Whodunit: A Generative Model for Murder Mysteries as an Information Game

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A Thesis

in

The Department

of

Computer Science and Software Engineering

Presented in Partial Fulfillment of the Requirements

for the Degree of

Master of Computer Science (Computer Science) at

Concordia University

Montréal, Québec, Canada

March 2022

CONCORDIA UNIVERSITY

School of Graduate Studies

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Entitled: **Whodunit: A Generative Model for Murder Mysteries as an Information Game**

and submitted in partial fulfillment of the requirements for the degree of

Master of Computer Science (Computer Science)

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Abstract

Whodunit: A Generative Model for Murder Mysteries as an Information Game

Arian Saffarizadeh

This research focuses on creating a model to generate information for a narrative-based game of murder mysteries. The literature review aspect of this research will review previous related research works in the subject of procedural narrative generation, explains the concept information game in the context of murder mysteries as well as on how the narrative structure of murder mystery stories in fiction can assist us in constructing a model that can generate information for a game experience.

I developed a proof of concept using the existing knowledge about the structure of murder mysteries and procedural narrative generation in a way that it can provide information for a murder mystery narrative-based game. After developing this proof of concept, I tested the prototype using a human-computer interaction method called *Wizard of Oz*. I hypothesized that this prototype is able to provide narrative information coherently for a compelling narrative experience with a believable cast of characters that can evoke feelings of suspense and surprise. By surveying participants after the play-tests, we concluded that the proof of concept can create a coherent narrative experience with a believable cast of characters in a way that it sometimes can create the feeling of suspense for players, but it was not able to create the feeling of surprise on the revelation of the culprit for most users. Based on this study, the prototype was also able to create a generally compelling narrative experience for the users.

Keywords: Procedural content generation, procedural narrative, murder mysteries, information games

Acknowledgments

First and foremost, I would like to thank my great supervisors Drs. Popa and Lessard for their mentorship, guidance, and patience. I would also like to thank my friends and colleagues at Technoculture, Arts, and Games (TAG) lab, specially Gina Hara and Dr. Pippin Barr for all of their help. A special thanks to everyone who participated in playtests and helped making this research happening. Last but not least, I would like to thank my parents, Katy and Khosrow Saffarizadeh for their support that without it none of this would have been possible.

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Chapter 1

Introduction

1.1 Background and Motivation

The idea to increase playability of games has been an ever-evolving and ongoing challenge for developers. One of the prominent solutions to tackle this challenge is to let the game generate parts of its own content by its own ongoing processes in way that these content are either completely new or have few similarities with other existing content. This approach towards game design is called procedural content generation (PCG), which is defined as a set of algorithms that will produce objects, elements, or mechanics for games with limited or indirect user input. [36] PCG technique allows for games to gain more replayability value while lowering the cost of development, mainly because core game processes will take care of content creation to a degree. Creating graphical objects like trees, vegetation, maps, and characters cosmetics have been practiced multiple times in games, but this technique has been less used for narrative elements.

Stories and characters can be categorized as narrative elements, and rules that define or connect these elements can be categorized as mechanics. *Dwarf Fortress* [1] has been a successful example among games in creating stories that emerged from a system that uses PCG to create characters with distinctive backgrounds living together in a community of dwarves and other creatures. In such a world, every generated character has their unique story, and inter-character interactions are determined by their agency. The concept of procedurally generated characters with unique backgrounds encourages a phenomenon in the domain of games narrative design that is called emergent narrative.

This phenomenon usually occurs when an underlying, predefined narrative structure allows stories to be created from itself by the player's interaction with that structure. [2] [37]

Now, instead of a game about a community of dwarves, let us assume that the goal is to create a game with a murder mystery narrative experience that manifests unique characters, and their relevant life events. This concept can involve a game mechanic that includes investigation of generated information in an engaging and interesting way. Clearly, mysteries are both popular as a genre of fiction and as games of information. This game concept is considered an information game because by definition; an information game is a type of game that a player's task is to seek knowledge in order to understand a certain complex artifact within the context of the game, for example, a sequence of events leading to an outcome. [6] PCG is a proper design approach towards this problem because the narrative of information games derives from information structures and PCG can generate coherent and structured information more easily than fully-realized narratives. [40] What measures interesting and immersive in this context can be categorized into matters of coherency of events within the narrative space, believability of characters and their life events, surprise, and suspense. [12]

1.2 Problem Statement

The purpose of this research is to create a system under conventional name of *Whodunit* for a murder mystery-based information game that uses PCG in order to provide a compelling storytelling experience.

The main assumption to design this system is that it can provide all the necessary information for a murder mystery narrative experience in order to allow the investigation process. Based on this, research objectives are:

- To model a system that will support a detective game with procedurally generated content.
- To provide all the necessary information to the player for a coherent experience such as characters, events, relationships, means of murder, opportunities, motivations, and state of crime scene. The sequence of events in narration are clear, related, and will be gradually revealed through the experience.

- Creating a believable cast of characters in the context of a murder mystery in a way that the generated relationships and events reveal the motives and opportunities for characters.
- Creating a meaningful narrative experience in a way that solving the mystery is possible through the investigation process.
- Creating a generally compelling and entertaining experience that maintains narrative elements of surprise and suspense, in a way that is similar to human-authored stories

Every murder mystery plot is made out of two distinctive yet connected stories, one is the story of the crime and how the murder happened and another is the story of investigation being progressed by the sleuth in order to solve the mystery. [18] [35] We can generate the story of the crime and let players interact with the system through *Wizard of Oz* technique [28] [9] in order to collect information from different characters and solve the mystery by finding the culprit.

Previously there has been some research conducted in order to model story generators with the assistance of neural networks, [11] that are widely popular methods to solve certain various generating problems due to their novelty. Even though these methods with the help of adequate data sets, can result in high volume of generated results but they also have major disadvantages in terms of semantic errors, difficulty of interpretation and readability with generated content that are not very author-friendly. [11] [27]

Procedural text generation methods on the other side, allow a balanced approach towards player's agency and maintaining complexity of pre-authored narrative arcs. [21] It is also expected that with using this method, generated stories would be more qualitatively comparable to examples of murder mystery literature narratives.

1.3 Approach

Approach of this research in order to reach its objectives as stated on the previous section is to create a model capable of creating procedurally generated murder mysteries with constraints of coherency, believability, suspense, surprise, and general appeal of an interesting emergent narrative experience. Our method facilitates a simple simulation model for creating new characters, new

backstories, and new relationships every time the system is being used. Since this research focuses on the narrative of murder mysteries, the story of crime will be created on the generative phase . This part of the plot that provides information about characters and their attributes, relationships, backstories, and some details of the story related to the murder mystery. The next phase of narrative experience is the story of detection, which proceeds by the player's investigation in order to solve the crime. This model consists of two emergent narrative segments converging into the final experience. First, the narrative emerged from the simulator and second, the narrative emerged from interaction with the system.

This research focuses on defining, implementing, and evaluating a model that supports a murder mystery generator facilitating PCG methods, specifically social simulation and pseudo-random number generators (PRNG), aiming for a model that will support an interactive experience. The primary goal of this system is to present a completely new murder mystery case for each play session so that these cases would contain all the related information in a way that is appealing in terms of immersion, narrative quality, and novelty. Regarding to all of these considerations, a proof of concept in the form of a generator prototype has been developed on Unity game engine with scripts written in C# programming language. This system will be tested in an experimental method to observe how well it can reach its goals based on user's experiences.

The next chapter will cover the literature review aspect of the research that reviews and analyzes prominent research-creation works (both academic and commercial) related to the subjects of procedural narrative generation, information games, emergent narrative, as well as discussing mystery novels and detective novels, their fundamental differences and how they project themselves into this body of work. We will also describe contributions of this project regarding state of the art.

Chapter 3 will discuss different design aspects and implementation details of the generator and how the mechanics work.

Chapter 4 will discuss results of the play test sessions along with analyzing and validating the gathered data from the tests.

Chapter 5 will discuss advantages and disadvantages of the system on reaching its goal based on data gathered and final analysis.

1.4 Contributions and Limitations

This thesis presents an outline for design, implementation, and evaluation of a system for procedural narrative generation for murder mysteries and ways of distributing information to the player using the asymmetric method of *Wizard of Oz* in order to promote emergent narrative. This system uses PCG in order to generate unique characters with distinct motivations, trust levels, and perceptions towards each other that engage in different events using social simulation in a context of a murder mystery.

The limitation of this project is that it does not consist of a fully constructed game, but it provides an information engine for potential games. The *Wizard of Oz* technique will assist us in evaluating the qualities of this engine. This technique will be used as our method of evaluation to test a fundamental system without having yet developed an actual user interface.

The project's prototype will be tested using user interaction and live asymmetric play-tests. At the end of every play-test, users will answer questions on a survey that will measure the outlined qualities of the system.

Chapter 2

Related Works

This chapter will cover the literature review aspect of the research along with some research-creation case studies related to subjects of interactive storytelling and procedural narrative generation along with concept of information games that are inspirational to this research whether in aspects of PCG techniques or means of distributing information in a game experience. First, we will talk about PCG as a concept and its application to create narratives. Then, we will briefly discuss information game and its definition. After that, there will be an overview of interactive storytelling as a research concept followed by a review of crime mysteries, detective stories and how these genres of fiction literature will lay the foundation for designing a support model for a narrative experience. We will also discuss in what ways these research topics inspired this body of work in design and implementation. Lastly, there will be a review of some influential generative models

2.1 Procedural Content Generation and Generative Narratives

PCG is generally being addressed as a technique in the game design and development process that usually consists of a set of algorithms, which will produce objects, elements, or mechanics for games. Depending on the type of generated content, it might result in a lower amount of authorship effort from the designers, therefore, in some cases resulting in lower costs, whether financially or in terms of team efforts. However, as a usual case, the main goal of using PCG methods in game design is to create a vast volume, if not infinite, amount of desired game content with less authorship

effort while maintaining a certain level of design control over generated artifacts. In other words, it can be described as the concept of 'algorithmic creation of game content with limited or indirect user input'. [36]

Two terms of 'procedural' and 'generation' imply the application of certain algorithmic procedures in order to instantiate desired elements or objects. 'Content' can be any object or aspect of a game such as maps, levels, rules(mechanics), stories, characters, textures, items, quests, music, etc. [30]

Procedural narrative generation is a term for designing procedurals defined in a set of algorithms in order to generate narrative content such as plots, storylines, characters, lore, quests, or any type of element that contributes to the process of narration or storytelling in a game. In classical authorship, the author's role is to create and develop character story arcs and interpersonal relationships for a coherent chain of events and narrative steps of the story. In a narrative generation scenario, however, the game designer or narrative designer's objective is to manifest and translate these events and story processions into narrative procedurals for a game. Moreover, in classical authorship, the goal is to narrate a plot in the context of a strict narrative space of the story, whereas in procedural narrative design, the goal is to create a story volume within the narrative space. A story volume is a narrative space created by a procedural system in a way that it allows similar but not identical stories to emerge from that space. [26] In other words, a story volume consists of numerous storylines with similar themes that are generated from an authored and procedural narrative space.

Generating a story volume in narrative space usually leads to more non-linear and unique narrative experiences. We will discuss examples on this subject in detail in 2.5 where we review some essentially narrative-based games.

Procedural narrative generation is one of the fields of PCG that has been less researched than the other fields of generative contents, i.e., graphical objects. This is primarily because of challenges that this design process imposes for defining a model that supports desired story objects or characters' interpersonal relationships as well as defining these objects and elements for a computer.

2.2 Information Games

Because this research focuses on the application of narrative generation in the context of murder mysteries, it requires us to review a form of games that specifically focus on detecting information and deducting knowledge; these games are called information games. [6] An information game is a type of game in which a player's task is to understand a certain complex artifact within the context of the games such as a sequence of events leading to an outcome or a physical system that manifests the mechanics of the game. Moreover, by progressing through the game, players should gain knowledge about these artifacts, link them together if necessary, and using all of the information gathered, seek out new knowledge, and reach an outcome based on the context of the game. [6]

Apart from the focus of information games on concepts of mystery, discovery, and deduction, numerous properties distinguish games of information from other types of games, specifically in aspects of modelling the system and design. This leads us to one of the main factors of information games: their high level of difficulty to model. Most games model interaction of player with the game world and its progress by measurable and mostly mathematical ways. For example, keep counting the number of quests that player must finish before progressing to the next chapter or finding five chests in order to gain a reward. However, in information games, these means of progress are primarily defined by concepts such as language and semantics or interpersonal relationships and character personalities that generally are not easy concepts to model or define for a computer. In addition, these games are usually designed in a highly non-linear structure that creates more autonomy for the player in ways to investigate and explore the world to solve its core-manifested mysteries. This non-linear structure both requires and imposes the need to distribute the information thinly throughout the game instead of focusing them only in one or some particular areas or scenes. [6]

The concept of information games is a relatively new topic in computer science and computational design. The prototype of this research aims to provide information for an information game in the context of murder mysteries.

2.3 Interactive Drama and Storytelling

Classical method of storytelling that usually traverses Aristotelian narrative arcs typically follow strict plot points that are all finely and carefully set in events connected by precise causal chains. [31] On the other hand there are stories with sparser and diverse events that might not necessarily follow a strict structure but offer novelty and entertainment in terms of emergent stories or character's interactions. These narrative experiences can potentially be the desirable case for a procedural narrative generation because it suits the idea of generating story volumes rather than storylines. This essentially means that various storylines can potentially emerge from a space that they share contextually. [26]

When discussing interactive stories, another prominent factor that should be taken into serious consideration is the element of agency. Agency can be defined as the freedom of interaction offered by the author or designer to the player so that the player can meaningfully influence other sentient characters, non-playable characters (NPC), characters interactions, and even core of the story. Another form of agency is also the freedom of interaction between NPCs. [21] Implementing a successful agency is by no means an easy task because it has been proven that designing a system that can dynamically maintain a coherent story structure while being responsive to unpredictable player's choices and actions is an extremely challenging task. Agency can also appear in different forms and formats. [34] [33]

In the process of creating a complex interactive narrative system, design choices will affect the dynamic behavior of the system and the way it reacts to player choices and the types of emergent stories that system can offer to the player, hence increasing the likelihood of a rich narrative experience for the players. In other words, by designing the story elements that feed the story generator, it is possible to increase the levels of agency they offer to the player while creating sufficient narrative intelligence with character-rich stories and events that are causally sparse but still have cohesion and meaningful link between them. [21]

2.4 Murder Mysteries and Detective Fiction

Back in 1841, when Edgar Allen Poe wrote his famous novel, *The Murders in The Rue Morgue* [25], he laid a foundation for one of the most popular genres of fiction in the coming century. Mystery fiction genre had a century-old evolution and went through a metamorphosis by prominent writers such as Christie, Conan Doyle, Hammett, Chandler, and many others. Through these years of evolution of the genre, new styles of detective fiction and crime fiction emerged from previously known structures. However, one thing that usually stayed the same about the genre, which made it so plausible, is perhaps its simplicity of structure. Most classical mystery and crime fiction novels follow the Aristotelian form of narrative with the attempt to keep the mystery unsolved until the last pages, along with many other similar story elements that are always apparent depending on their styles. Moreover, many critics claim that this genre in many ways resembles puzzles and riddles in fiction rather than pure literature. [31]

Raymond Chandler, who is a formidable detective fiction writer, is in fact very critical of structural aspects of classic mystery novels and as one of his critiques of the genre, he argues that these stories are created by "cool-headed constructionists" with "contrived plots", and that logic and deduction in these stories are "adhere to arid formulas". [18] [5] Ironically, the issues that Chandler counts as implausible for classical murder mystery stories are what makes them simple and enjoyable and at the same time implies how structured these stories are hence gives blueprints for constructs of such stories to model.

Noticeably, due to this notion of riddles and mind puzzles embodied in mystery, detective and crime fiction, we have seen a rise in games based on murder mysteries, especially in board games. Famous board game, *Clue* might be one of the oldest one of these. Because of similar design patterns, if these table top games has been made by underlying structures and elements of a literature style, then it is possible to create them in video games medium as well.

Murder mystery-based games can be categorized as information games in terms of presenting a world and mystery events to the player and letting them discover by interacting with its world, characters, clues, and deducting links between this information to gain knowledge about the mystery. However, how a player gains this knowledge varies from a gameplay experience to another

and different players can use different methods and take longer or shorter times to solve the mystery or even sometimes succeed by chance. [6]

The structure of murder mysteries and detective stories makes them a reasonable testing ground for generative plot and gameplay. The emergence of certain patterns in the structure of these stories makes them easier to define and implement inside algorithms. [32]

Since this research focuses on procedurally generating a certain genre of murder mysteries in literary fiction, it is critical to study this genre, understand its structure, and study related literature works from similar genres that contributed to evolving it. This is highly prominent because the structure and narrative elements that typically manifest genres like murder mysteries or detective fiction are recurrent and will provide clues and a road-map to shape the framework our model.

One common misconception when discussing murder mystery fiction is neglecting its progress throughout the years and by different writers and how this evolution created different sub-genres with distinctive characteristics and structures. However, considering these differences, mystery, detective, and crime fiction sub-genres share many similar and recurrent narrative elements. It is important to recognize and observe differences that distinguish each of its sub-genres from another and their similarities.

Regardless of distinctions between genres, all murder mystery and crime fictions have the duality of crime and detection in common. First is the story of the crime and how it happened to unfold to the sleuth, and second is the story of investigation undertaken by the sleuth. [18] [35]

This double story is a narrative process for solving the crime happens in the early pages of any murder mystery or detective fiction. The chaos starts with a crime scene that portrays a dead body with all the mess that accompanies these scenes, and thus the story of crime begins. Next, it is time for the sleuth to start the investigation in order to find the culprit and bring justice and order to the injustice and chaos created by the crime.

No matter what, this process always consists of "observing the rules, spotting the clues, and making appropriate deductions." [16] These simple conventions led to the creation of police procedural, which is one of the main characteristics of classic murder mysteries and later became more recognized back in the 1940s by different authors and later on depicted more on detective stories and crime fiction. Police procedurals are the investigation methods and routines based upon a set

of realistic notions like homicide investigation and forensics in order to make progress in solving the mystery. Moreover, Malmgren argues that police procedurals have been originated in mystery fiction and depicted primarily by Agatha Christie in ways in which objects like letters, maps, and other clues can be found in the environment during the investigation and this methodology later has been taken into consideration by other authors of detective and crime stories. [18]

It becomes gradually clearer that the simplicity of some story structures, formal patterns of detective fiction, and methods like police procedurals make the genre adaptable to other forms and modes, preferably to games in the case of this research.

The first person who drew a line between mystery and detective fiction is Raymond Chandler, who called classical mystery novels fictional and with less regard towards the reality of the world. [5] [18] The most defining difference between mystery fiction and detective fiction is the idea of centeredness. Whereas mystery fiction is centered and detective fiction is decentered. This means that the world in which mystery fiction takes place is anchored and has a center; therefore, external signs can be linked to internal conditions. Signifiers are related to the signified, and there is a connection between effect and cause. This centeredness is apparent in the physical aspect of the narrative as most mystery fictions have one essential and significant crime scene, for example, a train, village, or a mansion. The investigation starts with the detective examining this scene, revealing some clues that all have root causes. In mystery fiction, every action has a reason, and every clue has an explanation that can be traced back to its root. Nothing happens without a simple cause and effect connection. A centered world manifests certain predicates and usually avoids contingency. This rational world of cause and effect law guarantees that people would behave in certain ways or patterns for achieving certain goals and proposes that every action is motivated.

Adam Dalgliesh famously categorized these recurrent motivations into “the four Ls” of “Love, Lust, Loathing, and Lucre”. [14] This means murders in such stories are usually premeditated so there is always a link between the killer and the victim. Unless the culprit is a serial killer, all murders are motivated and that is one of the main reasons why serial killers are absent in mystery stories, because their motivations are driven by madness or incomprehensible urges that disrupts the notion of centeredness.

Conventions like the famous mansion setting guaranteed the link between signifiers and signified, which is an important function of non-arbitrariness in the mystery genre. Even with the structure of centered worlds that supposes an inevitable connection between signifier and signified, it is essential to distort or obscure this connection in order to keep the story intriguing and let the investigator decipher clues and make proper deductions. This disclosure of information through investigations is one of the pleasures of mystery novels. As Cawelti claims that "seeing a clear and meaningful order emerging out of randomness and chaos" brings pleasure [4], an emergent narrative evolving around an existing murder can also be compelling.

In comparison to what was described above, detective fiction is set in a decentered world where the author tries to depict the randomness and chaos of the outside world more realistically. There is not one significant crime scene or physical space in detective fiction. Instead, there are usually several scenes that can possibly reveal clues to the culprit. Moreover, the story does not guarantee a causal link between the revealed clue and a fundamental root cause related to the crime. Culprit traverses different physical spaces and investigates suspects, and normal people. In detective novels, knowledge is obscured, and signifiers point to a signified that might be another signifier, therefore are no real solutions or resolution, only clues. [18] Detective fiction is more about the story of the investigation and the investigator rather than the story of murder event. It revolves more around the detective's character, how he or she tries to solve the irredeemable act of murder and how these events affect him or her. Even though the crimes eventually will be solved in such stories, but justice and resolving the crimes are not guaranteed. Grounding in detective fiction occurs in the detective's character, and his or her motivation towards solving crimes is the anchor of the story.

By presenting a revisionary perspective towards previous genres, crime fiction emerges. This genre also revolves mainly around the story arc of the protagonist. However, this time the protagonist is not anchored, and their selfhood goes through question and might even fall into criminality. The world itself can be centered or not centered but what matters is a decentered narrative of the protagonist's life and how he or she copes with criminality and the ways this world can be understood through psychopathology.

To summarize the distinction between the three genres, mystery fiction is story dominant and set in a centered world with centered characters, including the investigator. Actions are motivated,

and everything happens within the law of causality. Detective fiction is narrative dominant and sets in a decentered with decentered characters, but the investigator is centered and has grounded motivations. Actions can be motivated but mostly occur without causal effects and it can be difficult to detect signifiers, and signified in these stories. Crime fiction is also narrative dominant but can be set in either a centered or a decentered world. The characters are not grounded. Motivations and even selfhood of characters, especially the protagonist, change. Crime stories are more revolved around the reader's perspective. [16]

Mystery fiction and detective fiction are both highly influential on this research, while crime fiction remains outside of the scope of our work. As we discussed before, these genres still share some similar characteristics. These properties lay the foundation for our system and give us clues about what elements to consider when designing. This system is able to generate a story of crime and lets the story of detection proceed during the interaction of the player and the system in the form of an emergent narrative. This is similar to how this part of the story narrates in literature, manifesting the differentiation between the story of crime and the story of detection. The detection part is being handled by the investigator which in the case of an interactive system is the player's role. In order to generate the story of crime, the system has to consider murder events and their related objects as the center point of narrative generation similar to mystery fiction. Recurrent key elements of means, motivation, and opportunity will be essential in designing and implementing the prototype. Moreover, four L's of motivation [14] will be used in designing character modeling and motivations of generated characters.

2.5 Generative and Simulating Models

In the next subsections, we will discuss researches that influenced this body of work in different aspects. *Façade* in its approach towards balancing players agency and strict rules of pre-authored narrative arcs, *Talk of the Town* and *Bad News* in their procedural generation process for generating characters and their relationships, *Prom Week* in its complex system to simulate characters social affinities and their effects on characters actions, and Cozy Mystery Construction Kit (CMK) in its attempt to model a system that is capable of procedurally generating mysteries using social

simulation.

2.5.1 Façade

Façade is one of the successful and influential examples of interactive drama with a dynamic world that facilitates natural language processing (NLP) techniques along with real-time render of character animations responsive to interactions. In this game, the player can choose their name and gender to participate in an evening get-together with the game's main characters, Grace and Trip, a successful couple in their thirties living in an apartment together. Grace and Trip are old friends of the player and have known each other for a long time. However, the game's story soon takes some peculiar and dramatic turns based on the player's choices and actions. During the course of gameplay, the player has to face numerous irreversible choices, taking sides, and some accusations that ultimately affect Grace and Trip's lives and their relationships with the player. Important choices that change the course of the narrative in *Façade* are finely designed and are kept well intertwined within the story volume; therefore, it is difficult to recognize them and trace them to a certain outcome or point in the story. Because of this, the narrative does not resemble the traceability of usual branch-based narratives. This element also encourages the players to experience the game again, use different interaction choices and try different narrative decisions, which highly increases the playability value of the game.

Façade aims to create a good, playable and intriguing interactive drama experience with a high level of agency and encouraging players to be more dramatic about their choices; however, the system's framework still highly relies on human pre-authored behaviors written in a hierarchy. Between two approaches of traversing handcrafted graph nodes that resemble events and decisions in typical branch-based models, and the approach of procedural simulating a virtual world, Façade designers decided to take the middle ground and combine both methods. [20]

Façade received high praises for its way into pushing boundaries on interactive drama and its technological innovations in terms of mixing the advantages of procedurally simulated worlds and graph-based event design while trying to avoid the disadvantages of branch-based narratives. Moreover, the application of NLP algorithms and integrating them with dramatic reactions of agents through facial and gestural animations really assisted this game to reach its goals in the theatrical

level of drama about being personal relationships in the form of an Aristotelian tension arc.

One of the main challenges that *Façade* tried to tackle is the trade-off between a well-formed and highly structured narrative yet plausible story that holds its structure amid influence from the player and a dynamic interactive experience while simulating its content procedurally and in relation to player activity. As argued by the designers themselves [22], *Façade* had limited authoring effort, resulting in a high number of sequence beats therefore not using all of the potentials of the drama manager process and highly relying on those pre-authored behaviors, dialogues, gestures, etc. which alternatively could have been automatically generated.

Another major challenge that the designers believe that the game fell short of is the difficulty of communicating the stats, social scores, and affinities through the interface to the player, albeit it performed quite well in terms of communicating these stats and affinity scores through the emotions and reactions of the agents in the background processes. With the assistance of efficient NLP through the local and global agency of the agents, objects in the environment, and their interaction, *Façade* brilliantly brought an interactive theatrical drama experience revolving around a falling apart marriage into life. [22]

Façade is one of the pioneer examples of interactive drama experience that facilitates social simulation, NLP, and some PCG methods. This game has inspired almost any research on the subject of procedural narrative generation to some degree. In the case of this research, *Façade* was influential because of its nonlinear aspect of gameplay and narrative progression as well as the high level of agency that it offers to the players.

2.5.2 Talk of the Town

As part of reviewing examples of procedurally generated narratives parallel with emergent narratives, we will come across a fine example that even though it never really reached the point of completion as a fully independent game, but laid a strong foundation for some other successful systems such as *Bad News* which we will review in the next section.

Talk of the Town was an ambitious research project developed by James Ryan and Adam Summerville focusing on creating an asymmetrical multiplayer gameplay experience for the players interacting within a fully simulated town with other characters, NPCs, town's history, relationships,

and conflicts. The game's concept is set in a small American town with the population of around couple of hundred. At some point, one of the residents of the city who happens to be one of the richest people of the town passes away and has no precise note for his or her inheritance. Therefore, a member of the family along and a secret lover of the deceased are set to find the note through conversations and interactions with other characters that ultimately shape the core of gameplay revolving around knowledge propagation. [27]

In *Talk of the Town*, each simulation takes two time-steps on each day, and at any of those time steps, characters will interact with each other and the environment. This is correlated to every characters personality that is designed based on the big-five personality traits factor [7] and is simulated beforehand. There are many different entities in the system, including characters, town, businesses, buildings, jobs, etc. Characters have different attributes and properties such as names and how they received that name, date of birth and possibly date of death, job title, appearance attributes such as color of eye or skin color or even shape of the head, marital status and most importantly their personality traits values of extroversion, neuroticism, openness, conscientiousness and agreeableness. The core of interaction between characters is that on each time step characters decide where to go or what to do and based on their personality and their prior taken action. Suppose two characters happen to be in a same location. In that case, there is a chance for them to interacting or make a conversation considering that all of these interactions and possibility of them happening is related to their character's personality traits. The core principle for emergence of these interactions is a probability function that determines a certain event or action to be executed based on previous events and personality traits. [27]

One of the most interesting phenomena of the *Talk of the Town* simulation procedure is its social simulation, which is driven by multiple affinity score values that determine the level and type of relationships shaping between characters and affecting probability functions mentioned above.

Another main aspect of *Talk of the Town* that appears even more strongly in its successor's, *Bad News*, is its subtle ability to create emergent narratives in a non-conventional emergent storytelling way that James Ryan calls it "emergent scenarios". [27] In the process of shaping an emergent scenario, the generator delivers some story elements such as the character's personality or a series of causal events related to the character without fully narrating a story but rather suggesting a scenario

that other stories can emerge from it. Emergent scenarios tend to make players or human readers of simulation results fill some of the gaps that the generator will not narrate, accompanying some general ideas or concepts about certain characters and their life events. So even though *Talk of the Town* does not necessarily generate a fully structured story but gives a context and story space about characters and their connections and relationships with others in the city that lays the foundation for various stories and narratives to emerge from that generated scenario.

Talk of the Town's method of character generation using different personality tags and its simulation modelling for creating character relationships that uses idea of spark and random first impression between characters which propagates further connections between characters, are essentially influential to this research as *Whodunit* also uses similar but simpler methods. As discussed in the next chapter, *Whodunit* uses static personality tags for character modeling and a value for good first impression that affects initial relationships between generated characters. In addition, the idea of social simulation as a method for generating narrative volumes inspired *Whodunit* to take the same path regarding murder mysteries.

As mentioned before *Talk of the Town* never got finished as a standalone game, but its simulation core and its generative procedures assisted development of a prominent game named *Bad News*.

2.5.3 Bad News

Bad News is a successful, award-winning hybrid game that uses both computer simulation and live performances as key elements of its gameplay mixed with the *Wizard of Oz* technique of presentation. [29] [19]

At first, the game starts by procedurally generating a hundred years of history in a small American town, which works with executing *Talk of the Town* system as its backbone. At the end of the simulation process, which usually takes around a couple of minutes to finish and is fulfilled by the wizard role in the game, one of the characters in the simulated town passes, and the performance phase starts. Now the players have to improvise as NPCs and make conversations to find the next of kin of the deceased character to tell them about the occurred death. The cause of death is unknown to players, and they must find the identity of the deceased and the identity of the next of kin and eventually deliver the bad news to that person.

The simulator can give the reader exact descriptions of the deceased character since this part of the game has been implemented and supported by *Talk of the Town* system. The basic information presented by the console are the name of the town (which is always unique), character's full name, age, and date of death. Moreover, by using Python console commands, the wizard can demand various questions from the system such as the occupation of the deceased character, their relatives, their spouse or spouses, if any, or any notable life events such as buying a property or establishing a business that are all accompanied by precise dates of when they occurred.

In terms of narrative, the wizard and the actor have a prominent role in creating the narrative artifacts that emerge from *Talk of the Town* and into the *Bad News* conversational storytelling experiences. This is possible because of "overgenerating" [27] of the potential narrative scenarios that *Talk of the Town* system instantiates and then embodies into *Bad News* interactive experience, making it playable for the players to explore the town events and talk about its citizens. Another important narrative element is that even considering the entire century of history being simulated for a town, the death of only one person is in the epicenter of attraction in *Bad News* narrative and this solely creates an interesting comparison between death of only one person to the larger context of the city. An advantage that *Talk of the Town* simulation creates for *Bad News* is an emergent narrative phenomena called "aesthetic of the uncanny" [27], which to simply define means that when a highly improbable event or scenario emerges from the system which in this case is mainly driven by simple probabilistic functions.

On the other hand, one of the disadvantages of *Bad News* mentioned by its designers is its high dependence on human-driven narrative and their curation. This human curation can result in some wonderful and dramatic experiences driven by human's natural taste in storytelling and detecting more interesting drama. However, at the same time, without those human interactions, there is no automatic or computational system to support this, and therefore the game would remain almost unplayable. [27]

Evaluation of *Whodunit* is dependent in the same way on human curation of narrative artifacts and user interaction, and because of that it needs *Wizard of Oz* method to assist it to complete the storytelling experience. A human interaction method like *Wizard of Oz* method can result in some interesting and dramatic narrative experiences because of human's natural taste in storytelling and

creating drama that we have described above.

2.5.4 Prom Week and Comme Il Faut

Prom Week is a game driven by procedurally generated social simulation about the dramatic week leading to a high school prom. The game's core mechanic is the social interaction between the players and characters driven by an AI system named Comme Il Faut (CiF). CiF works as the underlying system in order to store personality descriptions, emotional states, personality traits, memories, and social facts of a series of character agents while these values shape their intention towards a certain goal. These values (called social affinities) [24] then will be updated on both sides for agents based on social games that they may decide to play with each other. [23]

All of these components stated above are designed and authored in a context of a social game between characters in a high school and will change accordingly. Social games played on CiF are multi-character interactions that will modify the social states of characters participating in that interaction. It enables characters agents to decide on type of social games next depending on their current status and their response to them according to their personality description. [24] All social games have effects, which might result in changes in states, affecting how future social games are going to be played.

Apart from being another notable research-creation work related to narrative PCG, *Prom Week* is inspirational to this research specifically because of its application social simulation and step-by-step social games played by characters that will affect their current status. *Prom Week* characters interact with each other based on their current attributes. Those interactions will affect the social affinities based on the result of interactions so now characters can interact with new social affinities. This is inspirational in design and implementation of the social simulation phase of *Whodunit* that characters have attributes such as trust, perception, and attitude that will affect their interactions with each other, and events they participate. Events will result in outcomes that can change these attributes, and then characters will again participate in events with their new attributes. This process will be fully covered in the next chapter.

2.5.5 Cozy Mystery Construction Kit

CMK is the research project name for another PCG-based mystery game prototype centered on character's social simulation of and motivations. On that research, the objective was to move forward on the works like *Prom Week* and CiF system and their contribution towards generating social simulation using affinity points and changing the interaction of characters based on their current social status. However, this research focused on identifying an experience offering to the players and then developing a social model accordingly to help implement design goals for a mystery. [15]

In CMK, characters are generated with one primary and one secondary type of personality traits for example: 'optimistic' or 'eccentric'. After that, the system treats characters as vertexes of a graph. On the next step, based on characters personal values and their relationships, a connection (edge) between the characters will be defined. Eventually, the result will be a generated graph of characters with different personalities, values, and professions that will define and represent their inter-character relationships that generates their social simulation. [15] This will allow the system to derive different functionalities from the generated data and put them into a loop, similar to CiF system.

Similar to CMK, generated characters in *Whodunit* have different motivations as one of indicators towards their interactions because motivation is one of the main recurring concepts in almost all murder mysteries. Motivation along with trust levels, perception levels, and attitude would determine characters relationships with each other, and events they participate. Based on outcome of these events, trust and perception values of characters towards each other will be updated but their attitude and motivation will always remain the same.

Chapter 3

Implementation

3.1 Modelling and Overview of the System

There are central concepts that have assisted us in the modeling of *Whodunit* in a way to align it more with the constructs of classical murder mysteries. One of those concepts is the notion of centeredness of murder events which originates from literature examples of murder mystery fiction as recurrent themes. [18] [4] [16]

As described before on 2.4, centeredness means that the murder event is the center point of any murder mystery narrative that manifests different characters such as culprit, victim, suspects, and their relationships, along with important details such as motivations of each character, means of murder, opportunities for murder, and state of crime scene. Consequently, the goal is to provide a final output, which we call the chronicle of murder, that is constructed by all the parts mentioned above. Definition of the chronicle is based on Hayden White's model for process of storytelling as defined as a record of unprocessed data from a historical phenomenon. [38] [27]

As shown in figure 3.1, the murder chronicle is consisting of different parts. First, we need characters with different names, occupations, initial values of feeling and trust, motivations, and other traits generated by the character generator class. Function of this process is to create characters that are distinctive from each other and aids us in achieving the goal of creating a believable cast of characters. After this step, we have a set of strings that are assigned to those values mentioned above. Process and examples of character generation are covered in section 3.2 in detail.

These characters will now form a group that need to form inter-character connections and relationships. The Relationship generator class will initially connect these characters to each other in a random process to from the first set of relationships. Moreover, relationships can change dynamically depending on characters' trust levels and events which will be discussed in depth in section 3.4.

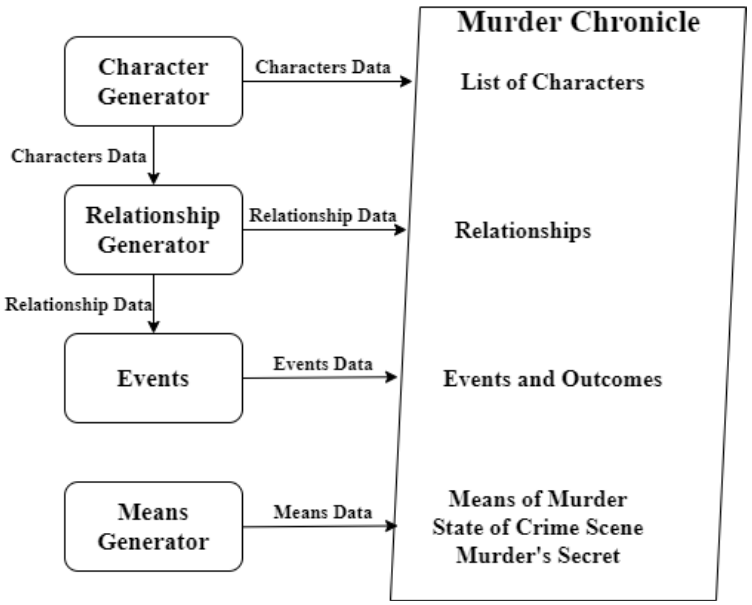

Figure 3.1: Construction of Murder Chronicle as the Output

The generated cast of characters can now engage in individual or group events depending on the prerequisites of those events that will form the next section of murder chronicle, the event log. Event log holds the chain of causality in the story. Each event results in a predefined outcome. Some of these outcomes are neutral in a way that will not change the characters' trust levels, but most events outcomes will change those values; therefore, this will affect the subsequent events that characters would engage in because of their updated states. This subject will be discussed in detail in section 3.3.

Other details such as means of murder, state of crime scene, and murder's secret are randomly generated from a separate class explained in section 3.5.

At the end, we will have the murder chronicle that the system compiled consisting of the list of all the characters, their attributes, relationships, events that they participated in, details of murder

weapon and crime scene. This is the final output that requires curating in the form of narrativization in order for it to become more comprehensible to the user. [27] This procedure is the wizard's job who in the framework of *Wizard of Oz* method, is the user that will mediate the interaction of the user-detective with the compiled information from the system. These procedures will be discussed in section 3.7 and ultimately for evaluation purposes on section 4.2.

3.2 Characters

The character generator is located at the initial point of the simulation process to create the chronicle. The automatic process of generating each distinctive individual character is:

1) Generating names for five characters that will be randomly selected from a pool of strings containing forty unique names.

2) Assigning value for motivation from a list of enumerates.

3) Calculating initial values for social affinities, including feeling, attitude, and perception based on figure. 3.2

4) Generating random string values for occupation, primary personality traits, and enjoyments.

Items in the occupations lists are in order to conceptualize the plot of murder mystery in a small rural American town. Personality traits and enjoyments lists are based on [8] and [10], and their use is to add a touch of realism and more details and depth to generated characters. (see appendix A)

Motivation is absolute necessity of character modelling in narrative of murder mysteries because it indicates the rational connection between culprit to victim and explains why the murder event occurred. Without motivation, it is implied that the culprit is possibly a psychopath or even a serial killer [5], which completely shifts the shape and scope of the story and turns it into a serial killer plot which is not the goal of this project.

Static values of attitude and motivation will determine how characters will decide if a character is willing (or has prerequisites) to interact with others. In contrast, feelings and perception would determine their trust towards other characters, thus shaping their relationship with each other.

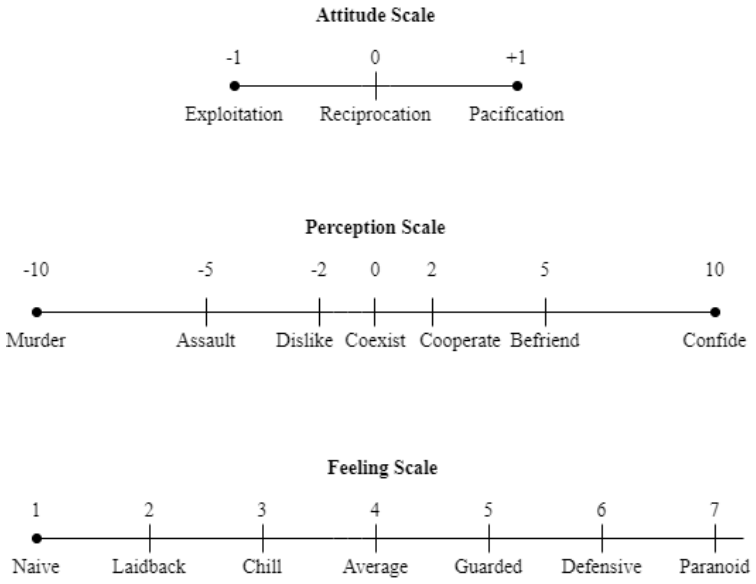

Figure 3.2: Characters Social Affinity Scales Inspired by [8] and [10]

For example, if a character has a feeling of 'Laidback' towards others, then she is more likely to form positive perceptions of 'Befriend' or 'Confide' towards others, while a character who stands on 'paranoid' scale is more likely to form negative perceptions towards others like 'Assault' or 'Murder'. In other words, trust level uses perception scale and is a product of feeling and attitude. For Example, if a character stands on 'Exploitation' on attitude scale, her feelings towards others will increase more slowly than a character with 'Reciprocation'. At the same time, her feelings will decrease faster. 'Pacification' attribute reduces decrease on feeling scale towards others. In simpler terms, 'Pacification' slows down the decrease of feeling towards others because the character is considered peaceful, and 'Exploitation' slows down the increase of feeling towards others because the character is considered hostile.

Table 3.1 shows a simple example output for character modelling of *Whodunit*.

Some elementary parts of this specific process are based on [13] with many modifications because that system generates random interactions. In contrast, by adding motivation and more depth in character modeling of *Whodunit*, interactions have become more relevant and coherent, specially to the context of murder mysteries. In other words, the emergence of murder event and its previous related events that led to that event are caused by interactions of generated characters depending on their motivations and trust, which we will discuss further in the next sections.

Characters Sheet						
Name	**Occupation**	**Base Attitude**	**Base Feelings**	**Motivation**	**Enjoyments**	**Primary Personality Trait**
Oliver	Chef	Pacification	Average	Respect	Competition	Awkward
Hayden	Waiter	Reciprocation	Average	Fear	Music	Friendly
Sam	Artist	Exploitation	Chill	Lust	Creation	Silent
Francesca	Manager	Reciprocation	Guarded	Lucre	Challenge	Talkative
Joelle	Mechanic	Pacification	Naive	Love	Collecting	Neurotic

Table 3.1: An Example of Characters Attributes

3.3 Events

After generating characters, social simulation commences, and characters will participate in different events. Events are a log of characters' activities in the world revolving around the murder event that indicates the chain of causality of the story. James Ryan describes this chain of causality as the concept of 'causal bookkeeping' that means tracking contingent events emerging from the generative system as they are generated. [27] This concept is important to the narrative because this will allow players to reconstruct the chain of events as detectives.

Events have prerequisites in order to be triggered that are a set of objects within event blocks in a way that they will dictate which characters can participate in a particular event based on their motivations and trust level towards other characters. For example, if a character is motivated by the type 'Lucre', he is eligible for event 'Forging a Will'.

Every event consists of some attributes and properties. These attributes are:

- Name of the event, indicating the event happening either by one character or more.
- Full description, that describes what happens during the event.
- A set of prerequisites that dictate the requirements for the event to generate. These attributes are hidden to the user and will not be shown in the final output.
- Roles that are filled by the characters involved that are shown as participants of each event.
- Possible results that are a set of probable results that can be the outcomes of the event that are also hidden from the user but one of them will be selected as the outcome. Some events

might have outcomes, and some might not. Outcomes are mostly accompanied by a positive or a negative magnitude of change that will affect trust levels.

- Text summary that describes the outcome and how values have changed.

As straightforward as it sounds, the name of the event is just a string value that stores the name of the event, for example 'Social Gathering'.

The description is also a string value but describes the event by what kind of activity is being conducted, which describes the detail of an even in plain language.

Prerequisites are the crucial aspect of constructing events. How events are created depends on how characters that are participating in that event perceive others (perception level) and what they think the others might think of them (trust level), and what they want to achieve from that event (motivation attribute).

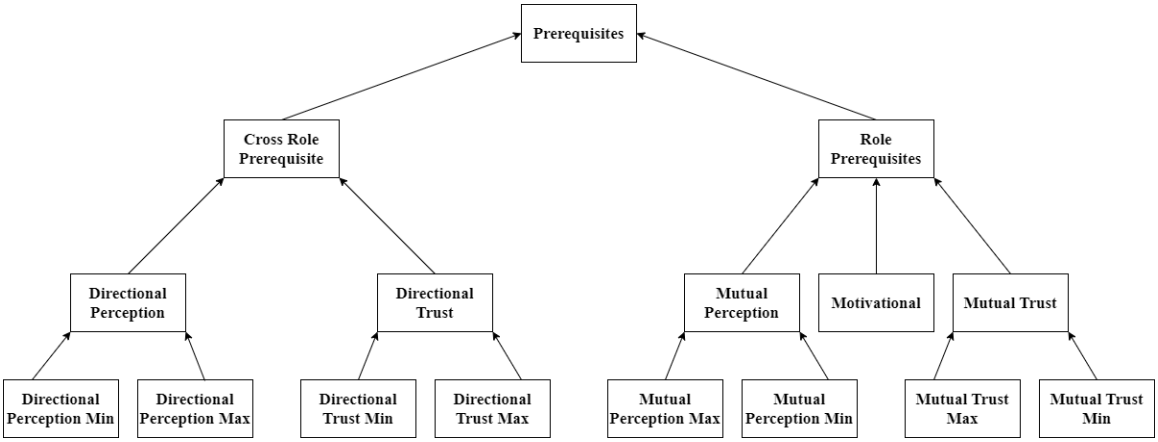

Figure 3.3: Types of Events Prerequisites

From a more high-level perspective, prerequisites are divided into two types: Role prerequisites and cross-role prerequisites. Role prerequisites are set of prerequisites related to the roles of characters regarding each event and consist of mutual perception, mutual trust, and motivation for each character.

On the other hand, cross-role prerequisites are independent of roles and consist of directional trust and directional perception. The difference between mutual and directional measurements is that mutual measurements of trust and perception take both values for parties that are participating into consideration and compare them, whereas directional measurements only considers values of

one party into consideration. In other words, mutual measurements compare what two or more characters think of each other, while directional measurements are for finding out what one character thinks of other parties. Whether mutual or directional, all of these values are categorized into different sub-classes for finding and comparing minimum and maximum values for perception and trust. This entire categorization can be seen in figure 3.3. The motivational prerequisite class inherits from role prerequisites, but it has a more straightforward implementation because it only checks if a character have the required motivation for an event. For example, forging a will requires a character to have a lucrative motivation; therefore, the motivational prerequisite checks of any character have this motivation as its attributes. If she does, then there is a probability for the generation of this event.

Roles in events define the relation of a character to an event. It indicates if a character participating in an event was the sender or the receiver, the attacker or the defender, the murder or the victim, etc. Roles have a direct relation with prerequisites in a way that when the system checks for a specific prerequisite in an event, it checks if a role in that event has the prerequisite. In other words, it checks if a character in a role fits the defined criteria.

Possible results of every event use a probability function that can take a numerical value corresponding to the percentage chance of emergence of that outcome. Each of those possible results will reduce or increase the trust level of characters towards each other by a magnitude of change depending on the context of the event. For example, suppose characters are participating in a social gathering event. In that case, there is a 70% chance that everyone will have a good time and everyone gain trust towards each other (positive magnitude). However, there is also a 30% chance that participants will have an argument and because of that some lose trust towards others (negative magnitude). These magnitudes of change in trust (M) are incorporated within events to modify trust values between characters after each event. We will discuss magnitude value of M further in the next section. The aim is to by using this mechanic, interactions will become more dynamic, and events can take drastic twists. Some events may not have possible results or outcomes. Log of events will indicate the outcome of the event out of defined possible results. In other words, an outcome (O) is a possible result (P_R) of an event (E):

$$O = P_R(E)$$

To explain the construct of events in a more explicit way, let us look at table 3.2, which shows just three different events with their distinctive attributes. Note that some events like the ”Forging Will” can have no outcomes that would affect trust levels.

Name	Description	Roles	Prereqs.	Outcomes
Social Gathering	A small gathering to...	Attendees	MinMutualTrust = Coexist	70% Bonding, 30% Distrust
Forging Will	With trickery...	Forger	Motivation = Lucre	100% No Result
Cheating	Parties decide to secretly...	Cheaters	Motivation = Lust, MutualTrustMin = Befriend	80% Bonding, 20% Distrust

Table 3.2: Examples of Events Attributes

As described before, every event is constructed of a name, a description, roles, and then during the social simulation phase system will check if those roles pass the required prerequisites (either motivational, trust, or perception), and next it will compile outcomes with their trust change levels that is based on the logic describe in section 3.4. These outcomes are accompanied with a probability of occurring. The final prototype of *Whodunit* has a library of 50 different events that is editable with the possibility of more events added to it. It is also possible to have multiple libraries and select from each based on narrative needs. These libraries can be saved as Extensible Markup Language (XML) files.

3.4 Relationships

Forming relationships between characters rely on their initial trust and attitude values dictated by their attitudes and feelings scales. Implementing values of feeling and trust are to oversee what individual character ”thinks” about others and is essential to simulate characters’ life events because there has to be some form of variable that controls inter-character relationships, conflicts, and animosities. As we saw in 3.2, the difference between feeling and trust is that feeling is a static value that determines character’s general inclination towards trusting or not trusting other. In contrast, trust is a dynamic value that determines the actual value of trust.

Both internal values of trust and perception are based on perception scale however, the difference

between them is that perception is the way a character thinks about the other characters, and trust is how a character perceives herself. For example, perception regards ”I would be willing to befriend them” and trust regards to ”I expect they would be willing to befriend me”.

In order to compute the value of initial trust, a Boolean variable for 'Good First Impression'(GFI) is defined, which will return a random value of 0 or 1. Based on characters' base feelings, if they have lower values (<4), which means lower than average based on scale 3.2, and GFI = 1, they form a higher perception value towards the other characters. For example, if a character has feeling = Naive and GFI = 1, they will form a perception of 'Befriend' towards the other party and if GFI = 0, they will form a perception of 'Cooperate.' This logic applies to all feeling values lower than 'Average.' In contrast, with values of 'Guarded,' 'Defensive' or 'Paranoid,' regardless of the value of GFI, the perception will fall towards less than zero. Note that the final value of perception is the initial trust in this step. Moreover, characters' attitudes will play a role on how the initial trust is shaped. If the attitude = +1 or 'Pacification' and GFI = 1, then initial attitude value equals to perception value of zero (Coexist) or two (cooperate). Once again, regardless of value of GFI, if attitude = 0 or 'Reciprocation,' then initial attitude is equal to initial trust. As for attitude = -1 or 'Exploitation,' the initial attitude will fall at least to perception value of -2 or 'Dislike.'

Algorithm 1 Creating an Initial Relationship Part1

procedure $CreateRelationship(self, other, random)$

Define I_T and I_P of type Perception Scale

$GFI \leftarrow randomvalue$

switch $self.baseFeeling$ **do**

case Naive

if GFI=1 **then**

$I_T = Confide$

else

$I_T = Befriend$

case Laidback

if GFI = 1 **then**

$I_T = Befriend$

else

$I_T = Cooperate$

case Chill

if GFI=1 **then**

$I_T = Cooperate$

else

$I_T = Coexist$

case Average

if GFI=1 **then**

$I_T = Coexist$

else

$I_T = Dislike$

case Guarded

$I_T = Dislike$

Algorithm 2 Creating an Initial Relationship Part2

switch $self.baseAttitude$ **do**

case Pacification

if GFI=1 **then**

$I_P = Cooperate$

else

$I_T = Coexist$

case Reciprocation

$I_P = I_T$

case Exploitation

$I_P = Dislike$

$r = newRelationship(self, other, I_T, I_P)$

return r

After calculating the values mentioned above, we have a group of characters with a level of trust towards each other. This way it is possible to categorize them in a certain manner. This is when the process gets a bit arbitrary, and we require a ”hammer” to categorize relationships. Basically, for initial trust levels of 'Confide', characters are spouses, for 'Befriend' they are friends, for 'Cooperate' they are considered colleagues, for 'Coexist' they are considered family members and for 'Dislike' they are mere acquaintances and anything other is considered a rivalry to create more tension and drama between characters.

By the end of explained steps, we have a group of characters with defined attributes, motivations, initial relationships, and initial trust towards each other. As events emerge, these values will go through changes, and therefore characters trust levels will change. The mechanic of how these changes will occur is based on the logic described in section 3.2. As mentioned before, attitude value will affect the incline and decline level of trust throughout the emergence of events. Every event has an outcome that will determine the magnitude of change in trust values of character if any. As discussed before in section 3.3, magnitude of change in trust or M, is incorporated within events to modify trust values between characters after each event. This value can be positive or negative

based on the outcome of the event and whether characters gained or lost trust towards each other. Value of M is multiplied by the scale of changes in trust levels (SCT), which is the number indicating how many events it takes for trust level to change. This is in order to take gaps between trust levels in perception scale into consideration since this gap has not been defined mathematically; there has to be a value assigned to it in the code. Note that after every event, previous values for the rate of change for perception (RC_P) will change on a 3/4 slope while these values will be updated and will form new values for RC_P'. These values are computed after every event by:

$$RC_P{}' = \frac{((M * SCT)/F) * 3}{4} + RC_P \tag{1}$$

If M>1.

Else if M<0 then:

$$RC_P{}' = \frac{(M * SCT) * 3}{4} + RC_P \tag{2}$$

Where F is an integer value of the character's base feeling. These equations will be computed in case of character's attitude = Pacification to reduce the curb. Otherwise if character's attitude = Exploitation or Reciprocation, M will only be multiplied by SCT. As an example, let us take these three generated characters and their correspondent numeric values into consideration:

An Example for Characters Relationships		
Name	**Base Attitude**	**Base Feeling**
Hunter	Reciprocation = 0	Average = 4
Elena	Pacification = +1	Paranoid = 7
Charles	Exploitation = -1	Average = 4

Table 3.3: An Example for Characters Relationships

Suppose these characters have a personal argument, based on construction of this particular event. In that case, there is an eighty percent probability that a mistrust by magnitude of -1 between them will occur as an outcome. Let us assume that this outcome has been generated and SCT = 20. In this case, computations will be done based on M * SCT, and therefore, since Hunter and Charles's attitudes are not equal to pacification then their RC_P = -20 on a scale of 100 for both. However, because Elena's attitude is equal to pacification, her RC_P = -15 based on equation number two, clearly we can see that her trust towards others will drop slightly slower because of her positive

attitude.

All of these processes are done in order to guarantee that hostile characters with negative attitudes will be more inclined to form negative trust and perception regarding others. In contrast, peaceful characters will be less inclined to do so.

3.5 Means of Murder and Story Details

As discussed before, the means of murder is one of the pillars of any murder mystery. An object that the culprit used to commit the aggression towards the victim has narrative importance that can create a true link between the murder event and the culprit or a false one between an innocent suspect to the murder event. Means are generated randomly from a list containing nine of the most common murder weapons in fiction. This list includes knife, gunshot, axe, hammer, drugs, poison, suffocation, electric shock, heavy object impact.

In order to create more depth in the plot and add more intricate detail into it, the state of crime scene and a victim's secret will be generated as well from two separate lists. The probability of the chosen items are the same, and these items are loosely based on similar recurrent objects in murder mysteries in other mediums.

Even though generation of these items is random, they can be coherently connected to the events history log and characters personality or occupation during the narrativization process by the wizard. In other words, the connection between these items and characters' life events is emergent.

3.6 Simulation Process

First step of the social simulation process for creating the murder chronicle is the character generation. In this step, five different characters with attributes such as names, occupations, motivations, base feelings, attitudes, base perceptions, primary personality traits, and enjoyments will be generated. Now, the output includes a list of newly generated characters with all their distinctive attributes. This is the process within the character generator class that has been fully described in section 3.2.

Next step, initial relationships between characters will be formed. This process is based by

characters attributes of feeling, attitude, perception, and GFI. Based on the computations described in section 3.4, relationship generator class will generate initial relationships between the characters. After this step, in addition to the list of characters, the murder chronicle now includes the list of relationships between those characters.

After generating characters and their relationships, next step would be to generate events. This step is carried on by the event generator class that uses an event library. These processes has been explained in section 3.3. Characters will engage in events in groups or individually based on matching of their attributes to the prerequisites of the events. In other words, events prerequisites will dictate which characters can participate in them. These prerequisites consist of number of participants, directional or mutual trust levels, directional or mutual perception levels, and motivations. In simpler words, based on events prerequisites, characters will qualify to participates in those events. For example, some of these prerequisites are easier to pass, like the number of participants, and some are more particular, requiring a certain type of motivation or a defined trust level towards another participant character. Characters who match the prerequisites of events will engage in those events and fill the role(s) within those events.

Relationships of the characters will undergo changes based on the events results. As we described before in section 3.3, each event has a set of outcomes and based on probability of occurrence for those outcomes, a result would emerge that will change the trust levels of characters towards each other. These trust level changes are triggered by M values or the magnitude of change. The mechanics of how trust levels would change based on events outcomes has been described in the previous section. Because of this mechanic, characters will have different trust values towards each other after an event (unless that event has no outcome), depending on the result of that event. After generating multiple events, trust levels of one character will drop dramatically towards another or the mixture of trust drop with their motivation would lead them a murder. The simulation stops when the murder event occurs.

Processes of character generation, relationship generation, and events generation based on social simulation will provide the principal information for the murder chronicle. The last remaining artifacts are the means of murder and secrets of crime generated by the means generator class explained in 3.5. All of this generated information, including the list of characters, relationships, log

of events and their outcomes, means, victim's secret, and state of the crime scene, will be printed on the final output, the murder chronicle. With all these essential items, the chronicle of murder is complete, and it will contain all the necessary information about a murder mystery.

3.7 Curating Chronicles

Chronicle of murder is a raw output that requires some form of curating to prepare it for user interaction and an immersive narrative experience. Mainly, two gaps require to be filled. The gaps between contingent events that might need sequencing and the interaction system with the user-detective. The former is the act of curating the generated chronicle into narrative artifacts, and the latter is the act of interaction covered in 4.2.

The process of transforming the output chronicle into a narrative artifact that can be used for user interaction is carried on through narrativization and story sifting by the wizard. [27] Here is a piece of generated chronicle and its narrativization by the wizard:

CHARACTER: Victoria

Base Attitude: Exploitation

Base Feeling: Guarded

Motivation: Belonging

Occupation: Farmer

Primary Personality Trait: Talkative

Enjoys: Creation

RELATIONSHIPS:

Friend: George

Family Member: Evelyn

Cooperation: Dylan

Acquaintance: Mike

PLOT: Event: Career Cooperation, Description: They decide to involve in a cooperative arrangement regarding their careers. Could be a contract or a loan. Cooperatives: Dylan, Evelyn, Victoria, Mike

Event: Aggressive social interaction, Description: A heated discussion turns sour towards another person. Maybe a threat, yelling, accusation or even blackmailing. Attacker(s): Victoria, Mike Defender(s): Evelyn,

NARRATIVE ARTIFACT: Victoria is Evelyn's sister and has a friend named George and has a partner named Dylan. Victoria, Evelyn and Dylan recently started to have a career cooperation and through that they got to know someone named Mike. Victoria recently had an argument with Evelyn.

Chapter 4

Evaluation

4.1 Method

The defined goal of this project is that *Whodunit* system would be able to provide information for a murder mystery-based information game that uses PCG for a compelling storytelling experience. The quality of this goal is defined within hypotheses that need to be evaluated. These hypotheses are:

(1) *Whodunit* is able to generate necessary data for a coherent murder mystery narrative for a game of information in a way that narration of the sequence of events are clear, related, and that gradually reveals the mystery.

(2) *Whodunit* is capable of generating information for a believable cast of characters in the context of a murder mystery, which means that generated relationships and events reveal the motives and opportunities for characters.

(3) *Whodunit* can provide meaningful narrative experience so that solving the mystery is possible through investigation and interviews with characters.

(4) *Whodunit* can provide a generally engaging and entertaining narrative game experience that maintains narrative elements of surprise and suspense, in a way that is similar to a human-authored stories.

The *Wizard of Oz* technique will assist us in evaluating *Whodunit* as an information game narrative engine and will help the system interact with the user-detectives. In *Wizard of Oz* study method, participants believe that they are interacting with an automated computer system, while in fact they are interacting with another human operator, the Wizard. [9] There is a bias issue accompanied with using this method. Wizard's role will naturally embed the experience through the process of transmitting the generated data to the user. The wizard should stay loyal to the generated data, but some minor narrative improvisation is inevitable for the flow of the story narration. However, because this system does not have a fully developed user-interface, *Wizard of Oz* is still a proper evaluation choice to test the core generative aspects of the system and the quality of its generated information.

Play-test sessions take place online and through an online chat. Wizard will run the prototype program and will transmit the generated information to the participant via chat transcript. By doing this the participant will have the initial information about the generated murder crime. Along with this, participant will also receive a list of characters that are suspects of this murder with some information about these characters. Next, the participant will decide who they want to interview first. The Wizard will role play as that particular character using the information that the system has provided regarding that character. Interviewing different characters will continue, and user-detective can choose the order of characters to interview and when they are finished or when they want to switch the interviewee. At any point, user-detective can decide to solve the mystery by accusing one of the generated characters as the real culprit, and the Wizard will reveal if that guess was correct or not. The game ends at this point. Play-tests usually take around 50 to 75 minutes to finish, depending on how the user-detective would play and how many questions are being asked from the characters.

After the play-test, the participant will receive a questionnaire regarding their experience that surveys different qualities of the experience. In order to measure and validate the results of *Whodunit*'s play-tests, we used a 1-5 Likert scale questionnaire including six different questions corresponding to hypotheses stated in section 1.2. On this scale, 1 is the lowest score and 5 is the highest. Data gathered from the experiment uses six different generated stories with 17 different participants that all have been distributed evenly. Because of the relatively low number of participants and the fact that this Likert scale survey uses ordinal data, we use non-parametric method of one-sample

Wilcoxon signed ranked test [39] to validate the results and their relation to hypotheses.

Questions asked on the survey are as following:

(1) How would you rate general coherency of the generated plot based on relevancy and connection of events?

(2) How would you rate believability of generated characters based on their relationships, life events, motives, and opportunities?

(3) How would you rate the gameplay's balance between maintaining mystery versus providing a clear path to solving the mystery?

(4) How would you rate the element of suspense during investigation process, relative to other murder mysteries you might have experienced as books, series, films?

(5) How surprised were you by revelation of the real culprit?

(6) How would you describe your general experience with this system?

Question 1 related to hypothesis number 1, Question 2 relates to hypothesis number 2, and Question 3 relates to hypothesis number 3. Hypothesis number 4 has broken into three segments that each respectively relate to questions 4, 5, and 6.

4.2 Player Interaction and Emergent Narrative

As we discussed in chapter 3, output chronicles will be transformed into narrative artifacts of murder mysteries by the wizard in order to be presented to the user-detective. The user now can investigate the plot and events by investigating different characters who are suspects in the murder case. This is the core of emergent narrative phenomena in the experience as wizard and user interaction. Some stories that will emerge from the generated story volume artifact surrounding the chronicle. Following example shows an example of how the generated chronicle after its transformation into a narrative artifact by the wizard in section 3.7 can alter furthermore within the story volume through interaction with the user:

User: Hello Sean, what is your relationship with the deceased?

Wizard: He was my best friend, I'm very sad about what happened to him

User: When was the last time you saw him?

Wizard: We went canoeing together, that was a fun day. Until I heard the news.

User: Did you two often go out on the water?

Wizard: Not often

User: You went canoeing the day his body was found?

Wizard: No that was days before that.

This was just an example taken from a generated chronicle during one of the play-test sessions. This example only includes one character and his relationship with the deceased and a recent event that they both participated. Obviously, there are more characters involved in that case that have their relationships and life events, and the user can interact with all of them. Clearly, there are two players in this game experience and both wizard and the user are the players. However, the roles are different as the wizard curates the chronicle and presents it to the user (story of the crime or fabula). The user takes the role of detective and investigates the story; this is the story of detection or syuzhet. [3]

As we discussed before, the main point of interest here is the emergent narrative phenomena and how this phenomena transforms the narrative artifact as the story of crime within the user interaction to shape the story of detection. By reading the conversations above, we can also observe that both players perceive characters and their stories as somewhat real characters and actual events, which might indicate the immersion value that the system can offer to the players, specially to the user as the detective role.

4.3 Results and Analysis

Results for question 1 that refers to coherency of generated plot shows that majority of participants rated the coherency of generated plots as 5 and 4.

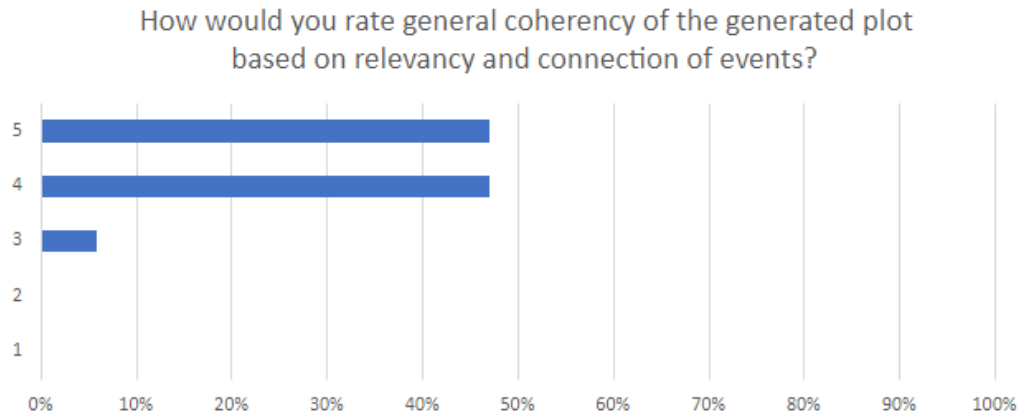

Figure 4.1: Percentage of responses about coherency of generated plots

According to the gathered data, overall median is 4 and mean is 4.41 where 47.1% of the participants answered 4, whereas another 47.1% of participants answered 5, and only 5.9% answered 3. (see figure 4.1)

Regarding believability of characters that is the subject of question 2, majority of participants (52.9%) responded 4 with overall median of 4 and mean of 3.94. Moreover, 23.9% of participants answered 5, 17.6% answered 3 and only 5.9% answered 2. (see figure 4.2)

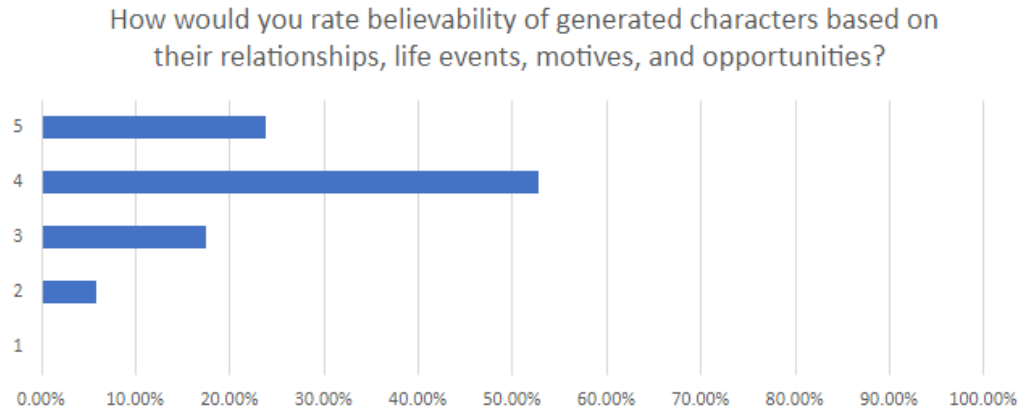

Figure 4.2: Percentage of responses about believability of characters life events

As for question 3, data shows that majority of participants (47.1%) rated 4, following 23.5% answering 3, 17.6% answering 2, and 11.8% rating 5. (see figure 4.3) Overall median for this question stands at 4 with mean of 3.52.

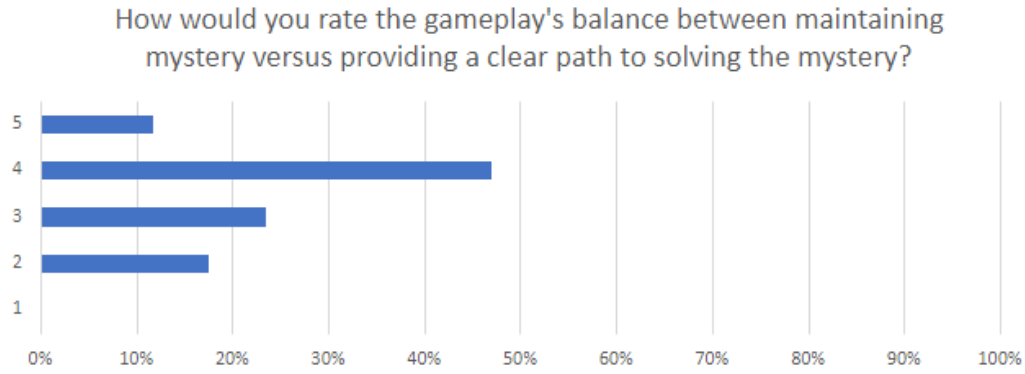

Figure 4.3: Percentage of responses about balance between maintaining mystery and showing a clear path for solving it

Question 4 that regards to element of suspense emerging from the generated plot has the overall median of 3 with mean of 3.29. In that regard, majority of participants responded 3 with 41.2%, following 35.3% which responded 4, and 17.6% rated 2. Only 5.9% rated 5. (see figure 4.4)

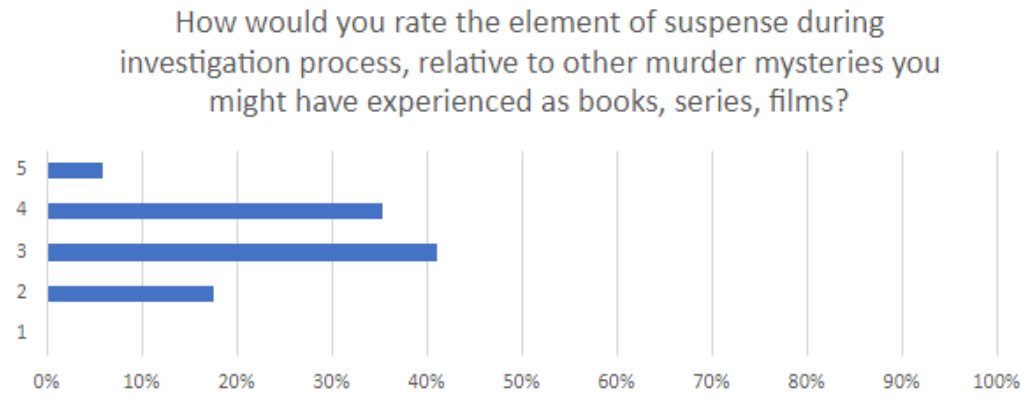

Figure 4.4: Percentage of responses about element of suspense during the investigation process

As for question number 5 which tries to measure users surprise by revelation of the culprit, majority of participants chose 2 with 47.1% of overall results, following by 35.3% who answered 3. Equal percentage of 5.9% of participants selected the other options. Overall median for this question stands at 2 with median of 2.58. (see figure 4.5)

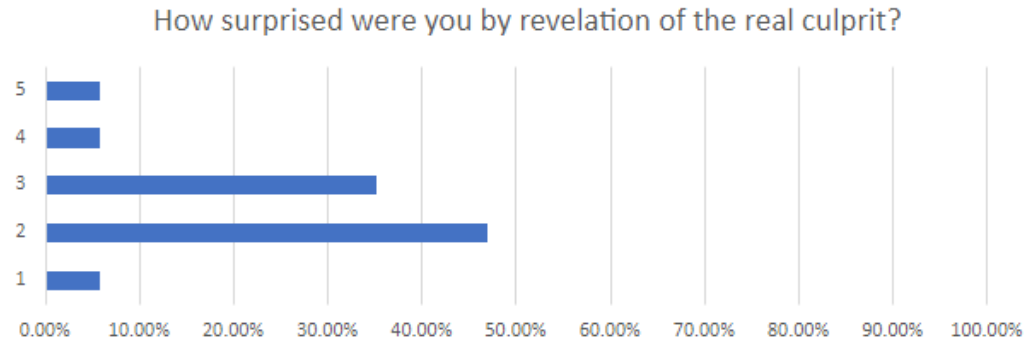

Figure 4.5: Percentage of responses about surprise after revelation of real culprit

For the final question and general experience of users, 64.7% have rated 5, 23.5% rated 3, and 11.8% have rated 4. Overall median for this question is 5 with mean of 4.41. (see figure 4.6)

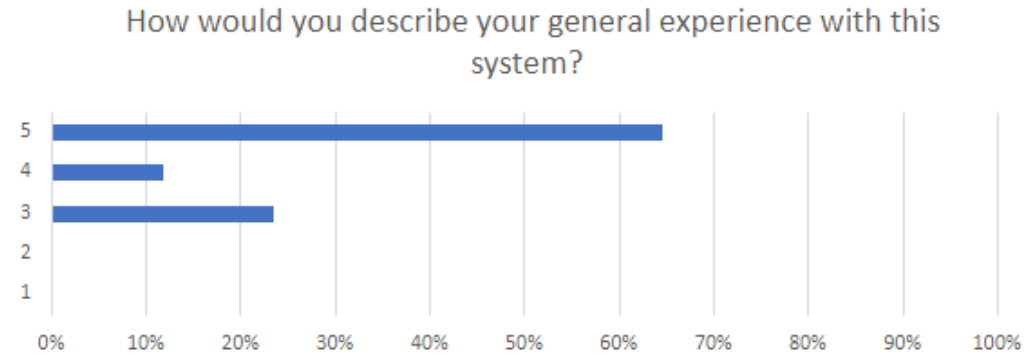

Figure 4.6: Percentage of responses about general experience with the system

For validating the results of each question and how do they corresponds to each research hypothesis, we use non-parametric method of one-sample Wilcoxon signed rank test.

For question 1, we assume the null hypothesis is that the median of responses is $\mu_0 < 3$ and alternative hypothesis is that the median is $\mu_A > 3$. After the validation test, we have discovered that the median is significantly different than 3, Z-score = 3.61, p-value ≈ 0.00029. Therefore, null hypothesis is incorrect and alternative is true. Meaning that Whodunit is able to generate necessary data for a coherent murder mystery narrative for a game of information in a way that narration of sequence of events are clear, related, and that gradually reveals the mystery.

As for question 2, null hypothesis is that the median of responses is $\mu_0 < 3$ and alternative hypothesis is that the median is $\mu_A > 3$. The validation test indicated that the median is significantly different than 3, Z-score = 3.08, p-value $\approx$ 0.002. Therefore, null hypothesis is incorrect and alternative is true. In other words, *Whodunit* is capable of generating information for a believable cast of characters in the context of a murder mystery. Meaning that generated relationships and events reveal the motives and opportunities for characters.

Regarding question 3, null hypothesis is that the median of responses is $\mu_0 < 3$ and alternative hypothesis is that the median will be $\mu_A > 3$. Validation test shows that the median is moderately different than 3, Z-score = 2.06, p-value $\approx$ 0.038. Therefore, null hypothesis is incorrect and alternative is true showing that *Whodunit* is capable of creating meaningful narrative experience in a way that solving the mystery is possible through investigation and interviews with characters.

Questions 4, 5, and 6 correspond to the hypothesis that *Whodunit* is able to provide a generally engaging and entertaining narrative game experience that maintains narrative elements of surprise and suspense, in a way that is similar to a human-authored stories. If we assume that the null hypothesis is that the median of responses is $\mu_0 < 3$ and the alternative hypothesis to be that the median is $\mu_A > 3$ for all three questions, then for question 4, the median is slightly different than 3, Z-score = 1.38, p $\approx$ 0.165. For question 5, median is moderately different than 3, Z-score = -1.65, p-value $\approx$ 0.097. Finally, for question 6, the median is significantly different than 3, Z-score = 3.41, p-value $\approx$ 0.00062. Based on these results, it is unclear that if null hypothesis for question number 4 is wrong, whereas for question 5, the alternative is false and null hypothesis is true. Results for question number 6 indicate that the null hypothesis is wrong and the alternative is true. In other terms, *Whodunit* is able to provide a generally engaging and entertaining narrative game experience with unclear indication that it can maintain narrative element of suspense, and it can not fully provide the element of surprise, in a way that is similar to human-authored stories.

As explained above using statistical numbers, all the research hypotheses passed the experimental procedures except one hypothesis that regards to the element of surprise after revealing the identity of the real culprit to the user. This hypothesis failed to reach statistical hypothesized median thus could not reach the desired result.

In addition, there are more observations about the details of the tests that will reveal more

insights on how the system performs and how the users engage with it that will be discussed on the next section.

4.4 Discussion

As described in the previous section, the general experience of participants' interactions with the system was very positive. Most of them indicated that their experience was very interesting and engaging. However, it is important to identify the details of these experiences with more in-depth observations to discover the individual aspects of the system that were more successful in creating an overall engaging experience and the weaker chains in the systems. Therefore, we will review some of these more detailed observations, ideas, and opinions from participants about the experience. We will categorize these observations based on their relations to the hypotheses and investigate in what ways the system was able to deliver coherency of plot, believability of characters, plot twists, suspense, and surprise.

One obvious consideration that has to be taken into account is the variation of opinions and experiences between players and the fact that each generated story might create different levels of intrigue.

There is a possibility of ambiguity in data between evaluating the generated information and the interactive experience with a wizard. Obviously, interaction with a wizard embeds the performance of the generated content and information by the system. The wizard must try to convey the generated information and stay close to the system's narrative. However, due to various reasons, including the type of questions that user-detective might ask or the innate drive of humans for storytelling in an emergent narrative environment, it is likely that the wizard might have to sometimes improvise the responses within the scope of the generated information.

There is a possible bias within the experiments results because the wizard's role was conducted by myself and therefore, my knowledge of the system could affect the interactions in the experiments to lead to more plausible results. Also, because some participants were acquaintances of mine, they might have overrated the system due to that relationship. A solution to overcome this bias would have been to present two different sets of results to the participants, one created by the system,

and one written by a human storyteller to see the comparison between two different sets of stories. Unfortunately due to COVID pandemic, it was very difficult to find a wide range of people to participate in this research in general, not to mention to double that size to conduct a new experiment with two separate groups.

We hypothesized the quality of coherency for generated stories as relevancy and connection of events. Based on this definition and the fact that the statistical data indicated that the system is able to provide coherent stories, some players' individual opinions also validate this hypothesis. Most participants described their experience as "engaging and enjoyable", "coherent", with "believable" cast of characters and responses. Both written responses and gathered data from questionnaire suggest that generated stories and their characters were rich and believable that had a logical connection and coherency between events. This is a result of both generator system working well to create a compelling group of characters and the chronicle of murder along with power of narrative creation of humans in both roles of wizard and user-detective. This made the experience in a way that the system did not feel "artificially" limited, as described by one of the participants.

Moreover, some participants opinions suggest that the story "felt" realistic because of very logical connection of events; therefore, the world created by the system did not seem very mysterious or full of "twists". This similar opinion is not very common but has been described by some participants in various ways. Of course, some stories might lean towards a more mysterious side with more plot twists than the others. With regards to that, perhaps the overall take from this phenomenon is that a very logical and clear path between characters and events might have had the downside of not manifesting many mysteries, which might have led to most participants not feeling surprised by the revelation of the identity of the real culprit as explained on the previous section.

The fact that user-detectives must interview characters through life events and personal relationships has made some participants curious about what type of questions they can ask from characters. Frankly, this emphasizes on how to ask the "right" questions which leads to how well someone can solve the mystery and find the culprit in return. Some participants tried to pressure certain characters and imply that they were the actual culprit, so those characters would be forced to contradict themselves, lie, or accuse someone else. This method could lead to a faster resolution to the story. In addition, if some characters divert the focus to others or lie, it might add to the realism aspect of

the story and create more suspense, which was an initial goal of the system.

A few participants criticized that they expected to have access to other types of information than characters' life events. Even though information about the state of crime scene, murder weapon, and characters secrets have been generated and distributed to user-detectives, these particular participants expected the system to provide a different and wider variety of access to these types of information on top of what was the system was offering to them. This brings us to the next point of criticism which was the initial limitation of this project, and the lack visual aspects. A few other participants indicated that they would prefer some visual features, which can also solve the previous issue by giving a view of the crime scene. This feature can be a future goal for improvements on this project.

Chapter 5

Conclusions

The goal of this research was to model, implement, and evaluate a system capable of creating a procedurally generated narrative for a murder mystery experience. This system has aimed to provide coherent narrative information to the player and a believable cast of characters so that it can create feelings of suspense and surprise encapsulated in a compelling narrative experience for players.

After modeling the system based on conventions of classical murder mysteries, we were able to implement a narrative engine capable of procedurally generating characters, stories, and other information needed for a murder mystery narrative, while considering the constraints of coherency, believability, suspense, surprise, and general appeal. After design and implementation, to evaluate the system's quality on reaching its goals, we developed an experiment using online play-tests and *Wizard of Oz* technique as the method. Players were handed out a survey containing questions related to this research's hypotheses. We gathered user inputs to the survey after each play-test session, and these statistical data was validated using one-sample Wilcoxon signed ranked test. Based on gathered data, we have discovered that *Whodunit* is able to create coherent narrative experiences with a believable cast of characters in a way that it sometimes can promote the feeling of suspense with a compelling narrative experience, but it was not able to create the feeling of surprise on the revelation of the culprit for most users.

As part of future works to improve the prototype made for this research, one of the objectives could be to offer more visual aspects to the users to promote immersion. As an effort to increase feelings of surprise for users from generated plots, one method is to add more elements that are

considered less realistic to the event templates list that the generator uses. This way the generated plots might contain more unpredictable story arcs. However, it is possible that this method would affect coherency and relevancy of events.

To provide a modular approach for designers and authors in an attempt to create author-friendliness [17], another future objective is to create a feature for authors to save different lists of events that the generator uses as templates without needing to code.

Whodunit proved to be a reliable narrative engine that can support a game of information based on murder mysteries with the potential to be expanded to support other kinds of mysteries and story narratives for video games.

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Appendix A

A.1 List of Enumerates

This section contains enumerates used in character generator.

List of motivations: Adventure, Control, Lucre, Love, Lust, Loathing, Acceptance, Fear, Sense of Belonging, Respect.

List of occupations: Baker, Butcher, Farmer, Doctor, Truck Driver, Priest, Lumberjack, Fisher, Bartender, Waiter, Postman, Artist, Manager, Construction Worker, Blacksmith, Chef, Herbalist, Mechanic.

List of primary personality traits: Enthusiastic, Silent, Talkative, Awkward, Friendly, Neurotic, Kindness, Impulsive, Selfish, Untrustworthy, Reliable, Careless, Intellectual, Anxious.

List of enjoyments: Affection, Novelty, Adventure, Fear, Duties, Challenge, Prestigious Status, Collecting, Creation, Competition, Collaboration, Art, Nature.

List for state of crime scene: revenge note found, cryptic notes found, victim clothes torn apart, pieces of glass found, victim crucified, victim butchered, burning marks on victim's body, stabbing wounds on victim's body, drugs found in autopsy of victim, body dropped in a lake.

The list for victim's secret: family feud, shameful habit, history of aggression and violence, drug habit, financial feud.

Appendix B

This appendix includes a log and chat transcript of one of the play-tests and its generated story.

B.1 Generated Output Log and Murder Chronicle

Characters:

Dylan:

Base Attitude: Exploitation, Base Feeling: Average, Motivation: Lucre, Occupation: Lumberjack, Primary Personality Trait: Reliable, Enjoys: Competition

George:

Base Attitude: Pacification, Base Feeling: Guarded, Motivation: Sense of Belonging, Occupation: Waiter, Primary Personality Trait: Impulsive, Enjoys: Fear

Mike:

Base Attitude: Exploitation, Base Feeling: Average, Motivation: Loathing, Occupation: Manager, Primary Personality Trait: Kindness, Enjoys: Creation

Victoria:

Base Attitude: Exploitation, Base Feeling: Guarded, Motivation: Sense of Belonging, Occupation: Farmer, Primary Personality Trait: Talkative, Enjoys: Creation

Evelyn:

Base Attitude: Exploitation, Base Feeling: Average, Motivation: Respect, Occupation: Butcher, Primary Personality Trait: Neurotic, Enjoys: Challenge

Relationships:

Dylan:

Best Friend: Mike

Friend: Victoria

Cooperation: Evelyn

George:

Friend: Victoria, Evelyn

Rival: Mike

Mike:

Friend: Victoria

Best Friend: Dylan

Spouse: Evelyn

Victoria:

Family Member: Evelyn

Spouse: Mike

Cooperation: Dylan

Evelyn:

Family Member: Victoria

Friend: George

Plot: Event:

Event: Receiving inheritance, Description: People involved have received a good amount of money on inheritance. Receiver(s): Evelyn, Victoria

Giver: Unknown

Event: Romantic Rejection, Description: A heartbreak because of romantic rejection. Party Rejecting: Evelyn

Party Being Rejected: George

Event: Career Cooperation, Description: They decide to involve in a cooperative arrangement regarding their careers. Could be a contract or a loan. Cooperatives: Dylan, Evelyn, Victoria, Mike

Event: Unrequited love, Description: A love interest that has not been reciprocated.

Rejected: Evelyn Target: Mike

Event: Initiating Romantic Relationship, Description: Parties decide to date each other and pursue a romantic relationship.

Parties: Victoria, Mike

Event: Holding Grudge, Description: Because of some unpleasant past experiences, a feeling of grudge grows between them. Jealous: Evelyn, Towards: Victoria,

Event: Holding Grudge, Description: Because of some unpleasant past experiences, a feeling of grudge grows between them. Jealous: Evelyn, Towards: Mike,

Event: Career Deception, Description: Parties plan a treacherous act related to their work. Maybe to deceive other coworkers. Deceivers: Mike, Dylan

Event: Social Gathering, Description: A small gathering between people to enjoy a cup of coffee and maybe discuss some matters. Attendee(s): Evelyn, Victoria,

Event: Secret Reveal, Description: A person finds out about a secret regarding some other person. Revealer: Evelyn

Secret holder: Dylan

Event: Going to Bar, Description: Going to bar to enjoy a drink and forget problems.

Drinker: George

Event: Murderous Aggression, Description: Thou shall not kill, but not this time. A murderous strike emerges. Attacker(s): Mike,

Defender(s): Evelyn,

Location: cabin in the woods

Others locations: Dylan at cabin in the woods

Victoria at home

George at bar

Event: Secret Reveal, Description: A person finds out about a secret regarding some other person. Revealer: George

Secret holder: Mike

Event: Murderous Aggression, Description: Thou shall not kill, but not this time. A murderous strike emerges. Attacker(s): Dylan,

Defender(s): George,

Location: cabin in the woods

Others locations: Mike at cabin in the woods

Victoria at home

Means and Secrets: Weapon of Murder: Gunshot

State of Crime Scene: Body dropped in a lake

Characters secrets: History of Aggression and Violence

B.2 Summary of Curated Narrative Artifact Text

Victoria is Evelyn's sister, has a friend from high school named George and has a spouse named Dylan. Evelyn had a crush on Dylan but Dylan decided to pursue a relationship with Victoria instead and that made Evelyn hold a grudge against her sister. George had a crush on Evelyn since high school but she always rejected her. Some time later, Victoria, Evelyn, Dylan, and Mike who is a friend of Dylan's started to have a career cooperation because of the wealth that Victoria and Evelyn have inherited. Evelyn found out about a secret agreement between Dylan and Mike in order to go behind her and her sister. She told Victoria about it but she did not believe it. Evelyn confronted Dylan and Mike in their cabin and Mike murdered her in order to make her silent. George witnessed this and confronted them but Dylan killed him too.

B.3 Test Chat Transcript

Ok detective. Two bodies have been found in lake, one of victim's name is Evelyn and another is George and there's evidence of gunshot for both. Current suspect names are: Mike, Victoria, and Dylan. Which one would you like to interview first? It seems like that they've been shot by two different guns

User-Detective: ok, lets go in alphabetical order. Dylan

Wizard: Alright Dylan is here. Hello detective!

User-Detective: hi there. how are you feeling?

Wizard: Not bad, thanks for asking.

User-Detective: what is your relationship to the deceased?

Wizard: Which one?

User-Detective: Evelyn.

Wizard: She was my coworker and a friend from high school, We worked in a wood workshop together, along with her sister Victoria.

User-Detective: you were not very close friends I guess.

Wizard: Not that much.

User-Detective: how old are you?

Wizard: I'm 32. So basically Evelyn and her sister were interested in investing in our shop before and we were in dire need of money so we agreed on sharing ownership.

User-Detective: who is the owner of the shop?

Wizard: It used to be just me and my friend Mike but after their investment, we share it with Evelyn and Victoria as well.

User-Detective: so they did invest. how much?

Wizard: Quite a lot. they inherited a lot of family money and Victoria urged her sister to invest on that shop.

User-Detective: what is your relationship to Victoria?

Wizard: She's just a coworker and also she's married to Mike

User-Detective: is the shop going better now with the investment?

Wizard: Yeah we managed to buy some equipment that we were missing, getting more material, etc.

User-Detective: ok, thanks for now.

Wizard: no problem!

User-Detective: I would like to talk to Victoria.

Wizard: ok Victoria is here. Hello!

User-Detective: hey, how are you feeling?

Wizard: Not good, detective. I'm very sad because of my sister.

User-Detective: sorry to hear.

you have lost a lot of family lately, right?

Wizard: Just my sister recently, one of my uncles passed away a year ago.

User-Detective : is he the one who left you the money you invested in the shop?

Wizard: Yes, he had no kids so he gave all his money to me and my sister.

User-Detective: how long have you been working at the shop?

Wizard: It's been around three months since we started investing and working there I urged my sister to join me on this because I thought she needed it but it was not an easy decision for her.

User-Detective: How come?

Wizard: We had a turbulent relationship.

User-Detective: Tell me more!

Wizard: Specially considering that Mike was a co-owner of that shop.

User-Detective: did she have a past with mike?

Wizard: So Evelyn liked Mike since high school but Mike was not into her and instead we started going out and got married. Evelyn was furious about that and even though we tried to work on our relationship, she always held a grudge against me.

User-Detective: How did you end up convincing her to invest?

Wizard: Because she didn't know what to do with the money and she was not working either

User-Detective: how did she make a living before? and what did you do?

Wizard: Evelyn used to work in the butcher shop and I used to help my uncle at the farm.

She had problem sticking to jobs, I thought maybe this will be good for her.

User-Detective: I see. thank you.

Did you know George as well?

Wizard: Yeah he as also a friend of mine from high school days.

He used to have a huge crush on Evelyn.

User-Detective: I guess Evelyn didn't like him?

Wizard: I think so, she was more interested in Mike

I don't think she ever got over that

User-Detective: where did George work? was he involved with the shop?

Wizard : No he was a waiter at a restaurant in town.

User-Detective: were you close with George?

Wizard: Not really but we were still friends.

Sad to see him go too.

User-Detective: ok, thank you.

could I talk to Dylan again?

Wizard: Yes

Dylan is back!

User-Detective: I forgot to ask you about George. how did you know him?

Wizard: I don't know him that well.

I just know that he was friends with Victoria.

User-Detective: not with Evelyn?

Wizard: There were rumors that he was in love with Evelyn.

User-Detective: how was George's relationship with Mike?

Wizard: Same thing.

Saw him couple of times,

He was a weird dude.

User-Detective: Dylan, what did George do the day after Evelyn died? did he come to the shop?

Wizard: No he came near Mike's cabin where we were hanging out.

User-Detective: who was at the cabin?

Wizard: Just me and Mike, we go there a lot.

User-Detective: what did George say at the cabin?

Wizard: He was angry and sad about Evelyn's passing but he was crazy.

He thought we did something to her, nonsense!

User-Detective: you two? or one of you?

Wizard: Both of us.

User-Detective: why would he think that? what motive would you have had?

Wizard: Nothing, he had no proof. Just saying he saw something, he saw a lot of thing, He was crazy anyways.

User-Detective: what did he see?

Wizard: He said that he saw shadows at the night near the shore I think he was just imagining things.

User-Detective: ok, thanks. lets talk to Mike.

Wizard: ok Mike is here.

User-Detective: hi. how are you feeling?

Wizard: I'm okay, thanks for asking.

User-Detective were you close to Evelyn?

Wizard: I mean she was my wife's sister. She expressed her feeling couple of times when we were younger but I was not interested. I think she held a grudge against her sister because of what happened between us. She always was a bit neurotic.

User-Detective: you don't seem to have a good opinion of her, yet you accepted her investment and started working with her.

Wizard: I was skeptic of accepting that offer but we needed money.

User-Detective: what did you do the day after Evelyn died?

Wizard: I didn't hear about that till today. I was hanging out with Dylan at the cabin.

User-Detective: did anyone come by the cabin?

Wizard: That crazy dude, George showed up, Talking nonsense.

User-Detective: what did he want/say?

Wizard: He was angry at us, talking nonsense and accusing us I think he was the one who killed Evelyn, Crime of passion.

User-Detective: what did you do on the day Evelyn died?

Wizard: I was working at the shop and then went to the cabin. It's near water and we fish there with Dylan.

User-Detective: and how did you learn Evelyn was dead?

Wizard: I heard the news today.

User-Detective: ok, thanks could i talk to Victoria again?

Wizard: Sure, She's here.

User-Detective: I would like to know what you did on the day Evelyn died and the day after.

Wizard: So on the day I was talking with Evelyn at the shop and she was very stressed. She was talking to me about a conspiracy that Dylan and Mike are planning to steal our money, But she was always a paranoid person so I didn't take that seriously.

User-Detective: why would they steal it? you already invested.

Wizard: She was saying that they want us and specially her out of the agreement But she had no proof, she just said that she heard things.

User-Detective: did you leave her alone in the shop that night?

Wizard: She said she's gonna stay a bit longer.

User-Detective: where were Mike and Dylan?

Wizard: They went to their precious cabin after work.

User-Detective: how far is the cabin?

Wizard: Not that far maybe 15 minutes drive, this is a small town.

User-Detective: how far is the lake from the shop / cabin?

Wizard: Cabin is close to the water but shop is quite farther from that.

User-Detective: what did you do the day after Evelyn died?

Wizard: I went to work but she wasn't there and Dylan told me that she called and said that she's sick.

User-Detective: did he say this over the phone? what time?

Wizard: In person, at the morning when I arrived.

User-Detective: didn't he stay at the cabin the next day?

Wizard: I think so.

User-Detective: so you went to the cabin too?

Wizard: No I went home, Wanted to check on Evelyn but she wasn't home.

User-Detective: so where did you meet Dylan in person if he was at the cabin?

Wizard: He went to cabin afterwards, after work. I talked to him at work.

User-Detective ok. thanks. User-Detective: i suspect the guys did both murder. which guy did which or if it was the same guy who did both, i do not know.

Wizard: Yeah Mike killed Evelyn and George saw them so he went to the cabin and Dylan killed George.

Appendix C

This appendix includes the raw data gathered from the survey.

C.1 Questionnaire

- **Q1:** How would you rate general coherency of the generated plot based on relevancy and connection of events?

- **Q2:** How would you rate believability of generated characters based on their relationships, life events, motives, and opportunities?

- **Q3:** How would you rate the gameplay's balance between maintaining mystery versus providing a clear path to solving the mystery?

- **Q4:** How would you rate the element of suspense during investigation process, relative to other murder mysteries you might have experienced as books, series, films?

- **Q5:** How surprised were you by revelation of the real culprit?

- **Q6:** How would you describe your general experience with this system?

- **Q7:** If interested, please describe details of your general experience with this system.

C.2 Quantitative Data

This section includes the raw data from responses to questions 1 to 6.

C.3 Qualitative Data

This section includes the responses to the optional question 7.

Participant 2: Pretty engaging and enjoyable. I was surprised by the logical relationship between characters and the motive of the murderer.

Participant 3: I found the game's painting of a classic murder mystery to work quite well. While I would look into moving away from old tropes and stereotypes - The game could be improved by twisting and moving away from past expectations to think through the narratives and character backstories. The story itself was believable enough, and did generate intrigue in me as a player.

Participant	Q1	Q2	Q3	Q4	Q5	Q6
1	4	3	4	3	2	5
2	5	5	5	4	2	5
3	4	3	2	3	3	3
4	5	4	3	2	2	5
5	4	3	3	3	4	3
6	4	4	4	3	3	5
7	4	5	2	4	2	5
8	5	4	4	3	2	4
9	3	2	2	4	5	3
10	5	5	3	2	1	3
11	4	4	3	2	3	5
12	5	4	5	3	2	5
13	4	4	4	5	3	5
14	5	4	4	3	2	5
15	5	5	4	4	3	5
16	4	4	4	4	2	4
17	5	4	4	4	3	5

Participant 4: I have too many thing to say but let me try to at least get a couple down while fresh:

- I'm unclear on how interesting the system would be right now for a non-designer - could be very, could be less so, but as someone interested in how these things would I was very, very curious about the underlying system just as much as the narrative layer I was seeing it though.
- The story ended up being kind of "obvious" in that the creepiest person who the most people thought could have done it... did it. Plus it was the spouse which in terms of actual detective work is almost always the person. BUT I kind of like that realism... it makes it less compelling as a mystery, but in a way more interesting/enjoyable as a piece of verite? Like, I don't always want an amazing twist.
- I found it hard to extract the things that seemed like they would be most juicy, like how my victim was electrocuted or the true nature of the cult in the background, leaving me to construct those things in my head. Which is also: GOOD. It's more realistic... nobody in an investigation has complete information and most people know nothing except the murderer, so you'd essentially expect most people to not know much and the murderer(s) to lie to you.

- I assumed that my main job would be (aka Phoenix Wright!) to find contradictions in people's stories, but that didn't really happen in my case and I'm not sure if it should have (if so I might have needed guidance to ask the right sorts of categories of questions). Again, though, I find that pretty much find... the play ended up being more getting a kind of character evaluation of everyone and basic relationships and alibis (though nobody had a useful alibi). I absolutely did NOT learn enough through this to legitimately arrest someone without some physical evidence, but certainly a picture was painted that led to only one person.

- That said, and as I said, I was semi-disappointed it was the obvious choice. In an Agatha Christie or similar it would definitely NOT be that person, or they would be exonerated a bit later, only to turn out to REALLY BE THE MURDERER even later. That is, there would be a twist, but there was no twist involved. Again, that's more in line with what I'd imagine is true of real cases... the world isn't very twisty.

- I felt a bit hamstrung not know more about the crime-scene... if there's a weakness it's probably that. Could the crime scene be a "character" who knows certain things and wouldn't lie to me about them? It's the one obvious chance to find contradictions - I kept hoping, for example, that someone would show they knew something they shouldn't, but there wasn't much to go on (the electrocution angle was my big hope, and I could fit it into the cult narrative, but nobody accidentally said they knew about it). In short, it would be great to feel armed with a bit more contextual information before asking questions, as essentially you have no ground truth since you can imagine that EVERYONE may be lying to you for one reason or another.

Participant 5: I really enjoyed the more personal aspect of this game. It allowed for interesting questions and responses. As always with these types of generated things, some tidying up here and there by an actual human always helps, but it ran smoothly enough to begin with.

Participant 6: I'll explain why I had some hiccups and my reasoning for each question that is not at 5.

I felt that the generated plot was regularly coherent and engaging. However, I did feel like sometimes valuable information was given out of the blue. I would ask a question that I judge simple and would receive more than I asked for (See when I talk to Grant and he mentions the

painting).

The story took some time before it hooks me. The mention of the cult sent me on a quest to find who might be associated with them. But before that, I was lost as to what I should do, which I guess is part of the experience.

Once I knew who was a cult member, I was sure it was between them. All I had to do was see if one of them would accuse the other to save their skin. Because of this, it didn't surprise me that much.

I feel like the characters did their job and were adequate. However, it was troublesome to differentiate them, only a name and pieces of information about them. If characters had a way to speak, different manners, or emotions when they talk, it would flesh them out more and help the player tell them apart.

Participant 7: The connection between the subjects and perpetrator's was well tailored and the characters were carrying enough baggage and clues to fulfill the plot.

Participant 8: Good system, don't feel "artificially" limited by it, feels like I can ask the suspects any questions and they will answer. Perhaps an intro to the suspects (how they were found, etc) + known facts of the case would be a nice addition.

Participant 9: I enjoyed it partly because I knew it was being generated. The responses seemed believable and coherent. I would have liked the option of asking for police report type information at different points e.g. autopsy result, day and time of murder etc. Perhaps I could have a limit of 3 or 4 questions and ask them when I wanted? (I guess that might mean I would ask them all at the beginning - or not.)

Participant 10: Interacting with it through chat was the downfall of the experience. I am very visual, so not having anything to see made it hard for me to stay engaged. but the story was super good. the world seemed very rich and the characters very real and their connections deep and complicated. i think the content itself is great, but it needs a cool UI.

Participant 13: I'd love to have access to other types of information to be more immersive.

Participant 15: This was a fun mystery! I was surprised by the amount of detail there was in the characters' backgrounds since there always seemed to be an answer to the questions I was asking. The plot was very coherent and I was able to clearly understand the timeline of events

that the characters were describing. I liked the twist that one of the victims was also one of the murderers! A great experience overall.

Participant 16: It was exciting! the clue to the mystery came quite late in the process but perhaps this was to create more suspense. I suppose I was a bit hesitant about what kind of questions I could ask and the extent to which I could ask questions like ”do you think x could have murdered y”. But over all a fun experience!

Participant 17: It was really engaging! I had to remind myself it was being auto-generated at a few points. There were several possible motivations and the like which made my mind race.