transparency for the AI system, or the amount of the AI system that is exposed to the player, is a delicate balancing act.

For example, *Prom Week* encountered the *Tale-Spin effect* initially because the reasoning and representation of *CiF* were not being fully represented in the interactions between characters. Upon adding further information about why the characters make their

decisions, it was found that there was too much detailed information being given to the player via the user interface, which had a negative impact on the player's understanding of both the narrative and social play taking place. The resolution to this problem has been to aggregate information about *CiF*'s internal workings in a way that is more akin to how a player thinks while they play *Prom Week*. For example, players want to know information like "does Zack want to date Lil?" and "who would be mad if Monica cheated on Buzz?" instead of a more complete view of the encoded social rules as a graph or network visualization.

Pataphysic Institute presents information about its underlying AI system in a variety of ways. The values for the mind module are displayed to the player through numerical values displayed in a window. The mood, which is most central to the gameplay since the mood determines what an avatar can do at a given moment, is presented in two different ways to highlight its importance: in a mood color wheel where a dot is placed in the current mood-space of the character, and as a colored aura over the character's head. The aura is visible to other entities in the game, such as NPCs and other avatars, and signals to them what mood the character is in. All of the different actions the player can take are shown in a "button" bar on the screen and in the mood color wheel, where those that are currently possible according to the AI system highlighted as available to click. Some information, such as the potential consequences of the player's actions, is deliberately hidden from the player as the purpose of the game is for them to build their own mental model of how characters in the game react.

While *Mismanor* is still in early stages of production, it has faced similar issues with designing to allow the player to understand the AI system. Which social actions and quests are available to the player are chosen are calculated based on weighted rules that take into account story-level authorial goals, past events, traits and statuses of the character the player is talking to, and the relationship between the character and that NPC. However, presenting all of these factors to the player would be overwhelming and confusing. The current prototype tests distilling the reasons down to only present the highest weighted rule that was used in choosing the particular quest or social move.

Rathenn has also seen a need to aggregate information about the internal workings of *Launchpad*, but instead of aggregating the results of the system, the aggregation occurs for the input to the system. *Launchpad* has a large number of input parameters controlling rhythm and the appearance of components, and many of these parameters have complex, emergent dependencies. Providing the player with control over all of these parameters would be unreasonably complex, and informal playtesting at the beginning of the design process showed that players found it so overwhelming that they assumed the system was responding randomly. In response, *Rathenn* has collapsed all of these parameters into six master parameters for controlling the appearance of enemies, gaps, stompers, moving platforms, springs, and platforms.

A general lesson we draw from this experience is the need to aggregate information about the AI system to players, so that they can see the decision-making process but not be overwhelmed by extraneous information. Even though it is not necessary for the player to see all of the details of these AI systems, the more complicated state is still needed to provide an intelligent response to a variety of player actions. The internal workings of the system simply needs to be collapsed for presentation to the player.

Understanding Emergence in AI-Based Games

There are two major qualities of emergence that we discuss here with regard to AI-based game design: the emergent gameplay evident in AI-based games, and using AI-based game design to understand emergent qualities of the AI systems themselves. This is not to say that these are the only forms of emergence. Emergent gameplay, in which the player can interact with the system in ways for which it was not specifically designed, arises from a rich AI system underlying the mechanics of the game. Emergence within the AI system itself occurs when the system builds content with which the player will interact. Due to these qualities of emergence in AI-based games, it is important to design with this quality in mind.

Emergent Gameplay

Emergent gameplay is a fundamental quality of an AI-based game, as the player is supported by an underlying system that can respond intelligently to the player's actions. For emergence to occur, it is not necessary for the AI system itself to exhibit emergent behavior. For example, consider the following hypothetical game that is supported by an AI-system for pathfinding. The player must direct autonomous agents towards particular goals by manipulating terrain and forcing the agents to take a particular path. The AI system could always find only the optimal path for the lemmings, but its intelligent and rapid response to the player ensures a variety of strategies that the player can employ.

In the *Mismanor* project, both *CiF* and *GrailGM* were designed for emergent gameplay. *GrailGM* was created to support non-linear play structures within RPGs, with more robustness than a simple branching structure. Quests are designed with general pre-conditions such that the *GrailGM* can change the ordering that quests are presented while still respecting authorial goals. Also, quests have a goal state that is checked for completion instead of requiring a set of tasks that the player needs to complete. This allows emergence in player actions since they can take any series of actions within the game that moves them towards the described goal.

The Pataphysic Institute provides emergence through player interactions; all actions have an effect on the emotional states. If these emotions become strong then sentiments emerge which carry the emotional memories between contexts. The world is populated by manifestations with mind modules whose behaviors are authored by players. Players combine available actions (spells and affective actions) with behavior sequences, and add dialog text that these manifestations speak when they are in pre-specified states of mind.

Similar to how physics models in games allow for emergent gameplay through manipulation of the physical qualities of the game world, *Prom Week* uses the "social physics" model provided by *CiF* to allow for emergent social play. The player gets to choose how they want to change the social lives of the characters and the encoded social norms, social games and rules for the cascading consequences of social interaction determine the resultant social state. As there are vastly more possible, emergent states than could be prescribed, the combination of player interaction and *CiF* allows for emergent gameplay.

Emergence in the AI System

For the *Rathenn* case study, the *Launchpad* AI system itself exhibits emergent behavior in addition to the emergent gameplay experienced by the player. In this case, the design of *Rathenn* uncovered previously unknown and unexplored details about the emergent qualities of the *Launchpad* generative system. While there had been previous work in examining the expressive range of *Launchpad* (Smith et al. 2011), this work did not examine the impact of the length of rhythm groups on the expressivity of the system, nor did it closely study the effects of altering rhythm parameters on the appearance of various level components. The development of *Rathenn* requires an understanding of these effects, as the player should be able to feel in control of the generated levels; this is still being explored for the next iteration of the game. Through reflection on the design process of building *Rathenn*, patterns of design for both authoring tools and procedural level generation were uncovered. These design patterns can now be used in future projects.

Consequences of Emergence

An AI-based game designer must plan for this emergent gameplay during the design process. However, designing for emergence introduces a number of challenges. A major challenge is the loss of complete authorial control; when the player can interact with the system in many different and unexpected ways, it is impossible to script an experience for them.

There are a number of techniques for exerting limited control over this emergence that we are currently exploring in our games. They include adapting to player preferences by having the player classify artifacts generated by the AI system as good or bad, providing players with explicit guidance through the generative space of the game, and setting goals for the player to achieve by whatever means they choose.

In *Mind Music* the generative space formed by the variety of emotional states was so large that it was challenging to create adaptive music that would be both expressive and pleasing to the ear, even though there were no personality traits and there were a smaller number of *Mind Module* emotion nodes than were used in *Pataphysic Institute*. Though easier to control, a smaller combination space might lead to predictability. The challenge is to create not just any emerging pattern, but a system where the emerging patterns is ‘just right’ for the context. In this case, an important part of the context is how the individual listener interprets the music. A possible approach for achieving musical expression that matches subjective interpretations of emotional meaning for listeners could be to ask players what emotions they perceive that certain musical elements convey. It is our hope to experiment with this in future work, essentially giving each character a personal music setting. In this way, the constraint on the emerging patterns would not be achieved by limiting the number of elements in it, rather by adding more sophisticated filters as constraints.

Rathenn embraces emergence by allowing the player to explore the generative space of the system in whatever manner they choose, but also needs to ensure that players do not get lost or stuck. In early playtests it was found that it is easy for players to make a series of decisions that keeps them at a steady state in the generative space. For example, alternating between telling the level to introduce more gaps and telling it to introduce

more enemies averages out to no change at all, since gaps and enemies are opposites of each other in the generative space. This problem is being addressed in two ways. By creating a 2D map of the generative space that is constantly shown to players, they can use it to inform their exploration decisions. *Rathenn* also places story goals in pre-identified interesting sections of the generative space to encourage a complete exploration.

Telling interesting stories and the emergent properties of *CiF* are conflicting aspects of *Prom Week*. Two techniques for dealing with this conflict are having the game play revolved around solving social puzzles and by having ordered rules that activate chaining substories. Each story told in *Prom Week* consists of several puzzles each with their own set of goals comprised of social conditions. By having the player work toward a specific social state tied to a progressing narrative, the sequence of social actions that emerge are loosely constrained to an unfolding story. The second technique, involving ordered sets of rules that chain to tell substories, allows for concrete subplots to unfold during gameplay in a way that feels like the player is creating the subplot or is having the history of the world revealed to them. In both, the sequences of gameplay the player experiences is constrained to include more story telling and less inconsequential events.

While we largely consider emergence to be an extremely positive aspect of AI-based game design, the same characteristics that lead to good emergence can also introduce problems during the development process. A related challenge to that of controlling emergence is a marked lengthening of testing cycles, as the designer must build up an understanding of the emergent qualities of their system and learn how to address any issues. Since the player's experience in the game cannot be scripted, it is near-impossible to test for every conceivable strategy the player might use, and hard to predict and prevent undesirable strategies and effects.

CONCLUSION

In this paper, we have introduced and described the practice of AI-based game design. In each of the author's systems, we have demonstrated how co-formation of AI and game systems leads to both novel forms of gameplay and a deeper understanding of AI itself. We have also described how affordances and contexts work together to push AI architectures into new domains. Across each of our experiences, the themes of transparency and emergence have come up repeatedly. Transparency binds the AI and game designs with the player experiences and is critically intertwined in the iterative development process. Emergence from the AI system provides expressive power to the game design at the potential cost of a longer testing cycle and authorial control. These recurring themes are major design challenges facing practitioners of AI-based game design. However, facing these challenges also allow us to expand game design with new potential mechanics that were previously unthinkable within the confines of familiar genres. AI-based game design is an important part of enabling game AI innovation and helps move us towards new playable experiences.

ENDNOTES

- 1 A playable, early prototype of *Rathenn* is available to play online:
<http://users.soe.ucsc.edu/~gsmith/rathenn/prototypes/pcg11/>
- 2 More information about *Prom Week*: <http://promweekgame.com>

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