Planning a Story: Tracking Player Choices to Determine Player Preference

A thesis submitted for the degree
of Honours in Software Engineering of
the Australian National University

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October 21, 2015

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university. To the best of the author's knowledge and belief, it contains no material previously published or written by another person, except where due reference is made in the text.

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Summary of Thesis

This paper aims to prove and quantify a link between the actions of a player in an interactive narrative and their preferences for narrative content. It uses existing theories in narrative design, narrative generation and behavioural psychology to design, build and evaluate a system of interactive fiction that generates varying narrative content based on a player's actions. The proposed system uses a modified version of Bailey's Reader-Based Model that implements interactive elements and Reiss' Theory of Sixteen Motivators to select different content based on predicted player preferences. A web-based implementation of the prototype was created, and the results from a preliminary study using the prototype show positive but inconclusive results. Further development of the prototype and additional studies are required to successfully prove or refute this hypothesis.

Acknowledgements

I would like to thank all of the people who helped and supported me with this research project.

First and foremost, I need to thank my project supervisor, Patrik Haslum, for giving me the opportunity complete this project, as well as helping and guiding me along the entire process. His foundation of knowledge and practical experience made this research possible. This project is as much his work as it is mine.

I would also like to thank Henry Gardner, for providing insight into HCI tests and participant studies, as well as constant encouragement and enthusiasm for my project.

My thanks also to John Slaney, Shayne Flint, the rest of the ANU CSIT staff, and the ANU as a whole, for providing facilities and the opportunity to conduct this research

My gratitude also goes out to my immediate family, for their support and proofreading throughout the year, but especially in those last few days.

Finally, I would like to thank all of the people who participated the study component of this project. The time you donated by participating gave this research merit beyond what I could have achieved alone.

Chapter 1

Introduction

Narrative as a form of entertainment or instruction has always been a part of human culture, and the most important character in every narrative is the storyteller themselves. An important part of oral narrative discourse is the way that the storyteller can react to the audience responses, and tailor the content accordingly. However, with the mass production of narratives, via books, film, and more recently, video games, the potential for this immediate interaction has been reduced. The static nature of these media means that the opportunity for an author to change the content of their narrative while the reader is consuming it has been removed entirely. Improvements in software capabilities have, however, allowed for interactive narrative media to become more advanced. Systems that use software as a storyteller to create dynamic and personal narratives have become successful as both technology and design concepts improve.

Narrative generation (the creation of narrative without the direct input of a human author) uses software to great effect in creating a significant number of different variations around a central narrative. The process of determining the quality of a generated narrative variation is difficult, however, as the various elements that define what makes a narrative 'good' are often personal and always complex. The variations generated may make logical sense, but as they lack typical narrative elements like conflict and focussed character development they are more akin to lists of sequential events, rather than a coherent narrative.

A process that incorporates these narrative elements in its generation improves the overall quality of the variations produced. Furthermore, interactive fiction can build on this concept by integrating player actions. By interpreting a player's actions, it may be possible to tailor the narrative generation process to create content specifically for that player. This would result in more interesting, relevant and dynamic narrative content for each player.

This paper hypothesises that a player's actions can be used to understand their preferences for different types of narrative content. The prototype of an interactive fiction game is outlined, as well as an overview of the study of volunteer participants. The results of this study are then used to test both the core hypotheses and the validity of the game prototype more generally.

Section 2 of this paper outlines a variety of background concepts and related works, including narrative theory, a classification of the types of interactive fiction, narrative generation concepts and psychological theories.

Section 3 covers the interactive fiction prototype and subsequent testing of the hypothesis that a player's actions can be used to determine the narrative content they would prefer.

Section 4 contains analysis of the results with conclusions about the main hypothesis, the quality of the prototype and the merit of the study.

Chapter 2

Background Material and Related Work

This section will provide a discussion and analysis of various relevant background materials.

Section 2.1 will cover both the features of traditional narrative design, and the way that these theories are applied to interactive fiction specifically. An examination of Bruner's theory of narrative features, as well as the distinction between *Syuzhet* (medium) and *Fabula* (content), are vital in further discussions in the paper. Szilas' categorisation of the styles of interactive fiction provides an understanding of the field as it currently exists, the issues of the styles and how these styles can evolve.

Section 2.2 discusses the ways that narrative generation is used to create the Fabula of a narrative. Building on Szilas' styles of interactive fiction, a discussion of the way that simulated and structured generation aligns with Bruner's narrative features provides insight into how structured narrative generation can be improved upon. The core concept of Bailey's Reader-Based Modelling is also introduced.

Section 2.3 compares and contrasts the different motivational theories of Maslow, Alderfer and Reiss in relation to their usefulness for this prototype. Maslow attempts to generalise motivations to only seven unique tiered components, leading to and leaning on each other. Alderfer, building on Maslow's theories, reduces the number of motivations to only three, in an attempt to minimise overlap even further. Reiss, on the other hand, presents sixteen unique motivators that can be used both to define an action, and also a person. The functionality that Reiss' theory allows for in the prototype's implementation makes it the best theory for this project.

2.1 Narrative Design

The study of narratives has long been a focus of those who wish to build better and more successful stories. Since a major component of a narrative is the medium in which it is presented, generalising the core of what a narrative is has been difficult to disentangle from the medium in which it occurs. A group of literary theorists known as the *Russion Formalists* split narrative into two distinct areas: *Syuzhet*, the way that the narrative is told, and *Fabula*, the events of the narrative (*Behler*, 2001). This theory remains influential to literary study to this day.

2.1.1 Bruner's Features of Narrative

Narratives in interactive fiction have so far been relatively confined. When considering the application of narrative design into what is, in many ways, an entirely new medium, it is important to return to narrative as a more basic concept. Therefore, instead of examining specific cases of narrative implementation in particular media, we need to define a more abstract narrative construct. This paper will use the theories of Bruner (1991). Bruner's theories, outlined in his 1991 paper *The Narrative Construction of Reality*, rationalise narrative into ten distinct features, each of which is integral to the creation of narrative. These ten features are:

1. *Narrative Diachronicity*: a narrative occurs over time.
2. *Particularity*: a narrative is made up of events.
3. *Intentional State Entailment*: a narrative includes characters that make intentional actions.
4. *Hermeneutic Composability*: a narrative is created to be interpreted by the reader.
5. *Canonicity and Breach*: a narrative includes irregular components.
6. *Referentiality*: a narrative includes points of reference for the reader.
7. *Genericness*: a narrative's genre defines both the content and the reader's approach.
8. *Normativeness*: a narrative remains within expected boundaries.
9. *Context Sensitivity and Negotiability*: a narrative may have a variety of perspectives.
10. *Narrative Accrual*: narratives group together to become tradition.

While all of these features are an exhaustive explanation of a narrative, some are particularly relevant to this paper and prototype.

Intentional State Entailment is a fundamental concept in narratives. The idea that the characters in the story all behave in a way that is reasonably motivated is what helps us to understand the progression of a narrative in a more personal way. These actions are what ultimately drive the narrative forward, and their logical and individual behaviour not only allow the reader to believe in the character's motivations, but also to invest emotionally with the events of the story.

Canonicity and Breach makes an interesting point about the purpose of

narratives in general. This feature echoes linguistic theories of what makes a narrative worth telling, by establishing an understood setting for the reader, and then breaching that with a twist on events. Bruner simplifies this feature, using literary theorist Roman Jakobson's words, "to make the ordinary strange" (*Todorov*, 1977). Identifying the purpose of the narrative in general is vital to the successful creation of good story.

Genericness is another interesting expansion upon a fundamental concept of narrative. The genre that a narrative fits into is the driving force behind its content, but Bruner also explains that the genre of a narrative guides the reader's approach to it. For example, a murder mystery novel will always keep the reader looking for evidence and motives, simply because of the reader's mindset whilst reading. This idea also plays into the previous feature of *Canonicity and Breach*, as the breach in what is expected in the narrative can be based not only on content, but also genre itself.

Normativeness too focusses on the expected norms of the audience, but instead of breaking them, conforms in order to maintain relatability. This balances the features of *Referentiality* and *Canonicity and Breach*, so that while the narrative remains unexpected, it doesn't become ridiculous. Bruner explains that this feature is the most inconsistent, fluctuating as culture and audiences change. Truly timeless narratives are rare because of this dependence on the time and circumstances of their creation.

These features in particular are relevant to the other discussions in this section, as well as the development and evaluation of my prototype.

2.1.2 Interactive Narratives

The analysis of the existing styles of narrative in interactive medium, particularly video games, is important for the design process of this prototype.

The development of interactive narratives has developed into several distinct branches. A 1999 article by Szilas outlining a new design for interactive drama first overviews these different categories very succinctly. He defines them as:

Branching

Branching narratives involve the player making choices that result in the narrative taking different paths. The number of possible paths, however, is very limited, as the author must handcraft each path individually. This results in far fewer variations, but each being more developed and better produced. An example of this style is in *Telltale's* episodic adventure *The Walking Dead* (2012). Early in the narrative, the player is forced to choose between rescuing two different characters. The choice that the player makes results in different characters joining the player further into the game. Essentially this creates two distinct narratives, one with each character that survived. However, maintaining these two narratives for the whole game requires more significant resources than would be needed for only one. This results in 'narrative bloat'; the idea that more branches considerably increases the scale of the narrative overall. In the example of *The Walking Dead*, the two deviating narratives quickly converge with the death of the character who survived. This practice of convergence is common practice for this type of narrative to control the scale of the branching narrative.

Superposed

Superposed narratives take a far less interactive approach to narrative. This usually involves a clear distinction between player actions and the narrative of the game, usually forcing the player to perform in a particular way. This type of interactivity is prevalent in puzzle games, where the narrative will not continue until the puzzle has been completed. In reality, this is barely an interactive narrative at all. The puzzles in these games instead act as obstacles that the player must overcome in order to continue the story. Therefore, the player's actions only effect the pacing of the story, not the content.

Simulation

Simulation narratives involve far less direction than the other categories. This variety of drama is mechanically driven, with narrative either superposed above or non-existent entirely. The best example of this is the immensely popular adventure game *Minecraft* (2011). There is absolutely no story whatsoever, so the player is simply left to interact with the mechanics of the world as they see fit. The outcome from this lack of actual narrative is that the players themselves build their own narrative around their actions within the world. This concept is called an Emergent Narrative (*Janalta Interactive*, 2015). The player's personal story results in a far more emotional response to the game than one would expect a mechanics-focussed game to produce. While the player forms a strong attachment to their creations in these simulations, there is very little opportunity for the creator of such a game to direct the narrative into more interesting story developments. Leaving the progression and direction of the narrative entirely up to the user leaves the author no control over the narrative content, essentially removing the need for authorship entirely.

Some games also mix these styles based on their own style of narrative and gameplay. Typically, real-time strategy games rely on a superposed narrative that links the individual levels together, which in themselves are more similar to simulation narratives. While the player is given opportunity to advance their progress and narrative in an individual level, any deviation from the main narrative, like an important character death or a mission failure, forces the player to try again. While the player is allowed freedom to approach the problem any way they choose, the end result must still conform to the overall narrative.

In addition to Szilas' categories, there is an additional narrative style that is relevant to the design of any new interactive fiction when compared to other narrative medium. Cinematic games are a type of branching narrative where much of the player control in the game is removed in favour of a more film-like style and narrative direction. This style is notable for its use of many film techniques like cinematography and lighting. This style is a great example of how treating interactive media as if it were static limits the potential of the interactivity. In these games, the player still gets to make choices or actions for a character or characters, but their occurrence and scope is very limited due to the handcrafted nature of the film-like elements. Essentially, this style

encounters an even more pronounced version of the 'narrative bloat' problem that occurs in the branching narrative style. The resources required for the extra cinematic elements mean that more than a few short divergences in narrative becomes extremely costly. These cinematic games, while often containing engaging narratives, are effectively limited in their potential to harness interactive elements.

When considering the interactive elements of Szilias' categories of narratives, it is important to return to a fundamental understanding of narrative, in this case Bruner's features. In particular Bruner's narrative feature of *Genericness* is very important when considering the way that the player interacts with any game. For example, the way that a player approaches a classic first-person shooter game is incredibly different to their approach in a horror game, despite any similarities in presentation. The fact that the player expects jump-scares around every corner makes them much more hesitant, while the empowerment so integral to shooter games inspires a much more reckless approach. In interactive narratives, the expectations of the player drives their actions, which in turn drives the story's progression, making this expectation of the content based on the genre even more important in interactive medium. An excellent example of this is the narrative adventure game *Gone Home* (2013). While the game was marketed as a supernatural horror game and contained the atmospheric elements commonly seen in the genre, the game contained none of the other horror elements. As players came to the experience with an expectation for horror, the way they interacted with the story was drastically different than other similar games (*TotalBiscuit, The Cynical Brit*, 2015). This is a great example of how trying to keep the genre unexpected interfered with the *Genericness* of the game, and resulted in vastly different player interactions with the game.

2.2 Narrative Generation

Narrative generation is the process of using software, instead of a human author, to create different narratives. In the same way that the Russian Formalists split narrative into *Syuzhet* (medium) and *Fabula* (content), narrative generation too is split into the presentation of the narrative, and the events of the narrative itself. As the creation of *Fabula* that the player would prefer is the focus of project, this discussion of narrative generation will therefore focus on the different styles of generating story content only.

In general, the different styles of narrative generation cohere with Szilas' categorisation of the different types of interactive narratives. *Superposed* narratives, which contain no narrative variation at all, are built on a static narrative, so therefore have no room to incorporate narrative generation. *Simulation* and *Branching* narrative, on the other hand, provide much scope for the inclusion of narrative generation techniques. *Simulation* narratives, which focus more on mechanical interaction than authored content, are perfect for software constructions. Creating the rules for action and letting the simulated world act according to these rules results in complex calculations that can be easily performed. *Branching* narratives, on the other hand, can impose a narrative structure onto the simulated world created by narrative generation to create a more tangible and focussed story. However, this inherently trades the scope and freedom of the simulation for the structure of a more authored narrative. These different systems provide the groundwork for any further development in the field of narrative generation.

2.2.1 Simulation

The most fundamental form of narrative generation is the creation of a simulated world. While the content and initial setup for each world may vary, all contain a strict set of rules about the world and a number of characters that can interact with the world and each other in a number of ways. The simulation is usually focussed on these characters, with the decision processes behind each character's actions being defined by some number of stimuli and some internal logical algorithm. This internal logic, or number of *Character Goals*, is what provides each character with the agency to act, and the narrative is then built by the changes in the world and these actions.

This is the essence of Bruner's narrative feature of *Intentional State Entailment*. Creating a cast of characters that exist and perform actions based on their own personalities and *Character Goals* creates a simulated world that progresses and advances as each of these characters act. In this sense, this simulated world is comparable to a narrative. Indeed, this kind of simulation exhibits this feature far more than any conventional narrative. The actions of the characters are the major driving force behind the progression of the world, while other narratives have an overall structure that controls the events.

In effect, this simulation model is generating an individual narrative for each of the characters, providing a reasoned progression based on personal motives and the actions of others. However, the reasoning behind a character's actions, while easily calculated by the generation process, is often incomprehensible from only the actions themselves. Sengers (1999) discusses the use of various techniques in a character's behavioural processing to make the actions of that character more directly relatable to their motivations and therefore more understandable. This serves to change the actions of a character from a progression that is logically sound for the system but unclear to the reader, to a narrative of reasoned and related actions that is easy to understand. This makes the behaviour of each character a story in its own right.

However, any simulation that has multiple characters existing in a single world quickly becomes unfocussed and chaotic. A lack of overall narrative structure to the world makes it impossible for the reader to fashion these events as a whole into a cohesive story. In fact, following the definition of Bruner's narrative feature of *Canonicity and Breach*, this type of generation only produces the ordinary world, without the strange or interesting occurring at all. Due to this, the distinctly disparate actions of each character cannot be interpreted as a narrative at all. However, the generation of the character actions within a simulated world is the bedrock on which more cohesive narrative generation models are built.

2.2.2 Structured

In order to turn the chaos of a simulated world into a cohesive story, the narrative generation process must include some form of target world states, or *Author Goals* (Riedl, 2009), that advance the story in a meaningful way. In the simulated world, the success or failure of a given *Character's Goals* is completely arbitrary, based so much on other character's actions that it seems random. In the structured narrative generation model however, the success or failure of each *Character's Goals* contributes to the progression of the world towards one of the *Author Goals*. This means that instead of the world developing in an indiscriminate way, there is always a structured progression towards some narrative purpose.

The process of adding this structural layer upon the simulation is performed with a planning system, as well as some form of control module to provide additional or more specific control. The planning system acts as an additional character agency algorithm, so that a character's actions are decided by their own internal algorithms as well as the larger planner. The additional control modules are usually focussed with creating tangential *Author Goals* or other narrative features. However, a 2010 paper by Porteus et al. argues that the inclusion of these additional control modules is often employed despite the fact that the same could be achieved with a better implementation of the planning system. Including all of the structured control algorithms within a single planner not only reduces complexity of the system as a whole, but also allows for better integration of these otherwise disparate elements. Either way, the planning system is the main method used to implement the *Author Goals* onto the existing simulation generation for better narrative control.

While using these *Author Goals* improves the quality of the story produced, any attempts to reach these new goals risk forcing characters to perform actions that seem incoherent. Riedl Young (2010), in their discussion of character intentionality, outline a narrative planner that fulfils the *Author Goals* of the narrative without jeopardising a character's credibility. That is to say, an individual will not do anything out of character simply to satisfy the *Author Goals* of the narrative. This is crucial in maintaining the reader's engagement in the story by reinforcing a character's believability through coherent and understandable actions. This builds on the concept of understandable character narrative from Sengers, and ensures that the inclusion

of the *Author Goals* does not reintroduce incomprehensible actions. It is important to note, however, that while balancing character and *Author Goals* to maintain character intentionality is important, there can still be conflict between goals.

For example, any *Author Goal* that includes the death of a character is likely to be in conflict with that character's own goal to remain alive. To keep a character's intentionality intact, that character should not kill themselves simply to fulfil that *Author Goal*. On the other hand, any actions taken by the character to avoid their death must be unsuccessful, so that that *Author Goal* is achieved. By balancing the Character Goals in the simulation-based model with the new *Author Goals* in the structured model, the quality of the generated narrative can be improved without sacrificing character intentionality and believability.

Suspense

In addition to creating more cohesive narratives, the addition of *Author Goals* allows for the inclusion of other narrative techniques to improve the quality and engagement of the story. Cheong Young (2008) discuss a system that incorporates the addition of suspense in a generated narrative. By measuring potential suspense of any selected action by its effect on the protagonist's goals, the system can attempt to maximise the engagement of the story with varying degrees of suspense. For example, any event that endangers the protagonist of the narrative heightens the sense of suspense for the reader. By including similar events at intervals throughout the narrative, this system can maintain the suspense, and therefore engagement of the narrative.

This system builds on the structure of *Author Goals* by also considering the reader's reaction to certain events in the story. While the *Character* and *Author Goals* are still used to generate the narrative, the inclusion of suspense serves to improve the quality of the story by introducing classic narrative techniques to the generation process. The preliminary results from Cheong Young's evaluation of their system show that their design was successful in improving the suspense and engagement of the generated narratives. It is likely that the suspense proven by Cheong and Young‘s testing will only be amplified by merging the player and protagonist.

2.2.3 Reader Modelling

The concept of including elements of interactive fiction into the narrative generation process remains mostly unexplored, however. Usually, the inclusion of interactivity into a medium still usually follows the trend of *Branching* narratives. For example, the 2010 paper by Porteus et al. includes the incorporation of narrative planning systems in interactive storytelling only by allowing the planner to re-plan in real time. There is no attempt to incorporate the response of the user into the planning process itself.

This leads to the concept of reader modelling; that is, attempting to understand the player based on their actions, and using that understanding to generate quality content for them. Essentially, this replaces the concept of *Author Goals* with the idea of *Reader Goals*.

Bailey (1999), in his discussion about creating quality stories from the perspective of the reader, outlines a model for narrative generation that focusses on the user's experience. This model is related to but distinct from the structured story model, because the narrative that is generated is not constrained by a pre-defined plot, as in structured narratives, but advances the story based on providing the best narrative for the reader. This focus on the reader makes this model more attractive when considering applications into interactive fiction.

Bailey begins his paper by outlining his primary assumption that "the appropriate reaction of the reader to a story is presented as an essential determinant of the story's success". This builds on the concept of Reader-Response Criticism, where the reader has a considerable impact on both the nature and quality of the work (see the various works of Holland, Fish, and others). This primary assumption is core to his development in his narrative generation model, but is even more crucial when considering adding this generation to interactive storytelling. The player's role in driving the story in interactive fiction, as well as the narrative freedom that narrative generation provides, makes the reader's reaction even more decisive in the quality of the story. Bailey's assumption that drives his model's design is highly important when considering the addition of interactive elements to narrative generation.

When discussing the existing model archetypes for narrative generation, Bailey notes that he is omitting interactive story-generation, as the different methods and aims involved make it distinct from non-interactive designs. However, many of the design concepts remain the same (as discussed in **Section 2.1.2**), and a variety of the same problems that confront interactive narrative generation are also relevant in non-interactive designs. Rather than being distinct, interactive fiction simply adds a number of additional elements to the narrative generation process, which create a number of benefits and potential problems. Therefore, the model that Bailey proposes and the ideas that he discusses provide a vital foundation to which the interactive elements can be added.

Reader-Based Model

Bailey's paper continues by describing a reader-based model, where the content of the story is selected from a large pool of alternatives to provide the best overall narrative for the reader. The focus on selecting what is best for the reader is the most crucial element of this model. A major problem with narrative generation is its failure to consider the quality of the story from the reader's perspective. This can often lead to narratives that are illogical or incoherent. This problem is partially solved by the inclusion of the structured style of narrative generation as outlined in **Section 2.2.2**. The structure of the narrative becomes more focused and far less disjointed. This style, however, has a major downside of limiting narrative interactivity by the player. The amount of freedom of player choice is severely reduced, as the narrative is forced to remain consistent with the planned structure. Bailey's reader-based model, alternatively, focusses the structure of the narrative not on some predefined author goals, but on goals specific to the reader. This allows the reader the freedom to make disparate choices, while still creating the narrative in a structured and coherent way. By focussing the generation of the story on the reader, rather than on the simulated world or defined story grammar, the story can better include more consistent and personal elements.

This reader-based model, however, is hindered by its dependency on the construction of an 'imagined reader'. This is a fabricated representation of the reader, including knowledge, questions and expectations, which are used to select the best story content based on those components. This reliance on the quality of the generated representation can cause a number of potential

risks, the most notable of which is the potential of incorrect assumptions on the author's behalf. For example, Bailey's reader-based model measures the strength of an expectation with a complex relation of premises and inferences, but which is ultimately based on assumptions made by the author. This inherently risks creating a story that makes sense for the author, but which is uninteresting for the reader.

Interactive fiction, on the other hand, can reduce the scale of these risks by instead inferring many of the elements in the reader representation directly from player's actions. In the same example, the way that the system could manage expectations changes significantly. Instead of calculating the strength of a given expectation in isolation, it is instead possible to incorporate the previous actions of the player into this calculation. By including information that is specific to the user rather than designed by the author, the risk of incorrect assumptions by the author is reduced. Generalising this idea, the inclusion of feedback from player's actions into all elements of Bailey's reader-based model improves the accuracy and individuality of the 'imagined reader', which will improved the reader's experience and the 'storiness' of the narrative.

Other Elements

Other aspects of reader modelling also translate well into interactive fiction. Bailey's discussions of questions that emerge from assertions and expectations in the story are vitally important in story-driven games. Having direct player involvement in the story means that these questions drive the action of the player, as they attempt to answer them. The scale of these questions is also highly important to the development of the story in Interactive fiction. Like in conventional narratives, the large mysteries of the story are what bring the player back. Smaller, more immediate questions, however, are far more important in driving the narrative in Interactive fiction than in other narratives. While other conventional narratives can rely on a more passive engagement, interactive fiction is reliant on the player's actions to progress the story. This makes these small questions far more important in advancing the story. As Bailey puts it, "such questions are a significant aspect of [the readers] response to a story". In interactive fiction, this response not only informs the player's perception of the story, but also, through their actions, the path the story takes.

As mentioned previously, player preferences also have good integration into interactive fiction elements. By using the previous actions of the player, it is possible to weigh the strength of the preferences differently, and more personally, for each player. This creates a better representation of what the player truly prefers, which improves the selection process for story content.

On the other hand, the knowledge structure in the reader-based model is more difficult. In Bailey's model, this knowledge base is what defines the importance of questions and expectations, but with the focus shifted to the player's actions, the knowledge base is far less important. This is most evident when considering the questions. While the knowledge base in the player's representation may produce a number of different questions, the player may only choose to attempt to find an answer to some of them. This means that the importance of a question is not only affected by the knowledge base that informs it, but also by the actions of the player in the story. In fact, the actions of the player carry greater weight than the knowledge base itself. This element of the reader-based model needs significant work when incorporating elements of interactive fiction.

Player Modelling

There have been a few examples of the implementation of such a reader modelling system to interactive fiction. Most notably, a 2007 paper by Thue et al., outlines a system whereby the player of a game is presented with narrative content based on their previous actions. Many of the design elements of this system rely on similar theories and concepts as provided in this paper.

The system presented in this paper uses the player's actions to determine which of five distinct 'player types' the player is most likely to belong to. This is then used to create content that caters for that player's style of play. This example uses Robin's Laws that defines the five player types as *Fighters* (who prefer combat), *Power Gamers* (who prefer gaining special items and riches), *Tacticians* (who prefer thinking creatively), *Storytellers* (who prefer complex plots) and *Method Actors* (who prefer to take dramatic actions).

The content that is then provided for the player is based on whether it is applicable to that player's measured playstyle. This allows for the generation of game content that is relevant to each type of player. Such a system could easily be implemented alongside a system that focusses on the generation of appropriate narrative content for the player.

Plan Recognition

Reader-based modelling, while closely related to plan recognition, is distinct in both form and goal. While plan recognition is focussed on attempting to infer larger long-term goals from different actions, Reader -based modelling is instead focussed in using these actions in an attempt to predict how the player will react in a certain situation. Plan recognition could be used to interpret the goals of the player, and increase suspense by interfering with them, but cannot be used to understand the player in a more general sense. Reader modelling relies on the creation of an image of expectations and preferences, which are not always directly related to goals specifically. While the methods used to measure user actions remain similar, the way that those actions are interpreted and used is very different. While dissimilar, plan recognition could be used in conjunction with a reader-based modelling system, as both could be used to understand the reader better and create better content for them.

2.3 Motivational Psychology

The next component needed to design a system that uses player interaction to generate varied content is some way to model the player themselves. The interactive medium allows a system to track the choices that the player makes, but in order to create tailored content, we need to understand why the player made that choice. To do this, we need to first answer the question: "How do we measure motivation?".

There are a large number of theories that propose to answer this question. By dividing up the larger cause of an action into a variety of smaller, unique categories, it is possible to trace an action to one or more of these 'motivators' that trigger it. There is no consensus, however, upon which theory of categorisation is most accurate. This paper will examine the theories proposed by Maslow, Alderfer and Reiss to determine which is best for this design and implementation.

The criteria that determine the best theory to be used are threefold. Firstly, the categories proposed must be sufficiently distinct. There needs to be as little overlap as possible between the categories, so that they can be measured and implemented individually by the system. Secondly, the categories need to unambiguous. As they are going to be tied to actions directly, each category must be able to reflect a specific motivation in its entirety. Finally, the categories must be able to be used both to define an action, but also to define the player. The motivations behind each action need to be able to contribute to building a picture of the player that can be used to generate content for them. The theory that sufficiently fills these criteria is the best for this system.

2.3.1 Maslow's Basic Needs

An early psychological theory of motivation was put forward by Maslow in his 1943 paper *A Theory of Human Motivation*. This theory splits the motivations of people into eight (originally five) distinct categories: *Physiological, Safety, Love, Esteem, Cognitive, Aesthetic, Self-Actualisation and Transcendence*. Each category is less urgent than the last, so that the earlier categories effect action in a more immediate way. The latter categories, on the other hand, affect long term goals and aspirations, and are more individual than the former needs. Maslow's categories provide a broad but unfocussed depiction of the motivations of an individual.

Maslow's categories can be generally described as:

1. *Physiological*: The needs of the body, like hunger, thirst and maintaining body temperature.
2. *Safety*: A need to preserve physiological needs and avoid illness or injury.
3. *Love* (or more accurately, *Belonging*): A need for social affection and acceptance with a person or group.
4. *Esteem*: A need for self-respect and, therefore, respect of others.
5. *Cognitive*: A need to gain knowledge.
6. *Aesthetic*: A need to appreciate beauty and form.
7. *Self-Actualisation*: A need to achieve potential.
8. *Transcendence*: A need to help other achieve *Self-Actualisation*.

These categories are focussed on the distinction between the deeper goals of actions, so the categories are naturally very distinct. There is no overlap between the categories at all, and they cannot be used in conjunction with each other. Any action can be attributed to a single basic need, and never more than that. This focus on distinction would make it very easy to implement into a software system.

Some of the categories, like *Safety*, *Cognitive* and *Aesthetic* are simple and relatively easy to generalise into specific actions. On the other hand, *Esteem* and *Self-Actualisation* can result in vast spectrum of action depending on a personal understanding of these needs. For example, the way that an individual gains respect from another depends vastly both parties involved. One attempt to gain *Esteem* might involve an act of vengeance for a perceived injustice, while another could involve a completely selfless action. This makes it extremely difficult to ascertain the true motivation behind an action. This will result in a number of discrepancies if this theory is used in the design for the proposed system.

This theory approaches motivation as in tiers of action, whereby an action performed by an individual belongs to a single motivation. This means that the criterion of defining the player is not applicable. While a single action can be accurately attributed to a motivator, any choice made only defines the individual at that moment, rather than more generally. This means this theory cannot be used to generate an understanding of the player in a general context.

2.3.2 E.R.G Theory

Another psychological theorist, C. Alderfer, re-examined Maslow's categorisation of motivation in his 1969 paper, *An Empirical Test of a New Theory of Human Needs*. He criticises the fact that Maslow's categories are based on incorrect assumptions about the relations between them. Alderfer continues by proposing a new classification, E.R.G theory, with only three core needs that are the root of all action. These needs are *Existence, Relatedness* and *Growth*. As Alderfer's theory is an amendment to Maslow's theory, these needs are generalisations of Maslow's proposed categories given above. The first category, *Existence*, covers the basic needs for material and physiological survival, like hunger and thirst, while the second, *Relatedness*, encompasses the myriad of needs surrounding social relationships. Finally, *Growth* includes all of the more intrinsic motivations surrounding self-improvement, productivity and achieving a sense of purpose.

A core concept of this theory is that the increase or reduction in fulfilment of one core need affects the level that others effect action. A basic example of this is that as an *Existence* need (like hunger) becomes less satisfied, the desire to satisfy it increases. Another example is that *Growth* needs feed upon their success, causing an increased desire to achieve even more. This method of a mathematical approach of linear relationships lends itself well to a technological application of this theory. These relationships can be measured individually, so the criterion of distinctness is well aligned to this theory.

However, Alderfer's attempt to reduce overlap between categories has resulted in a much broader classification of motivations. This makes it far more difficult to accurately and precisely deduce the underlying motivation behind a given action, and these needs are far more ambiguous. As this theory is based on the Maslow's tiers of action, this theory also defines an individual at an instant, rather than over time. This makes a system that uses the motivations behind actions to define an individual incompatible with this theory as well.

2.3.3 Reiss' Sixteen Motivators

More recently, the American Psychologist Steven Reiss (2004) conducted some research into the intrinsic motivations that affect an individual's actions. Using prior motivational theories, he initially compiled a list of all previously proposed motivations, and after removing redundancies, provided this list to a pool of participants over several studies. This original list contained nearly 500 different motivators. The objective of his following studies was to ask the participants to answer how important each motivator was in effecting their behaviour. These results were then analysed and grouped, effectively turning this large list of all possible motivators into a much smaller number of root motivators. This process was balanced to be as encompassing of the original motivators as possible, while also producing a smaller, but still reasonable and justifiable, list.

This process resulted in the following sixteen motivators:

Power – The desire to influence others
Independence – The desire for self-reliance
Curiosity – The desire for knowledge
Acceptance – The desire for inclusion
Order – The desire for organisation
Saving – The desire to collect things
Honour – The desire to be loyal to one's parents and heritage
Idealism – The desire for social justice
Social Contact – The desire for social companionship
Family – The desire to raise one's own children
Status – The desire for social standing
Vengeance – The desire to get even
Romance - The desire for sex and beauty
Eating – The desire to consume food
Physical Activity – The desire to exercise muscles
Tranquility - The desire for emotional calm

(As summarised by *Bizpart*, 2013)

Each of these motivators can be used to justify an individual action. For example, eating a meal is directly linked to the *Eating* motivator. Unlike the previous theories examined however, an action can be effected by more than one motivator. For example, while eating a meal is motivated by *Eating*, a meal shared with friends and family becomes additionally motivated by *Honour*, *Social Contact*, *Family* and/or *Romance*. The ability of this theory to define an action based on multiple core motivators provides opportunity both for more intricate understanding and the reduction in possible misunderstanding. This broadening of the definition of an action is integral in the potential of this theory in the integration of this prototype.

More importantly, the method used by Reiss to gather these motivators is critical to this theory's implementation. By asking the study participants how much each motivator affects them generally, this theory can be used to build a profile of the individual. This is a vital component for this prototype, as in order to truly create custom narrative content for the player, the system must be able to build a profile of the player. Reiss' system allows the use of these motivators as a definition of an individual, based on how much each motivator affects them.

For a software implementation of this system, there must also be very little overlap between the motivations. The distinction between correlation between motivators and overlap of actions effected is crucial. It must be possible to have a single actions effected by several different motivators, while ensuring that presence of one motivator does not require or exclude another. Correlation analysis performed by Havercamp (1998) showed that the average correlation among Reiss' motivators was approximately 0.15, while 81% were less than the absolute value of 0.2. This proves that these motivators are mostly distinct, allowing for an implementation that tracks each of them independently.

Additionally, the list of sixteen motivators is much more manageable and usable than the original, uncondensed one of over 500. While the original list might result in a more comprehensive understanding of the psychology of player actions, its massive scale makes successfully measuring the motivators impossible. An unreasonable amount of actions would need to be observed to in order to gather enough data to properly understand the player's tendencies towards each motivator. Measuring the player's personality with this list of only sixteen is much more feasible.

As well as the above features, the way that Reiss produced and validated his theory makes it more attractive for this prototype than either Maslow's or Alderfer's. The use of several studies with large and varying populations makes this theory far more empirical. The inclusion of various methods of validation, including application to different areas, comparisons with other theories and other data analysis gives it a more grounded justification. Therefore, Reiss' theory will be used in this project.

Chapter 3

Project Overview

The aim of this project is to prove a hypothesis related to interactive narratives and narrative generation.

Primary Hypothesis:
The player of interactive fiction will (through their actions) project a particular personality onto the player-controlled character, and the player will have a preference for narrative content that remains consistent with that personality.
This personality can be measured adequately using Reiss' theory of motivators.

The testing of this hypothesis involved the creation of an interactive fiction game, which allows the player to make different choices for a player controlled character, and through those choices express that character's personality. The system records the choices made, then estimates the character's personality based on these choices and attempts to predict the narrative content the player would prefer.

The interactive story game and narrative preference prediction system are then tested in a user study of player participants to confirm that the system can consistently predict the narrative variation that the user will prefer.

The participant of the study is presented with the choice-based, text-based interactive game that allows for choices to be made that express the player character's personality. At the half-way point of the narrative, the interactive part ends, and the player is presented with three conclusions to the narrative. One of the conclusions is selected by the prediction system, while the other two are random. The player is asked to select which of the three variations they prefer as the conclusion for the narrative. The variation that they choose is reflective of their preference towards each of the narratives presented.

The main outcome from this study will be whether or not the player consistently chooses the variation that the prediction system selected, i.e. that the system can consistently predict the player's preference based on their choices.

Main Outcome:
At what frequency is the developed system able to predict which variation the player will prefer?

As the implementation of the system involves a choice between three variations, the baseline frequency for this outcome will be approximately 33% (see **Section 3.3.2**). Any result significantly higher than this indicates that the system is more consistently predicting the choice that the player will make.

However, as the testing of this hypothesis involves the creation of and reliance on a software system, there are also a number of supporting hypotheses that also need to be tested. These are related to the correct and valid implementation of the system.

Specific Supporting Hypotheses:
A player that repeats the game will behave in the same way as a player who plays it for the first time.
Each component of a variation contributes to whether or not that variation is chosen.
The weightings of motivators assigned to each player choice reflect most players' reasoning behind that choice.

Information to test these hypotheses is gathered from the study via general information and a feedback process (see **Section 3.3**). If these hypotheses are proven by the additional results of the study, then the system is correct and valid. However, if they are proven invalid, the system needs to be improved before the system can be used to prove or refute the main hypothesis.

The last of these hypotheses is directly related to a risk outlined in the discussion of Bailey's Reader-Based Model from **Section 2.2.3**. This is the risk that the author may make incorrect assumptions about the way that the system should interpret the reader. As this design is built upon the same reader-based model, this risk remains in this prototype. The motivator values attributed to each choice and each story element were determined individually and in isolation. It is possible that the motivators assigned might not be aligned to the player's actual motivation. This means that there is a considerable risk that the system might misunderstand the motives of the players, and fail to predict the narrative content they would prefer. This potential failure of the system is tested specifically by this last supporting hypothesis.

There is one other major supporting hypothesis that, while still potentially relevant, is much harder to measure or control.

Other Supporting Hypothesis:
Each player makes their choices to reflect the personality of the player-controlled character.

As this study focusses on using the player's choices to understand their preferences, it is assumed that these choices do indeed reflect the player's perception of their character. Otherwise, the information gathered about these choices is entirely irrelevant. So, if the player makes choices randomly or not to express a consistent character, then those choices cannot be properly used to understand the player's preferences. This is an inherent risk when performing a self-selected study. A closely observed, laboratory study would allow for better control of this hypothesis through better observation and supervision of participants, but would result in far fewer participants for this project. As many of the Specific Supporting Hypotheses require a high frequency of relevant results to prove, an anonymous online study with this risk present is optimal to obtain a larger results set.

There are, therefore, three possible results from this project. Firstly, if any of the supporting hypotheses are proven false, then more development of the system and further studies need to occur. The improvement of the system needs to take place before any meaningful examination of the primary hypothesis can occur. The areas that require improvement will be evident from the analysis of the results obtained from these studies.

Once the system is proven correct and valid by the verification of each supporting hypothesis, then the main outcome of the study can be used to prove or refute the primary hypothesis. If the main outcome indicates consistent prediction by the system, then the primary hypothesis is proven. If not, then the primary hypothesis is refuted.

3.1 Prototype Design

As the main part of testing the primary hypothesis is a system that can predict player preferences, the design of the prediction system was the first course of action. The features of the system to be tested can be split into three distinct components.

Firstly, there needs to be a section whereby the system can record the actions of the player. In this prototype, this component is a text-based choice-driven **game**. The player is provided with a relatively freeform social situation, allowing them to converse with other characters and exhibit their protagonist's personality.

Next, there needs to be a **generator** that creates a number of different narrative variations that continue the narrative from the interactive game component. This selects all possible combinations of a list of predefined events, and compiles them into unique *fabula*, or list of narrative events.

Finally, there is a **heuristic** that selects which of the *fabula* of events that were generated is most appropriate for the player, based on the character's personality that is estimated from the choices made in the game. This is achieved by finding the generated variation that most closely matches this measured personality. This is the most important component of this prototype, as its success proves the main hypothesis, i.e. that there exists a correlation between player choices in the game and the player's preference towards different narrative variations.

With these core concepts in mind, several versions of a general narrative were drafted. These had to cohere with the narrative theories already discussed (see **Section 2.1**), as well as contain scope for the application of both the choice-based game and the narrative generator. The final setting and general *fabula* was decided upon, and is outlined in **Section 3.1.1**.

A modified version of Reiss' Theory of Sixteen Motivators (see **Section 2.3.3**) was created to fit the narrative. Some of the original motivators were either not relevant or core to the plot, so they were not included in this prototype. The motivators included are described by definitions specific to the narrative of this prototype in **Section 3.1.2**.

The interactive story **game** itself was developed using the Twine interactive fiction creation software, which includes a variety of important features for the implementation of this prototype (see **Section 3.1.3**). The player's choices in the game contribute to their character's personality as measured by the system.

The **generator**, using a set of narrative events and a framework of how they fit together, creates a list of possible alternative variations. As each narrative event is associated with a number of Reiss' motivators in greater or lesser degrees, each variation can also be expressed by these motivators. The definitions of these events, and the way they are joined to create a variation is outlined in **Section 3.1.3**.

Finally, the selection **heuristic** matches each potential set of player choices with the best variation for that player. This uses a normalisation process to allow the easy comparison between the measured personality of the player character and each of the potential narrative variations, and chooses the closest variation based on a weighted edit distance system (see **Section 3.1.6**). This way, the personality that the player projects onto their character can be used to find story content which that player prefers.

Section 3.3 describes the study in which the system was used.

3.1.1 *Fabula*

The *fabula* (content) of the narrative puts the player in control of an ordinary individual on their way to a nearby café. When they enter the café, however, they discover that it is deserted, and there is a large strange portal in the centre of the room. They are magically pulled through it, and are transported to another dimension.

It is important to establish that the protagonist as an individual that the player can project onto. They are given no background or personality of any kind. This provides the foundation for the player to influence the protagonist's character in whatever way they see fit. The introduction grounded in reality is important to establish Bruner's concept to C*anonicity and Breach*. By setting up the world as ordinary, the events can be more interesting, and more relatable by an ordinary player.

Shortly after the protagonist arrives in the other dimension, they are joined by a group who call themselves the Demonic First Responders (DFR). They introduce themselves, and explain they are there to close the portal that pulled you and many other people into this other dimension.

This section includes limited interaction, mostly to introduce the concept of player choices to those players who may not be familiar with this style of interactive fiction. These choices are not used to define the protagonist's personality.

While the other members of the DFR busy themselves, the protagonist is provided the opportunity to ask a variety of questions of their leader. These questions cover a variety of topics.

This is the main content of the interactive narrative. As the protagonist discusses these topics, the player is making choices about their character's responses. These choices are what allow the player to express their character's personality. What the player chooses their character to say defines their character. The implementation of these questions and choices and some specific examples are provided in **Section 3.1.3**.

After all of the questions have been asked, the player is given one final choice, whether to stick with the DFR, or whether to progress through this dimension alone.

This creates two distinct initial states for the next stage of the narrative; one where the protagonist is alone, and one when they are with the DFR. This is important for the narrative generation process, as it initiates the concept of two states for the content. **Section 3.1.4** elaborates on how this is implemented in the narrative generation process.

The narrative now changes to a non-interactive list of events. These narratives contain varied elements but follow the same structure. The protagonist travels deeper into the other dimension to retrieve a keystone needed to escape, and returns to the entrance. They then encounter the demonic owner of this dimension, and interact with her in one of a limited set of potential ways. The narrative ends with the protagonist escaping the dimension and closing the portal. The variation on potential events in this section is further detailed in **Section 3.1.4**.

3.1.2 Motivators

The most crucial concept to this prototype is the ability to accurately measure the motivations behind a player's actions, as this is an important part of using those actions to predict player preferences. To do this, this system uses Reiss' Theory of Sixteen Motivators as outlined in **Section 2.3.3**. However, some of these motivators are not entirely relevant to the narrative that was created for this prototype. For example, as the game is focussed on the social interactions with a number of strangers, the socially focussed concepts of *Honour*, *Social Contact* and *Family*, are not applicable. In addition, the concept of *Tranquillity* is the central goal of the narrative, so all characters need to exhibit it. Of the sixteen motivators, only seven are applied in this prototype[1]. They are:

Power – The desire to influence others
Independence – The desire for self-reliance
Curiosity – The desire for knowledge
Order – The desire for organisation
Saving – The desire to collect things
Idealism – The desire for social justice
Vengeance – The desire to get even

(As summarised by *Bizpart*, 2013)

[1] In more developed examples of this system, the greater scale of narrative will allow more of the motivators to be relevant.

The application of these motivators within the *fabula* of the prototype results in more limited manifestations of each [2].

Power – Demonstrating strength or the use of objects found
Independence – Working alone and questioning the DFR's methods
Curiosity – Understanding events and taking objects
Order – Agreeing with the DFR and looking at the big picture
Saving – Taking objects for use later
Idealism – Trying to save the other people
Vengeance – Fighting or killing Kalvash or other demons

There are two important areas of distinction within these motivators. Firstly, the way that the player interacts with the DFR (Demonic First Responders) reflects either *Order* by supporting them or Independence by questioning them. Idealism also plays a role, by focussing on rescuing people with or without their help.

The other factor is the motivation behind the collection of powerful objects. The *Power* motivator wants to use powerful objects immediately, to save people with *Idealism* or kill demons with *Vengeance*. Curiosity, on the other hand, often conflicts with Vengeance, as it wishes to collect to learn and understand before destructive action. *Saving* is focussed on a more long term collection of objects, and their application back in the real world. While this is a very narrow application of this motivator, the story of this prototype doesn't allow for expansion of this idea any further.

The domain-specific definitions of these motivators are crucial for their later implementation in the interactive game and narrative generation processes. This allows for a more consistent application of each of the motivators to relevant actions or events. Therefore, these motivators provide the foundation for the system's ability to predict the preferences of the player. The correct definition and application of these motivators is therefore core to the success of this system as a whole.

[2]Again, future implementations of the system will cause the motivator's definitions to be more similar to their core meanings.

3.1.3 Narrative Implementation

With the general narrative defined and the relevant motivators characterised, the actual implementation of the narrative can be outlined. This component can occur in a variety of media, as long as a one core element remains the same. Actions taken by the player must be observed and attributed to one or more of the motivators (see **Section 3.1.2**).

For this prototype, an interactive text- and choice-based narrative was used. This reduces the resource cost of the development of the game section, which is ideal for such a hypothetical testing design.

The first component of the project was the creation of the text and choice-based narrative. To achieve this, a number of potential development options were examined. Apart from the basic functionality needed to create such a game, like text display and choice creation, the criteria for use in this project were threefold. Firstly, the software needed to contain functionality to allow for values to be attributed to choices made. This is very important, as it allows for motivators to be assigned for each choice. Secondly, the system needed to export into HTML, so that the game can be accessed online by any number of participants. Finally, it needed to be possible to incorporate data gathering elements for the collection of participant information as part of the study (see **Section 3.3**). To fill the above criteria, the software system Twine was selected. Below are some examples of the Twine creation interface and HTML output.

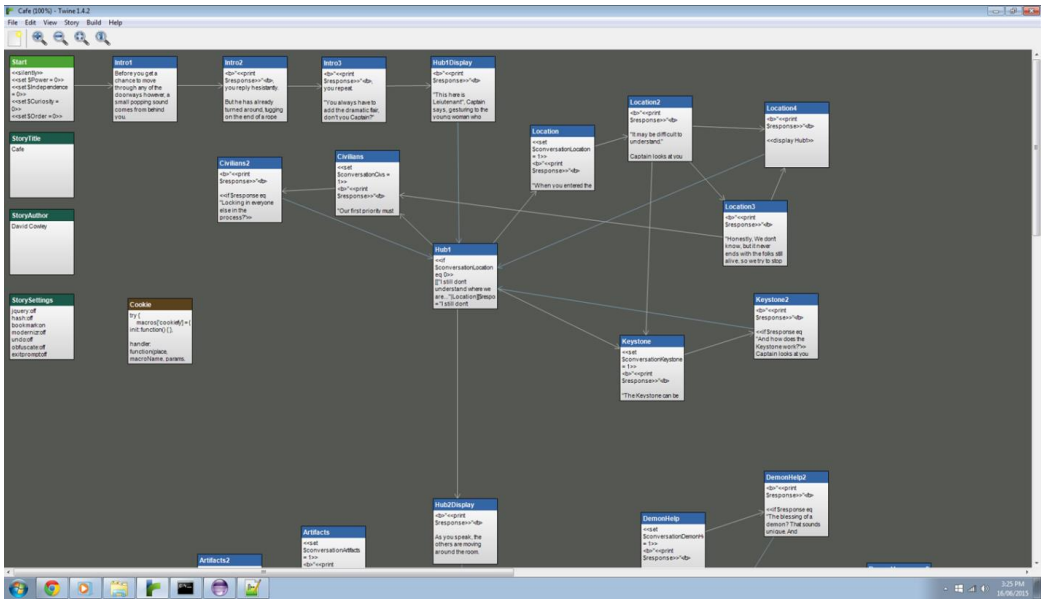

Figure 3.1: An example of the Twine user interface.

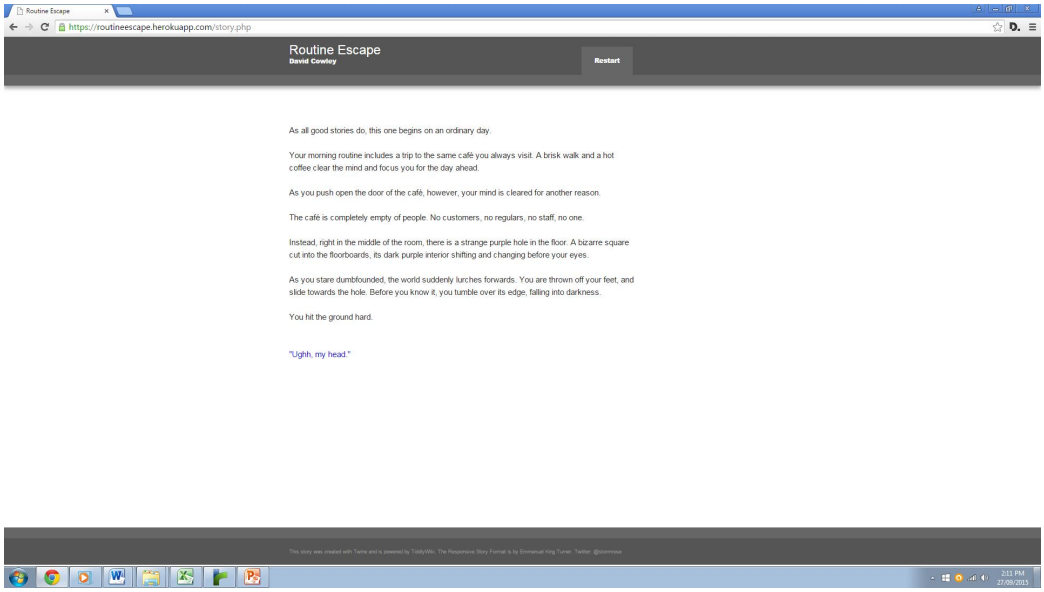

Figure 3.2: An example of the HTML output from Twine.

The main function of this software is the creation of different pages, or Passages, that are self-contained blocks of text with Links between these pages. **Figure 3.1** illustrates the Passages as the blue and white boxes, with the Links as arrows between them. This leads to some important functionality that is vital to the implementation of this system. The links between the passages can alter values as the user progresses. This allows for two crucial functions. Firstly, it allows the system to record which option the user selects when there are multiple options. Tracking the choices that the user made is vital when conducting the study, so that all relevant information about these can be collected. The narrative content of each of these Passages and related Links is included in **Appendix B**.

In addition to this, the ability to modify values depending on the user's choices allows for a simple implementation of the motivators described in **Section 3.1.2**. For this prototype, the user begins the story with values of zero for each of the seven motivators. When the user makes a decision that reflects one or more of the motivators, the value that corresponds to that motivator is modified by a given amount. An example of a few decisions is given below in **Figure 3.3**.

Passage	Option	Destination	Power	Independence	Curiosity	Order	Saving	Idealism	Vengeance	Total	Dialogue
DemonHub	a	DemonHelp									Surely people wouldn't help a demon.
	b	DemonVengeance									So she has killed like this before?
	c	DemonKill									If you know so much about her, why hasn't she been stopped?
		Hub2									
DemonHelp	7.1	DemonHelp2	1	1	1		4			7	The blessing of a demon? That sounds unique. And valuable.
	7.2	DemonHelp2	2	1				2		5	Couldn't you use that power for good?
	7.3	DemonHelp2	3		1				2	6	That blessing sounds very useful. Especially for killing Kalvash.
	7.4	DemonHelp2				2		2		4	Sounds like a fool's errand.

Figure 3.3: A selection of player choices and their associated motivator values. For a full list of choices and their associated motivator values see **Appendix C.**

Choice	Power	Independence	Curiosity	Order	Saving	Idealism	Vengeance
1.1			1			1	
2.1						1	
3.1		1	2				
4.2					1	3	
5.2			1		4	1	
6.3					-1		2
7.3	3		1				2
8.1						3	2
9.2		1					3
S	2	5					
Player Motivation Vector	**5**	**7**	**5**	**0**	**4**	**9**	**9**

Figure 3.4: An example of a set of player choices, each choice's associated motivator values and the Player Motivation Vector for that set of choices.

As described in the **Table 1** above, each link is defined by the passage it appears in, an identifier for within that passage, its destination, and the dialogue for that link. The passages in the narrative are grouped into sections, each of which is focussed on a particular topic. In the selection above, the **DemonHelp** passage involves the discussion of using the power of the demonic antagonist. Each option represents a different weighting of motivators, as defined by the seven values in the table. In this example, option 7.2 reflects the characters desire to use the described power for good. This is reflected by the motivators of *Power* (for demonstrating strength), *Independence* (for arguing against the DFR) and *Idealism* (for trying to help others). Each of the dialogue options is similarly weighted.

Each of the dialogue options that are weighted are part of a unique choice. After the player chooses one of them, they are taken to another passage. This means that each decision made cannot be reversed, and only one option can be chosen. Allowing the player to choose more than one option not only increases complexity, but could also cause problems with the logic of the narrative. In addition, these options are given unique identifiers, so that the important choices that the player made can be easily captured. The numbering of option 7.2 means that in the seventh mutually exclusive choice, the player chose the second option.

Not all of the dialogue options are mutually exclusive, however. In order for the user to access the different sections of content, there are a number of what are defined as Hub passages and links. These links allow the user to access all of the mutually exclusive passages only once. In the example above, the **DemonHub** passage contains three links to different passages. Once the player has accessed one of these passages, they will be returned to this hub, with that option no longer available. This prevents the player from becoming stuck within a particular conversation area, or being able to repeat previously completed areas. As the player can visit all of these areas in any order, it is not as important to record exactly which option was chosen. Instead, the simple letters were used as option identifiers.

At the end of the interactive part of the narrative, the user's choices can be summarised by a list of the options they chose. Many of the options have no motivators assigned to them, so they are not as important when defining the player character's personality. The motivator values attributed to each choice that the player made are added together to create the total values for that player's path through the narrative. These values are the **Player Motivation Vector**. An example of the choices that a player made and the resulting Player Motivation Vector can be seen in **Figure 3.4**. This Vector is the definition of that player character's personality, and is vitally important in the prediction of the player's preference of narrative.

It is important to note that if two Player Motivation Vectors contain the same values, then they are treated the same, despite whether the associated events for each are different or not. That means that if two players make different choices, but end the game with the same Player Motivation Vector, they are treated identically. This reflects the fact that the choices made may vary, but the underlying motivation tendencies are what define the character. This prototype does not distinguish between two different story paths that result in the same Player Motivation Vector. Therefore, only unique Vectors are used.

As mentioned in **Section 3.1.1**, the final choice of the narrative splits the narrative into two distinct sets, either where the player chooses to remain with the group, or set out alone. This final state determines the start of the next section of the narrative, and splits that section into two distinct sets as well.

3.1.4 Narrative Generation

The next stage of the narrative is generated by the system. This involved the creation of a number of narrative events and a framework for these events to fit together to create a variation. This prototype then used a Java program to create all possible variations within the defined framework.

The narrative generation process consists of nine stages . At each stage, one of the possible events for that stage is chosen, and the process moves onto the next stage. Once all the stages have an event, the variation is complete. The generation process then repeats until all possible combinations of the events has been created into variations. In total, there are 33069 possible variations.

The variations are comprised of events as arranged per the framework defined in **Figure 3.5**, and a full list of events and their details are in **Appendix D**.

Event Number	Potential Events	
	Group	Solo
1	Filler Group Event (**GA1-7**)	Filler Solo Event (**SA1-8**)
2	Filler Group Event (**GA1-7**)	Filler Solo Event (**SA1-8**)
3	Group Keystone Event (**GK**)	Solo Keystone Event (**SK**)
4	Filler Group Event (**GA1-7**)	Filler Solo Event (**SA1-8**)
5	Filler Group Event (**GA1-7**)	Filler Solo Event (**SA1-8**)
6	Group Demon Interaction (**GD1**)	Solo Demon Interaction (**SD1-4**)
7	*No Event*	(Optional) Rescue Group (**SG**)
8	Group Escape (**GE1-2**)	Solo Escape (**SE1-2**)
9	Group Close Gate (**GC**)	Solo Close Gate (**SC**)

Figure 3.5: The framework of events.

As mentioned in **Section 3.1.3**, the result of the final choice determines the initial state of this section of the narrative (either **Group** or **Solo**). There are also events that change the state from Group to Solo and vice versa during the filler stages (events **GA7** and **SA7** respectively). The potential events for each event number are different depending on the state.

Some examples of variation events and their associated motivator values are given in **Figure 3.6**.

Event Identifier	Event Description	Power	Independence	Curiosity	Order	Saving	Idealism	Vengeance
GA1	Defeat Creature	1						2
GA2	Defeat Creature Loot	2	1	1		2		2
GA3	Storage Room			2				
GA4	Storage Room Loot	1	1	2		2		
GA5	Find dead			1			1	1
GA6	Find survivors			1	1	1	2	

Figure 3.6: A selection of variation events and their associated motivator values. For a full list of events and their associated motivator values see **Appendix D**.

The narrative content of these events defines each event's motivator values. For example, the event **GA1** has been assigned Power and Vengeance scores, because that event demonstrates the protagonist's strength and action in taking revenge. Event **GA2**, which adds looting the creature in addition to defeating it, subsequently contains a number of other motivator values. Additional Power, Curiosity and Saving values express the character's desire to use what they find, while Independence is present as this is an action that defies the DFR, who represent Order. The core reasoning behind these tendencies is outlined in **Section 3.1.2**.

The following table is an example of a complete variation as created by the Java program, along with the motivator values for each event and the **Variation Motivation Vector**. This Vector is made by summing the motivator values for all of the events into a single list of seven values.

Initial State = Group									
Event Identifier	**Event Description**	**State**	**Power**	**Independence**	**Curiosity**	**Order**	**Saving**	**Idealism**	**Vengeance**
GA1	Defeat Creature	**Group**	1						2
GA3	Storage Room	**Group**			2				
GK	Find Keystone	**Group**			2	2			
GA7	Become Separated	**Group**		1					
SA1	Defeat Creature	**Solo**	1	1					
SD2	Speak With Demon	**Solo**	1	1	2				
SG	Rescue Group	**Solo**		3			1	2	
SE1	Escape	**Solo**							
SC	Close Gate	**Solo**		3		3			
Variation Motivation Vector			**3**	**9**	**6**	**5**	**1**	**2**	**2**

Figure 3.7: An example of a variation, the events associated motivators, and the Variation Motivation Vector for that variation.

The motivator values assigned to each event in a variation are summed to create a list of seven values (the **Variation Motivation Vector**) that can be used to define overall narrative content of that variation. This works in the same way that the choices made by a player in the interactive game results in a similar list of seven motivators values (the **Player Motivation Vector**). The similarity of these two Vectors is vital for the comparison process outlined in **Section 3.1.6**.

3.1.5 Variation Selection

The final step of this system is to choose a narrative variation to match the choices that the player made. As both the player's choices and the variation can be defined by a list of the values for each of the seven motivators, finding the best variation is simply a matter of finding the best match. Firstly, both the **Player Motivation Vector** and the **Variation Motivation Vector** are to be normalised. The amount of normalisation that occurs directly controls the complexity of the selection process. For this prototype, a scale of six values (0-5) for normalisation provides both reasonable complexity and manageable calculation times[3].

The normalisation process is performed on four different Motivation Vectors Sets. As the final choice of the interactive story (**Solo** or **Group**) results in a change in the potential initial variation event, the original Sets for the Player Motivation Vectors and Variation Motivation Vectors are also separated in this manner. As mentioned previously, each Set contains only unique Vectors. The major Sets of Vectors are therefore:

Vector Set	Total Size	Quantile Size
Solo Player Motivation Vector	12960	2160
Group Player Motivation Vector	12960	2160
Solo Variation Motivation Vector	22483	3747
Group Variation Motivation Vector	10586	1764

Figure 3.8: The distribution of Vectors into Sets, the size of each Set and the quantile size of each Set.

[3]Manageable calculation times proved to be a major restriction in the complexity of the normalisation process. Attempts to use a normalisation scale of 0-10 proved far too intensive, especially for the matching algorithm. The additional five values resulted in an increase of possible moves from twenty to seventy. While the better granularity of values that the larger normalisation scale provides better definition of values, which in turn improves the accuracy of finding the best match, the calculation times involved became unreasonably long. Therefore, the normalisation scale was reduced to 0-5 in order to maintain reasonable deployment times.

While the Player Motivation Vectors are split evenly into their two associated Sets, the difference in the number of initial potential events increases the number of total variations if the player's final choice was **Solo**.

The normalisation process itself is relatively simple. In order to normalise each value, each value in the Vector is treated individually. As each Vector is made up of seven values, each value in a given position is normalised in relation to the value in the same position in other Vectors in the Set. The value is then changed to the number of the quantile it is part of, with the remainder going into the last quantile. In this implementation, the first quantile is numbered **0**.

For example, the Vector **4776140**, which is part of the Solo Player Motivation Vector Set, is normalised to **2245210**. This means that the first value, **4**, is located within the third quantile, so is changed to **2**. Alternatively, the sixth value, also **4**, instead lies within the second quantile for that value, and is therefore labelled **1**. Interestingly, the second value, **7**, is located in the third quantile. This is because there are a number of high scores for this value within this Set, so the value of **7** is comparatively low.

This process converts the initial Vector, which may contain values between negative four and fifteen, to one that only contains the values from zero to five, allowing easy comparison.

Even though Vectors from story choices and generated variations can now be easily compared, there are only a fraction of story paths that result in Vectors that exactly match a variation's Vector (385 out of 25920). It is possible, therefore, for the selection system to judge how 'close' two Vectors are. This is completed with the use of a weighted edit distance system. Alternatively, using an unweighted system or (as the values are all numbers) a more mathematical comparison process would treat each difference equally. However, the implementation of these motivator values as indicators of the player's tendency towards or against a certain preference makes this equal treatment undesirable. The reasoning for different weights for different distances is important in highlighting tendencies towards these preferences.

If there is no exact match, there are a number of changes that can be made. Each change has a weight associated with it (see **Figure 3.9**) and the selection algorithm will attempt to find a match using any number of changes with the least total value. The particular weights of each move have also been justified.

Move	Value	Reasoning
0 -> 1	2	Extreme values are more unlikely, therefore these should be a priority to modify. In addition these changes represent a minor scaling of tendency.
5 -> 4	2	
1 -> 0	3	These moves are unlikely to find a match, as they are making the scores more extreme. However, they have little impact on the overall personality of the character, so there is little downside in including them.
4 -> 5	3	
1 -> 2	4	These are the most common moves. They are small scaling changes on each side, and lie in the central groups. As these changes impact more on the representation of tendency, however they have greater weight. These changes are most useful in combination with the earlier ones, and may provide a small change that delivers a match.
2 -> 1	4	
3 -> 4	4	
4 -> 3	4	
2 -> 3	10	Because these moves cross the middle mark percentage, they represent a shift from a weak tendency to a strong one, or vice versa. This makes them very poor choices for moves, as they might change the core personality of the character
3 -> 2	10	

Figure 3.9: The list of values for each move.

In general, the value of each move is based on how likely a move is to find a match and whether it changes scaling direction. Moves that represent a scaling of the score, like 1 ->2, are far more preferable to those that represent a change of tendency, like 2 ->3. Also, the values at the extreme ends of the scale are more unlikely to find matches, and any moves to minimise these extreme cases are also preferable.

As there can be multiple moves on the same integer, the above table results in the following values:

Start Value							
	5	23	20	16	6	2	
	4	21	18	14	4		3
	3	17	14	10		4	7
	2	7	4		10	14	17
	1	3		4	14	18	21
	0		2	6	16	20	23
		0	**1**	**2**	**3**	**4**	**5**
	End Value						

Figure 3.10: The table of all total values.

For example, as the difference between the values of 5 and 4 is only 2, the distance between the Vector 0125443 and the Vector 0124443, which only requires a change from 5 to 4, is therefore 2. Other cases result in much higher distance values. The distance between the Vector 0000000 and the Vector 5555555 is 161.

These values can be used to determine how close two Vectors are, and can therefore be used to find the closest Variation Motivation Vector for a given Player Motivation Vector. This is achieved by a simple algorithm that calculates the difference between the Player Motivation Vector and each Variation Motivation Vector in the relevant Vector Set. For example, if the Player Motivation Vector is within the Solo Player Motivation Vector Set, then only the 22483 Vectors within the Solo Variation Motivation Vector Set are checked. The algorithm returns the Variation Motivation Vector that is the closest to the Player Motivation Vector. In the case of several equally close Variation Motivation Vectors, the last one checked is chosen.

Variation Retrieval

As the calculation of the best match requires comparing the choices that the player made with either 22483 or 10586 variation alternatives (see **Figure 3.8**), it is not feasible to generate and compare all of these variations at runtime. In fact, as this prototype is to be used in a voluntary study, it is important to not force the participant to wait for the system to perform time-consuming calculations. Instead, both the narrative generation and matching processes are pre-calculated. As the potential results from the player are limited, it is possible to simply calculate every unique combination of player choices and the best variation for each of them. This means that when the player finishes the interactive story, they only need to wait for a quick database call to retrieve the best variation for them.

To achieve this, two PostGreSQL databases are used to store the values for every unique Player Motivation Vector and the contents of the variation that is closest matched, one for each state (**Solo** or **Group**). The column types of both databases are described by **Figure 3.11**[4].

Name	Type	Description
rawInput	Varchar(100)	The un-normalised Player Motivation Vector
BestMatch	Varchar(100)	The list of the event identifiers of the closest matched variation

Figure 3.11: The pre-calculation database.

[4]A Varchar is a string of text, in this case with a maximum of 100 characters

3.2 Preliminary Analysis

Before the prototype could be deployed for this project, it was important to perform some analysis on the data trends that exist within the story's design. As the data values for story actions are relatively arbitrary, it is vital to ensure that no unexpected or undesirable tendencies occur within the data as a whole. This analysis focusses on examining both the correlation between motivators and the balance of distribution in the story actions. This analysis led to minor adjustment of the motivator values until a more balanced outcome was achieved.

3.2.1 Correlation

The first process of the data analysis was to remove or justify any correlation within the story actions of the first half of the narrative. The design focus of this was to allow the player to exhibit any motivator independently, which means the player should be able to exhibit any motivator, without being forced to exhibit any other. Conversely, the player should also be able to exhibit any two motivators without them necessarily conflicting.

However, within the story of the design, some correlation was inherent. As part of the design of the story, the player is often given the choice between agreeing or disagreeing with the authority figures. This is reflected in the motivator values by a distinction between the Order and Independence motivators. The nature of the story, therefore, causes a negative correlation between these two motivators. This correlation is rationalised by the story, and can therefore be justified and kept intact.

In order to measure the correlation of the story components, a complete list of all possible choice paths was created. This resulted in just over 33,000 unique motivator values. A simple correlation analysis of these values resulted in the **Figure 3.12** below.

	Power	Independence	Curiosity	Order	Saving	Idealism	Vengeance
Power	1						
Independence	0.52601	1					
Curiosity	0.04011	-0.01502	1				
Order	-0.50884	-0.69681	0.10531	1			
Saving	-0.10204	0.05689	0.15094	-0.34561	1		
Idealism	-0.10860	0.19855	-0.05989	-0.27479	0.09548	1	
Vengeance	0.18257	-0.05816	-0.41458	-0.21478	-0.12468	-0.26570	1

Figure 3.12: The correlation analysis from Version 1.

As seen by the values highlighted, there were a number of high correlation (greater than positive or negative 25%) values within this first version. Specifically, the motivators with strong correlation were:

Independence and *Power*
Order and *–Power*[5]
Order and *–Independence*
Saving and *–Order*
Idealism and *–Order*
Vengeance and *–Curiosity*
Vengeance and *– Idealism*

These correlations could be grouped into the following:

(*Order*) vs. (*Power* and *Independence*), (*Saving*) and (*Idealism*)
(*Vengeance*) vs. (*Curiosity*) and (*Idealism*)

[5]The '–' sign before the motivator indicates that a positive value for the first motivator correlates to a negative one for the second.

These conflicts between motivators became the primary focus of this analysis. The previous example of *Order* vs. *Independence* exhibits a particularly strong negative correlation in **Figure 3.10**. Other examples, like *Vengeance* vs. *Curiosity*, make logical sense within the story. A character focussed on enacting swift revenge on the villain is unlikely to be too interested in gaining a scholarly understanding in the short term. In addition, the authority figures in the narrative discourage actions that relate to *Power* and *Saving*, so these motivators are also logically against the *Order* exhibited by working with them.

However, the correlations of *Order* vs. *Idealism*, and *Vengeance* vs. *Idealism* were unjustified. In order to reduce this correlation several iterations of modified values were implemented, with the focus of distinguishing *Idealism* from *Order* and *Vengeance*, as well as reducing the strength of the other major correlations.

This reduction of unwarranted correlation was achieved through a process of iterative adjustment. By adding or removing a motivator from a choice, high correlation can be reduced. For example, by including a value for the *Idealism* motivator in a choice that already includes the *Order* motivation, the negative correlation between the two is reduced. Conversely, removing a motivator value for the *Power* motivator from a choice that contains the *Independence* motivator reduces their positive correlation. Each change was chosen as an attempt to remove one of the unjustified correlations, or reduce the severity of one of the necessary ones. Adding or removing motivators required reanalysis of the existing values prescribed to each choice as well as the dialogue for that choice. This is to determine whether a change in motivators present in a choice fitted within the dialogue for that choice, or whether the dialogue choice needed to be modified to exhibit the additional motivator. An iterative process of adjustments and reanalysis removed the unjustified correlations and reduced the necessary ones.

An example of this was the inclusion of the *Independence* motivator in choice **5.2** (see **Appendix C**). This choice already reflected in the action made by the player of that choice, by the player acting directly against the DFR, so the inclusion of this new motivator was within the scope of the choice already.

The end result of these iterations are the correlations in **Figure 3.13**.

	Power	Independence	Curiosity	Order	Saving	Idealism	Vengeance
Power	1						
Independence	0.52601	1					
Curiosity	0.04011	-0.01502	1				
Order	-0.50884	-0.69681	0.10531	1			
Saving	-0.10204	0.05689	0.15094	-0.34561	1		
Idealism	-0.10860	0.19855	-0.05989	-0.27479	0.09548	1	
Vengeance	0.18257	-0.05816	-0.41458	-0.21478	-0.12468	-0.26570	1

Figure 3.13: The correlation analysis from Version 8.

The correlation exhibited in this version of the story is strictly in line with the justification provided above. The only strong correlations that remain are those which are inherent in the story. This means that the goal of allowing for a player to exhibit one motivator independent of others has been achieved within the bounds of the narrative. Within larger implementations of this prototype, the expanded narrative available will allow for even these remaining correlations to be minimised.

3.2.2 Distribution

The other major piece of data analysis that was performed before the start of the study was the distribution of motivators. This was to ensure that the story actions provided equal opportunity for the player to exhibit any level of intensity towards each motivation. This analysis used the same base data that was created for the correlation analysis, but instead used it to produce distribution graphs for number of the occurrences of each motivator. The aim of this analysis was to understand the distributions and then produce a more rounded version. Ideally, a perfectly bell-shaped distribution graph would reflect that there is ample opportunity to exhibit a motivator in a moderate amount, while the more extreme values require more consistent actions. Therefore, a bell-shape is the ideal distribution graph, so the iterative changes to the motivation values are designed to achieve this outcome for all of the motivators.

Initially, several of the distribution graphs already exhibited bell-like shapes, but others were much less well defined. To rectify this, an iterative process similar to that which was used to reduce correlation in **Section 3.2.1** was performed. This was achieved in by performing one of two changes. Firstly, the value for a motivator score could be reduced, but not removed. These new smaller occurrences of a motivator score improved the shape of the distribution graph by allowing for a more gradually sloped bell-shape. Secondly, the inclusion of new motivator values to a particular choice increased the overall potential maximum for that motivator, and again improved the conformity towards the ideal bell-shaped graph by increasing the number of smaller occurrences of a motivator. Like in **Section 3.2.1**, this additional motivator also needed to fit the dialogue associated with that choice, or the choice needed to be adjusted to exhibit that motivator as well. Each change made to the existing motivator values of each choice contributed to one or more motivator's distribution among the choices improving as exhibited by the corresponding motivator distribution graph.[6]

[6]It is important to note that while these adjustments to the story actions were being made with distribution from **Section 3.2.2** in mind, these changes also had an effect on the correlation analysis from **Section 3.2.1**, and vice versa. However, as the analysis was mostly done in parallel, the data could be monitored for unforeseen side effects from each change. Therefore no major problems occurred as a result of these adjustments.

By performing several iterations of modifications, the overall conformity of the distribution graphs to the ideal bell-shape improved drastically. The final analysis (Version 8) resulted in the following distribution[7].

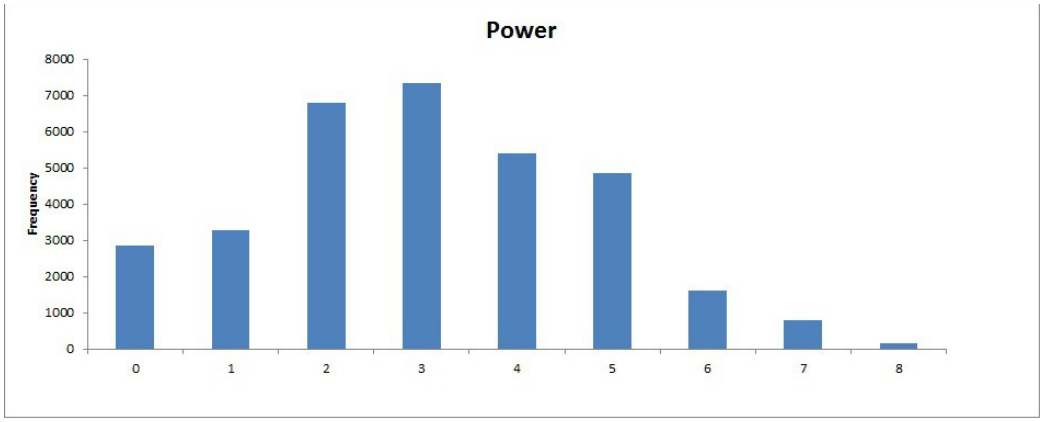

Figure 3.14: The distribution graphs for the *Power* motivator in version 8.

[7]Each of these graphs has an x axis of the total motivator value of that story path, and a y axis of the number of unique occurrences of that value.

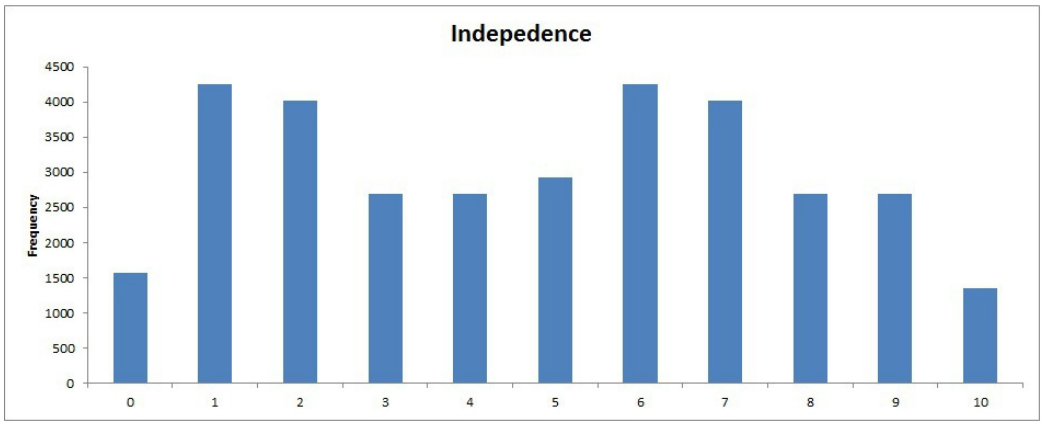

Figure 3.15: The distribution graphs for the *Independence* motivator in version 8.

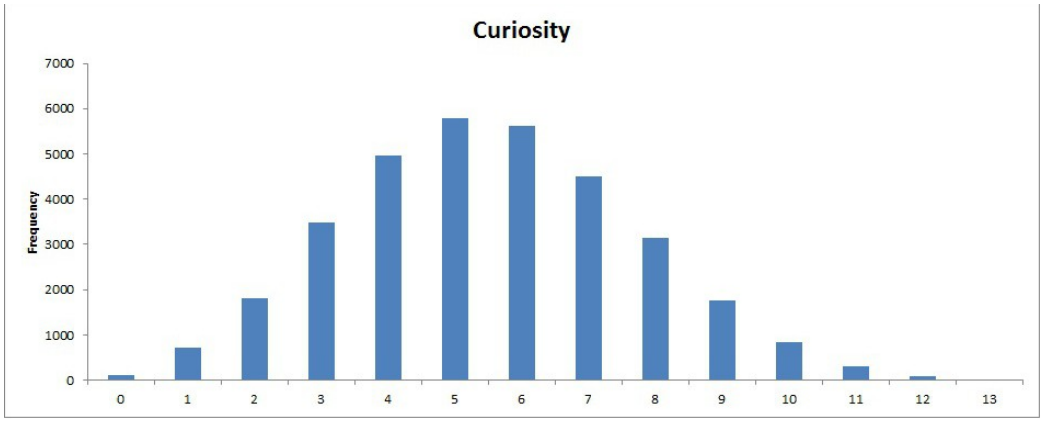

Figure 3.16: The distribution graphs for the *Curiosity* motivator in version 8.

Figure 3.17: The distribution graphs for the *Order* motivator in version 8.

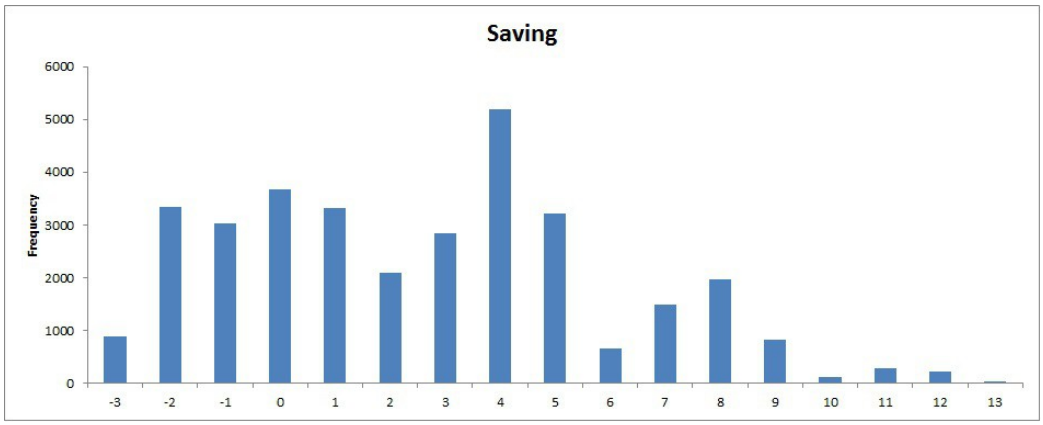

Figure 3.18: The distribution graphs for the *Saving* motivator in version 8.

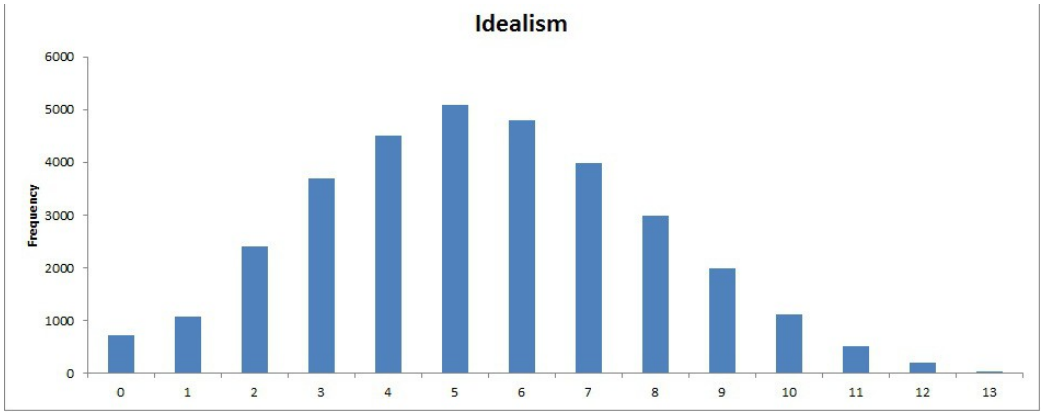

Figure 3.19: The distribution graphs for the *Idealism* motivator in version 8.

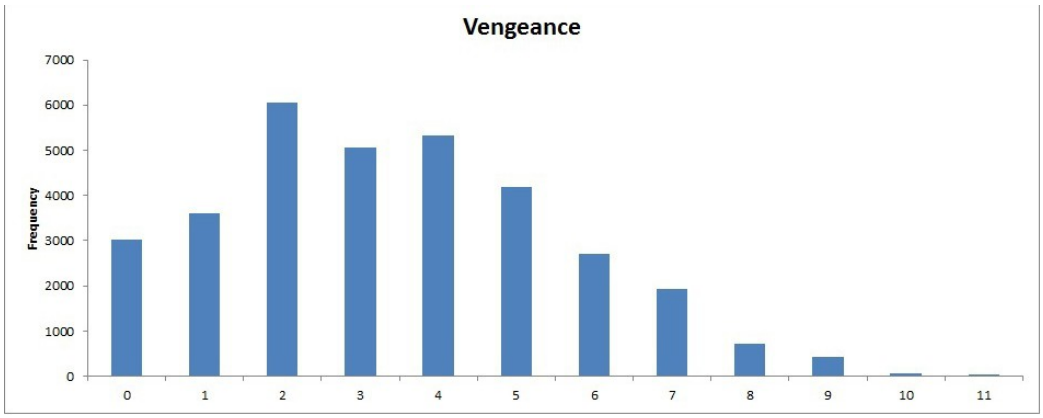

Figure 3.20: The distribution graphs for the *Vengeance* motivator in version 8.

The distribution graphs from data analysis of Version 8 demonstrate a distinct improvement towards the ideal bell-shape mentioned previously. There are only two distribution graphs that do not exhibit the ideal shape. *Saving*, which contains a few choices that exhibit either very strong positive or regular negative, remains quite unbalanced. It's very limited application to the story resulted in extreme motivators being assigned. Significant modifications of the overall narrative would be required to allow for a more nuanced application of this narrative. *Independence's* distribution graph also remains unbalanced, clearly exhibiting two peaks. This is due to the fact that the final choice very heavily exhibits this motivator. The player choosing to continue alone is a very clear demonstration of that player's desire to be independent, while the choice to remain with the group exhibits the opposite tendency. This results in two distinct bell-shapes within the distribution graph, with that final choice affecting the potential range of that each. Therefore, this distribution graph does reflect the opportunity for the player to exhibit their *Independence* in different ways.

The overall improvements seen in the distribution of the other motivators leads to more equal opportunity to achieve any level of intensity for each motivator. This, along with the reduction in unjustified correlation, improves the balance of the values attributed to the story actions, and allows for the player to exhibit any combination of motivators more freely.

3.3 Study

This study's primary goal is to test the primary hypothesis, but also to gather information that will allow for the additional testing of the supporting hypotheses as proposed in **Section 3**. While the main result of the player's preferred variation is used to test the main hypothesis, information about the alternative choices provided, the motivators of the player when making a choice in the game and whether the player has participated in the study before all allow for the proper testing of the supporting hypotheses, and the correctness of the system in general.

This study consists of each participant completing the interactive story as described in **Section 3.1.3**, answering a short set of feedback questions. The foremost of these is the player's choice of best narrative variation, which presents the player with three potential continuations of the narrative, and asks them to choose the one they prefer. The player is also asked to assign the motivators that impacted their choice at two random points in the game, and whether or not they have participated in this study previously. Data based on the player's choices in the narrative and their feedback responses are then recorded for analysis.

The data collected in the study is outlined in the following table.

Name	Type	Description
ID	Serial[1]	A unique identifier for each participation
Scores	Varchar[2](50)	The motivator scores from the players run
Path	Varchar(50)	The path the player took
Var1	Varchar(50)	List of events in column 1
Var2	Varchar(50)	List of events in column 2
Var3	Varchar(50)	List of events in column 3
Best	Integer	Which column contained the recommended variation
Choice	Integer	Which column contained the chosen variation
Question1	Varchar(50)	The first choice that the user is asked feedback about
Response1	Varchar(50)	The response about this first choice
Question2	Varchar(50)	The second choice that the user is asked feedback about
Response2	Varchar(50)	The response about this second choice
Previous	Integer	Whether the user has participated before

Figure 3.21: The data collected in the study.[89]

In each case, the final score for each of the motivators (**Scores**) and the choices that the participant made (**Path**), along with a unique identifier for that entry (**ID**), are recorded. These are vital for analysis, as they provide a foundation from which the player's choice of variation can be better understood.

This data is collected using cookies and SQL. As the player progresses through the interactive game, their choices are being recorded to a cookie local to their web browser. The other player response sections record the player's feedback into a local cookie as well. At the end of the player's participation in this study, the website uses SQL to record the contents of those cookies to the study's storage database. Once this recording process is completed, the cookies are removed from the participant's browser.

No personal information is gathered. This is a crucial decision to reduce any potential deterrents for participants. While additional information may allow for more detailed results, the voluntary nature of this study increases the risk that a participant may terminate their participation for perceived privacy reasons. Therefore, the information gathered will be limited to only what is required to fully test the main and supporting hypotheses.

3.3.1 Participants

Before discussing the nature of the other feedback gathered in this study, it is important to understand the participants involved, who fall into two distinct categories. The first group are those involved in the online interactive fiction communities. The creators of the Twine software host forum designed for writers to advertise their creations to potential readers. The forum post created for this prototype is located here . Additionally, many Twine[10] interactive narratives are also advertised on the Interactive Fiction Database. This is another online community of stories and forum that allows creators to advertise to interested readers. This prototype has a listing on this website here[11].

Both of these sites allow the prototype to attract participants who are interested in the field of interactive fiction, and have experience with the medium. These participants are likely to already understand the methods and concepts of the game that was created. In fact, many of the listings on the Interactive Fiction Database are written in Twine, so this prototype will be very familiar to these participants. Due to their experience in this area and their interest in narrative fiction in general, the feedback from these participants will likely exhibit more cohesive character motivations.

The second group of participants are those that were recruited personally by the investigator of this project. While these participants are not necessarily familiar with this type of implementation of interactive narrative, or even interactive narratives in general, the operation of this system is simple enough that even novices in this area will be able to participate easily. The more general experiences from these participants will cover the more broad case of an average user.

While the differences between the two groups may yield different results, this study is designed to test the system in a generic manner. Therefore, collecting information about which group a participant belongs is not necessary.

Each participant is provided with an information sheet that outlines the

[10] http://twinery.org/forum/discussion/4678/narrative-generation-and-interactive-stories-research

[11] http://ifdb.tads.org/viewgame?id=pgyqu7kvpfphn1j4

project and their involvement in it. This information sheet is provided as **Appendix E**.

3.3.2 Variation Alternatatives

The most vital component of the study is checking whether the variation selected by the system was preferred by that player. This is the information that will be used to calculate the main outcome of the study, which can be used to test the main hypothesis. In order to do this, the user is provided with a choice between the variation that the system chose, and two completely random other variations. Put simply, if the player consistently selects the variation that the system chose, then the variation selection process is a success.

The expected baseline for this variation selection is 33%. If the system also chose a completely random variation, then statistically the likelihood that the player would select that variation would simply be one in three, or 33%. Any result higher than this shows that the system has some success at predicting the player's choice. For this study, a binomial test that demonstrates that the system improves upon the base line with 95% confidence will be used to confirm the this result is statistically sound.

Each of the choices provided, as well as the choice that both the system and the user chose, are recorded as **Var1**, **Var2** and **Var3** for the three variations presented, the position of the system's choice as **Best**, and the players choice as **Choice** (see **Figure 3.21**).

The events of each variation is presented in a simple list, so that the player can see all of the variation in its entirety and compare directly. The user then reads each list of events and chooses which list of events they think is best. An example of the variations provided is below as **Figure 3.22**.

Thank you for playing my interactive story.

But the story is only half done.
Below are three columns, each presenting a possible conclusion to the story.
Read them all carefully, and choose the one best suited for your character.

Variation 1	Variation 2	Variation 3
You find a room that is filled with strange objects.	You stumble across the Demonic First Responders, and rejoin their group.	You stumble across the Demonic First Responders, and rejoin their group.
You stumble across the Demonic First Responders, and rejoin their group.	The group moves to a new room. You encounter and defeat a strange demonic creature. You take a trophy from its corpse without the others noticing.	The group moves to a new room that is filled with strange objects. You take some without the others noticing.
The group moves to a new room, and finds the Keystone.	The group moves to a new room, and finds the Keystone.	The group moves to a new room, and finds the Keystone.
The group moves to a new room that is filled with strange objects. You take some without the others noticing.	You become separated from the group.	The group moves to a new room that is filled with strange objects. You take some without the others noticing.
The group moves to a new room that is filled with strange objects.	You find a room that is filled with strange objects. You help yourself to some.	You become separated from the group.
The group encounters Kalvash, and together, you defeat her.	You encounter Kalvash and speak with her before leaving peacefully.	You encounter Kalvash and speak with her before attacking and defeating her.
The group uses the Keystone to escape.	You encounter the Demonic First Responders under attack, and save them from certain defeat.	You encounter the Demonic First Responders under attack, and save them from certain defeat.
Back in the real world, you close the gate stopping any more people from being taken through.	You use the Keystone to escape.	You use the Keystone to escape.
	Back in the real world, you close the gate stopping any more people from being taken through.	Back in the real world, you close the gate stopping any more people from being taken through.
Choose Variation 1	Choose Variation 2	Choose Variation 3

Figure 3.22: The presentation of the variation choice.

Note: As the variations can be either eight or nine events long, there is often a blank space in the list of events.

In order to remove positioning bias, the order that the three variation options are presented is randomised.

As the alternatives are chosen randomly, there is the chance that they might be incredibly similar to the system's selected variation. In fact, it is possible that the three variations might be exactly the same, though this is statistically improbable. In cases that contain similar variations, while the user might not have made the same choice as the system, they may have chosen an alternative that was essentially the same. It is therefore important to record the alternative variations that are provided for the user to choose between in every case. The examination of these cases might prove that they are in alignment with the system, despite a different choice being made.

Recording the alternatives also allows for better analysis of other cases as well. If the user agrees with the system, the alternatives provided in that case are as much responsible for that choice as the recommended variation. For example, if alternatives that are not selected consistently contain a particular event, that event may be a specific deterrent. This kind of connection will be investigated in **Section 4.3**.

In the case that the user does not agree, that information will be vital in the improvement of the selection process. In general, these cases will indicate areas of difficulty which may be able to be traced back to mistaken assumptions or incorrect calculations. By analysing commonality and correlation between these cases, it will be possible to test the supporting hypotheses, determine where the issues in the system lie and provide focus for the further improvement of the system.

3.3.3 Assign Motivators

As mentioned in **Section 2.2.3**, a potential problem with player-based modelling is the assumption that users will agree with the weightings of motivators that were assigned in development. This risk is addressed by the testing of the third supporting hypothesis that "The weightings of motivators assigned to each player choice reflect most players' reasoning behind that choice". As this scope of this study is limited, this problem is compounded with greater risk of errors resulting from an incorrect assumption. Unfortunately, this problem can only truly be mitigated in the development process. By testing this hypothesis in this feedback section, the correctness of the assumptions made can also be tested.

After the main variation choice section, the user is prompted with two random choices that they made in the game. They are then asked which of the seven motivators are responsible for each decision. This allows the user to provide their own reasoning behind the decisions that they made. This will allow for a comparison between the motivators that the user selected and the ones that were included in development. This data is recorded as **Question1** and **Question2** for each of the choices the user is prompted with, and **Response1** and **Response2** for the motivators that they responded with (see **Figure 3.21**).

As the user answers by selecting one or more of the seven motivators, their response can be easily compared to the motivators attributed to that choice in development. Asking for a plain English answer is not practical, as the psychological concepts of motivation are difficult to explain in a consistent manner, and would require a sizable amount of interpretation, reducing the value of the responses. However, it is possible that the brief description for each may not be sufficient to explain the concepts behind them. This may result in some users giving flawed responses due to misunderstanding. However, unless there is consistent misunderstanding across the participants, these flawed responses will only appear as outliers in the data. The risk of this is far outweighed by the benefits that this data will provide. The definition of the seven motivators within the context of the question is below in **Figure 3.23**.

The results from these questions, in addition to testing the third supporting hypothesis, will also be vital in the further development of the system.

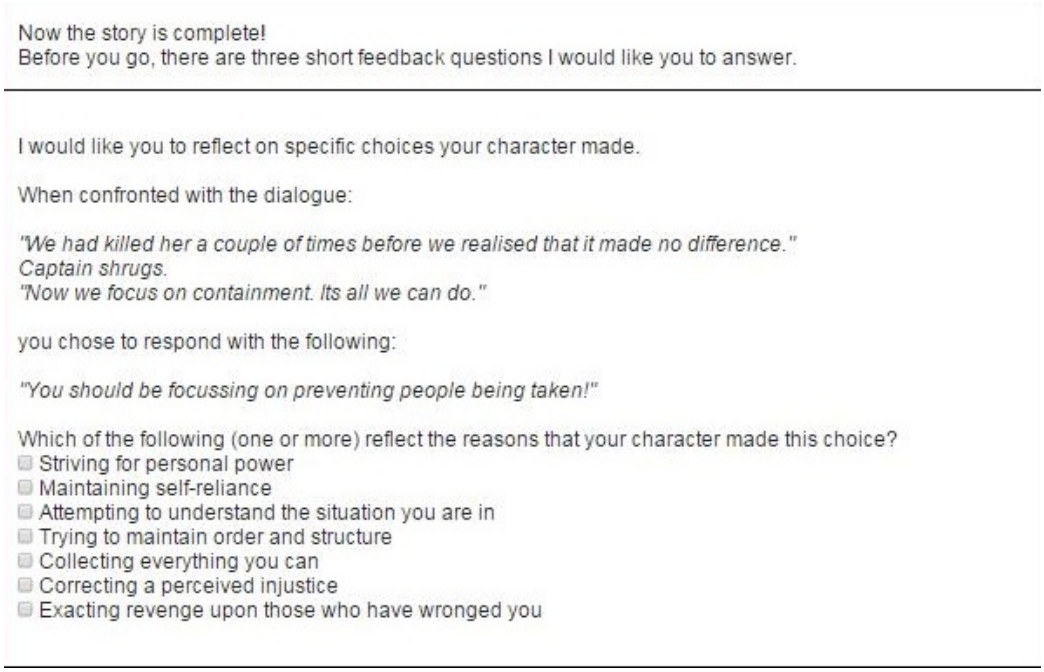

Figure 3.23: The presentation of one of the motivator assignment questions.

They provide direct feedback on any assumptions that were erroneous in the development of this prototype. These assumptions can be corrected in future versions of this narrative, but may also represent a trend in mistaken assumptions in the development process more generally. If these trends can be understood, they can assist in future implementations of the system by correcting the incorrect assumptions of the development process.

In the future, it would be best to couple such a feedback system in the testing stage of development with a more collaborative writing process. The greater number of backgrounds and opinions that are involved would reduce the magnitude of any incorrect assumptions, and lessen the risk of these assumptions interfering with the generation of quality narratives. Alternatively, this kind of assumption test could be more subtly integrated in the narrative of the system.

3.3.4 Repeated Participation

The final question in the feedback asks if the participant has partaken in this study previously (**Previous** in **Figure 3.21**). This data allows for the testing of the supporting hypothesis that "*A player that repeats the game will behave in the same way as a player who plays it for the first time*". It may transpire that individuals on their successive attempts at the story become more likely to agree or disagree with the system's decision. This kind of trend may demonstrate that the players are adapting to the system in either a positive or negative way. It is possible that players may become more used to the medium or be able to understand the system after repeated attempts. Either way, the collection of this data will allow for such analysis to occur.

Chapter 4

Results

The study for this project ran for six weeks, from the 26th of August to the 7th of October. During that time, there were 39 different run throughs of the game and feedback sections. While this was not as many participants as was hoped for, it still provides enough information to perform useful analysis on major trends and specific areas. Using these results to test the main and supporting hypotheses is vital to prove the validity of this prototype and the concepts involved. There is much more potential analysis that can be performed on the results of this study, and many improvements to the system that can be made as a result.

A full list of results can be found in **Appendix F**.

4.1 Matches

The most crucial result from the study performed is linked to the main outcome of this project: "*Whether or not the developed system is able to consistently predict which variation the player will prefer*".

This result is gathered by the comparison between the variation that the system selected and the variation that the player chose in the feedback section (see **Section 3.3.2**). If these two values are the same, then the system was able to correct predict which of the variations that the player would prefer.

The main result for this study was that in 15 of 39 entries, the variation that the user chose was the same as the system selected. This means the system was only able to predict the variation that the player would prefer 38% of the time. This marks a small improvement over the expect 33

By using a binomial distribution test, it can be said with 80% confidence that the system provides an improvement over the random case. This is far less than the 95% confidence required to confirm that the system does improve the likelihood of presenting a preferred variation. There is therefore not enough certainty to prove that the outcome of the system is consistently successful. It remains possible that the result is only an improvement over the base case due to normal statistical variation rather than the correctness of the system.

However, the result is not low enough to demonstrate that the system is unlikely to have caused the improvement. The confidence level of 80% indicates that while it is likely that the system did result in an improvement over the base case, it is also somewhat possible that it did not. This main outcome is therefore inadequate when suggesting whether the prediction is correct or not.

As this main outcome remains inconclusive, it cannot be used to prove or refute the hypothesis. It is therefore important to test the supporting hypotheses to test the validity of the system as a whole.

4.2 Repeat Participants

As part of the feedback section, participants were asked whether they had participated in this study before. This was an attempt to identify outliers in the data, as it was expected that participants who had played the game before would become more familiar with it, and be easier for the system to predict which variation they prefer. However this was not the case.

In fact, the opposite was true. The results showed that of the 7 entries of data from repeat participants, only 1 chose the variation that the system predicted. This result, 14%, is far lower than the 38% result from the data as a whole. This indicates that those participants who repeat the game are far less likely to choose the variation that the system predicts, than those who did not repeat.

The expected result from this data was that repeat participants would be more likely to choose the variation predicted. It was expected that on subsequent attempts, players would learn about how the system operates, and perhaps guess how the structure of motivators works. This better knowledge of the system and how it works would allow the player to act in ways that better match the system's design, which would in turn allow the system to be more accurate with its predictions.

The fact that the repeat players were less likely to choose the predicted variation shows that this assumption was incorrect. A potential explanation for this result is that on repeated play throughs of the game, the player tried new things. As they had already completed the game previously, these new attempts allowed the participants to explore the mechanics of the system, rather than project a personality onto their character in a consistent manner. This resulted in inconsistent and unpredictable actions by the player, reducing the ability of the system to accurately predict the player's preferences.

In fact, repeating participants are not ideal for this kind of player-based modelling system. The main focus of the game process is to build an image of the player's actions that can be used to select quality content for them. The longer the game continues, and the more actions the player makes, the better this image of them will be. By having a player repeat the game from

the start, the system loses this image entirely. It has no way of knowing that this new player has already completed the game, and that the system already has information about their preferences. The player, on the other hand, already knows a lot about the narrative and the game. This existing knowledge base affects their choices in ways that the system cannot predict.

An ideal case of player-based modelling would never involve such a restart. Actions would constantly and consistently build towards the same visage of the player, allowing for a better and more accurate understanding of that player's preferences. It is illogical to discard all of this important information.

So, if these cases are treated as outliers, the main outcome becomes considerably more positive. Of the 32 non-repeat participants, 14 chose the same variation as the system predicted they would prefer. This means that this outcome occurred 44% of the time, a significant improvement over the 38% if these outliers are included. This further demonstrates that those repeat participants chose the predicted variation far less often.

However, the binomial distribution test results in only 92% confidence that the system is the cause of this improvement. As this is still less than the prerequisite 95% confidence that would demonstrate sufficient certainty, the main outcome of this study remains inconclusive. It therefore cannot be used to prove or refute the main hypothesis.

4.3 Variation Events

The second supporting hypothesis aims to test the variation events to confirm that none have more or less impact on the player's choice of variation. Specifically, the hypothesis is that "*Each component of a variation contributes to whether or not that variation is chosen*". The results, however, provide a number of cases that refute this hypothesis. Additionally, other results highlight events that demonstrate or contradict the system's accurate prediction of which variation the player will prefer.

The first step of analysing the variation events is to look for cases where an event is chosen more than expected. For example, the event **GE2** (see **Appendix D**) appeared as part of a potential variation 7 times amongst all of the participants, and it was chosen 6 of those times. This means that when this event appeared as part of an option, 86% of players chose the variation it was in[1]. This reflects very badly on the variation generation, as it means that this particular event alone plays a large role in the player's opinion of the variations. The extreme likelihood that the player will choose a variation that contains this event essentially reduces the need for the creation of the player-model at all. This reflects that all of the information that the system is using barely affects the player's preference when this particular event is involved.

In order to rectify this problem, analysis of this particular event is needed. The most likely explanation for the large number of players who preferred this event relates specifically to lack of viable alternatives. The narrative content of this event is that the player escapes the other dimension with the other rescuers and a group of people they saved. This is the most heroic of the potential endings, which makes it highly appealing to most players. The other alternatives for this event include escaping either with only the other rescuers, with only some rescued people, or without both. As the event where you save everyone is clearly better than these alternatives, it is obvious why most players who were presented with this option chose it.

[1]This does not include cases where this event appeared in more than one variation presented to the same participant. Each time this variation appeared, it was not part of any other option.

This problem can be fixed with some changes to the contents of GE2 and the alternative events. By reducing the heroic quality of GE2, or improving the appeal of the alternatives, the other events become viable alternatives to GE2, making them more likely to be chosen instead. This way, the player-model will again become important when predicting the player's choice between these particular events.

Another point of analysis when comparing the selection of variations based on the events they contain is how well the system can predict the player's choice of specific events, as opposed to the variation as a whole. This works well when considering a variation point that has a few distinct options. For example, one point in the variation (Event number 6) can contain one of five different events; **SD1**, **SD2**, **SD3**, **SD4** and **GD1** (see **Appendix D**). The comparison between which of these events the player chose and the event the system predicted is shown in **Figure 4.1**.

		System's Selection				
Player's Choice		SD1	SD2	SD3	SD4	GD1
	SD1	71.43%	0.00%	0.00%	0.00%	28.57%
	SD2	20.00%	60.00%	10.00%	10.00%	0.00%
	SD3	20.00%	40.00%	40.00%	0.00%	0.00%
	SD4	20.00%	0.00%	20.00%	40.00%	20.00%
	GD1	0.00%	8.33%	0.00%	16.67%	75.00%

Figure 4.1: The comparison between the choice of the player and the selection of the system.

This comparison provides some interesting insight into the accuracy of the system in predicting which of these events in particular the player will choose. For example, when the player chooses a variation that contains the event **SD1**, the system can accurately predict that choice 71% of the time. The rest of the time, however, the system incorrectly predicts that the player would prefer **GD1**. Once again, the analysis of the narrative content of these two events is important in understanding why the results are split in this way. In this case, both **SD1** and **GD1** involved the player confronting

and defeating the demonic antagonist of the narrative. Therefore, the system can always accurate deduce from the player's actions that they prefer to defeat the antagonist. The only point of conjecture is whether or not the player wishes to defeat the antagonist alone, as in **SD1**, or with the other rescuers, as in **GD1**. This analysis not only validates the accuracy of part of the prediction process, but also provides focus for potential improvements.

The next event **SD2** also provides insight into the successes and failures of the prediction system. When the user prefers this option, the system will predict that the player will choose from one of the Solo event options (**SD1**, **SD2**, **SD3** or **SD4**). This demonstrates that the motivator of Independence plays a large role in the system's prediction, but the player relies on other factors as well. The other data in this comparison table, as well as the rest of the results more generally, provide suitable testing of the relevant supporting hypothesis and direction for improvement of the system.

This analysis in general has proven that the supporting hypothesis related to specific events is incorrect for this system. The result of the analysis has shown several areas that refute the idea that all events are equally important. This analysis, however, also provides potential changes that could be made to improve the correctness and validity of the system. More analysis of these results and the results of further studies will provide more areas that require improvement to verify this supporting hypothesis.

4.4 Motivator Assignment

An important part of the feedback section was asking the player to justify their choices by using the seven of Reiss' motivators that were relevant to this narrative (see **Section 3.1.2**). This was aimed at testing the supporting hypothesis that '*The weightings of motivators assigned to each player choice reflect most players*' reasoning behind that choice". Testing this hypothesis and the assumptions made during the creation of the interactive game is an important part of testing the validity of the prototype.

Quantifying the feedback from this section was done by comparing what the player assigned as motivators behind their choice, and the motivators that were designed for each choice in the narrative. The two values used represent the amount of agreement and the amount of disagreement between the two. The amount of agreement is the percentage of values that were present in the design of that choice that the player also assigned (higher is better), while the amount of disagreement was the percentage of values that the player assigned that were not present in the design of that choice (lower is better).

For example, if the player responded by saying the motivators *Curiosity* and *Idealism* were relevant to their choice, and the design of the choice also had motivators *Curiosity* and *Idealism*, then the agreement is 100%, while the disagreement is 0%. Other examples are; player assigned *Curiosity* vs. designed *Order* = 0% agreement = and 100% disagreement; player assigned *Power*, *Independence* and *Curiosity* vs. designed *Independence*, *Curiosity*, *Order* and *Saving* = 50% agreement and 33% disagreement.

The overall agreement and disagreement across all motivator assignment feedback was 50.43% agreement and 39.50% disagreement. This shows that overall, players often allocated different motivators to choices than were designed for those choices in the game. This refutes the hypothesis that the most players agreed with the system on the assignment of motivators.

More specific examples are required, however, to highlight the erroneous choices. Some choices showed consistently high agreement with the player base. For example, choice **8.2** (see **Appendix C**), with a designed motivator of 3, had agreement and disagreement scores of 100% and 14.29%. This

means that every single player who was asked to assign motivators for this choice also said motivator number 3 was relevant. Some players responded with 3 *and* another motivator, which causes the disagreement to be non-zero, but 100% responded at least 3. This demonstrates that the motivator assigned to this specific choice does indeed reflect most players' reasoning behind this choice.

A possible explanation for this choice's success was that it was only designed with one motivator, *Curiosity*. As most of the player's feedback for this section was only to select the single main motivator for that choice, disagreements between a few motivators are less extreme. However, this reasoning is disproved by other examples. Choice **4.3** (see **Appendix C**), which is only assigned one motivator as well, received agreement and disagreement scores of 43% and 57%. This shows that just because a choice has only one motivator designed, does not mean that it will have high agreement. Additionally, choice **5.2** has the motivators *Independence*, *Curiosity* and *Saving* assigned to it, and achieves the good scores of 77% and 15%, while the choice 7.4 has motivators *Order* and *Idealism*, but only achieved 16% and 87%. These [2] demonstrate that the motivator scores designed for each choice, not the number of motivators, determines whether most players will agree. By examining the responses of the participant, the motivator values of the choices with poor agreement can be altered to be more in line with the general consensus of players.

One other case of motivator assignment is particularly relevant for the future design of the system. Of the 78 times that participants were asked to assign motivators for a choice, only once did a player say that the *Vengeance* motivator was important to their choice. This is most likely due to one of two problems. Firstly, it is possible that the narrative of the game did not provide enough incentive to act in revenge. This is also reflected by the number of players that chose variations that included a peaceful conflict resolution with the primary antagonist. Making the conflict with the antagonist more personal and providing additional reason to seek revenge would result in more players exhibiting this motivator. The other possibility is related to

[2]It is important to note that due to the small sample size of this study, a number of the choices received feedback only twice, once or, in a few cases, never. The examples above all received feedback either 6 or 7 times, so the information presented is far more balanced than those cases with a smaller frequency.

the negative connotations associated with revenge. Culturally, we are taught that revenge is a bad thing, despite the fact that it is proven by Reiss' theory and many others to be an important motivator. Explaining *Vengeance* in the feedback section more neutrally, or even renaming it to something less stigmatised (like *Justice*), might make more players admit to exhibiting it in their choices.

Overall, the analysis of the feedback regarding motivator assignments has refuted the hypothesis that the system reflects the motivators correctly. It has also provided particular choices and motivators that need adjustment to allow for more accurate reflection of the player's own motivations.

Chapter 5

Conclusion

As discussed in **Section 4**, the main result of the study is inconclusive. The main hypothesis that a player's actions can be used to estimate the narrative content they prefer can therefore be neither proven nor refuted. The likelihood that the system can correctly predict which of the presented variations that the player will prefer was an improvement over the expected base case, but not to a sufficient degree that it confirms the theory. Conversely the fact that the system led to an improvement at all means that the hypothesis has potential.

However, the testing of this main hypothesis was not the sole outcome of the study. The other feedback received tested the correctness and validity of the system in a number of specific areas, and found that the system used had several shortcomings. These flaws mean that the system itself was not adequate to properly validate the main hypothesis.

These results indicate areas of the system that require improvement in order to increase the consistency and accuracy of prediction. The feedback gathered can be used to highlight specific areas that contributed to the overall inaccuracy of the system, as well as those areas that were consistently successful. Further analysis of the results gathered will identify other incorrect assumptions and areas of erroneous design.

The fact that the main result proves the potential of the core concepts behind this system is a positive outcome. With further development of the prototype and future studies involving a larger number of participants, this type of approach should be able to conclusively prove or refute the hypothesis that actions made by a player in an interactive game determine the narrative content they prefer.

Appendices

Appendix A

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Appendix B

Interactive Game Passages

Passage Title	Narrative Content	Choices Present (Appenix B)
Start	As all good stories do, this one begins on an ordinary day. Your morning routine includes a trip to the same café you always visit. A brisk walk and a hot coffee clear the mind and focus you for the day ahead. As you push open the door of the café, however, your mind is cleared for another reason. The café is completely empty of people. No customers, no regulars, no staff, no one. Instead, right in the middle of the room, there is a strange purple hole in the floor. A bizarre square cut into the floorboards, its dark purple interior shifting and changing before your eyes. As you stare dumbfounded, the world suddenly lurches forwards. You are thrown off your feet, and slide towards the hole. Before you know it, you tumble over its edge, falling into darkness. You hit the ground hard.	**a**
Intro1	You sit up, rubbing the spot where your head throbs. You are in a completely unknown room. Its walls appear to be made of cut stone, but the floor is some kind of soft spongey material. Probably saved you from the fall. You look up to the ceiling, but see no hole through which you could have fallen. As you stand, you notice that each of the room's four walls have a doorway. No doors, but an impenetrable darkness prevents you from seeing into the next room. Before you get a chance to do anything however, a small popping sound comes from behind you. You spin around, and come face to face with a perfectly normal looking middle-aged man in a suit. Normal, except for the large, ornate blunderbuss in his arms. He looks startled to see you, but his face quickly softens. "You didn't come through the first surge, did you?"	**a** **b**

2	Your reply is hesitant. But he has already turned around, tugging on the end of a rope that is tied around his middle. A rope that seems to trail...nowhere? Your brain begins to ache as you try to understand what you are seeing. The man looks over and smiles at your wince of pain as you stare at the rope. "Don't think about it, it'll drive you mad," he says. You are completely distracted from the perplexing rope, however, as three other people materialise in front of you. One of the people, a woman, immediately moves to the wall of the room and examines it. "Roughly hewn, volcanic granite," she says, running a hand along its surface. "And..." she actually licks the wall. "Tarragon. Definitely Kalvash." "Decent chance there are some survivors then," says the first man. "Let's focus on finding the Keystone," says the another woman. She jerks her thumb in your direction. "We don't want more civilians dropping in." "Right," agrees the man, turning to face you. "You walked into the wrong café this morning, friend." "Welcome to Hell."	**a**
3	The younger woman smirks. "You always have to add the dramatic flair, don't you Captain?" "We don't often get to show off to actual people, do we?" grins the Captain in reply. "And technically, it's the realm of the demon Kalvash, not Hell proper," says the younger woman. "Not nearly as punchy though," He turns to the last member of the group. "Hey, Private! Shut that gaping trap of yours before the Corpse Flies get in!" The young Private had indeed been staring open mouthed at the room around him, but now shuts his mouth quickly, looking startled. "The briefing didn't mention anything about Corpse Flies!" he says, looking worried. "That's because there is no such thing," says the older woman. "Come on Captain, give him a break. Don't you remember your first mission?" The Captain opens his mouth to speak, but the younger woman interrupts him. "Poor Captain's memory isn't what it used to be, Corporal," she says, the pity in her voice ruined by the sarcasm dripping off it. "There might be a scroll in the archive that records the ancient tale." They both laugh, the sound echoing strangely off the walls of the small room. The Private seems unwilling to join in. You don't either, still overwhelmed by this strange turn of events. Laughter will not come easily in this place. The Captain, looking disgruntled, unties himself from the rope, leans his gun against the wall, and approaches you with his hand outstretched. "We are part of the Demonic First Responders, fast response team against demonic incursion. The name's Captain."	**a**

Hub1Display	"This here is Lieutenant," Captain says, gesturing to the young woman who had examined the wall earlier. She looks quite young, but has a confidence that far surpasses your own. She grins at you, clearly comfortable in this place. "That's Corporal," he points to the other woman, who looks older than the first, yet still athletic and strong. She nods at you, but quickly returns her gaze to the room at large. "And the greenhorn is Private," he indicates the youngest of the group, who waves nervously at you. Captain turns to the others. "Let's check these doors. The Keystone must be our priority." He turns back to you as Corporal, Lieutenant and Private move to the doorways from the room. "Unfortunately, now we're in, we can't get out until we find the Keystone. That will allow us to open the Gate back to the real world," Captain continues. "Once done, we can shut the Gate from the other side, locking it for good."	
Hub1	**After <a> and <b> and <c>** As you speak, the others are moving around the room. Corporal and Lieutenant are examining one of the doors, discussing something complicated about it. Private on the other hand is moving around the room, carrying a large wooden mallet and a silver chisel. He is using them to systematically destroy a series of small red objects, something like totems or statuettes.	**a** **b** **c**
Location	"When you entered the café this morning, you were pulled through a Gate to another dimension. One created and controlled by a demon. Kalvash, to be specific."	**a**
Location2	"It may be difficult to understand," Captain smiles sympathetically. "Demons open Gates in populated areas. We are here to retrieve the keystone and close it before Kalvash takes anyone else."	**1.1** **1.2** **1.3**
Location3	"Honestly? We don't know, but it never ends with the folks still alive, so we try to stop it."	**2.1** **2.2** **2.a**
Location4	"Just hope that we don't run into them," Captain responds	
Keystone	"The Keystone can be used to open a way back to the real world, yes. More importantly, it is the only way that the Gate can be closed from the outside."	**3.1** **3.2**

Keystone2	**If <3.1>** Captain looks at you curiously before explaining. "It's quite simple actually. To return back to our world, you just have to touch the keystone to one of these granite walls," He says gesturing to the nearest rough wall. "That will turn it's door to a Gate back." "As for closing the Gate from the otherside, passing the keystone through the Gate is enough to disrupt the portal. We just take the keystone with us on our way out, and the Gate closes behind us." He looks at you shrewdly. "But we can show you exactly how it is done when we get it." **If <3.2>** Captain nods. "Exactly. The sooner we get it, the sooner we get out."	
Civilians	"Our first priority must be closing the Gate as soon as possible," Captain responds. "We will, of course, save anyone that we can, but we can't afford to lose focus."	**4.1** **4.2** **4.3**
Civilians2	**If <4.1>** Captain looks angry at you words. "It's not like we have a choice! We just don't have to resources to mount a full scale rescue operation every time one of these accursed Gates opens. Containment is more important." He looks at you imploringly, trying to make you understand. "Anyway, we can argue over ethics once we get the Keystone and get out of here." **If <4.2>** Captain grimaces at you words. "I know it seems callous, but we have to close the Gate as soon as we can. The greater good, and all that." He looks at you imploringly, trying to make you understand. "Anyway, we can argue over ethics once we get the Keystone and get out of here." **If <4.3>** "Exactly. We have to remember the lives we save in our world. And to do that, we must close the Gate."	
Hub2	After <**a**> and <**b**> "Hey, Captain!" Corporal calls from the doorway that she and Lieutenant are still examining. "We may have found it." Captain moves towards the doorway as well, and leans his blunderbuss against the wall. As you step forwards to join them, your foot bumps against something hard. You look down and notice one of the idols that Private is destroying lying at your feet.	**a** **b** **5.1** **5.2** **5.3**

Artifacts	"There are these strange red idols in these antechambers of Kalvash's domain. We don't really know what they do, but we destroy them. Out of habit mostly." "There are those on the outside, with more money than sense, who consider themselves 'collectors'," He grimaces. "Fools. They want to own a piece of the Abyss, and are willing to pay."	**6.1** **6.2** **6.3** **6.4**
Artifacts2	**If <6.1>** Captain gives you a wry smile. "Most of whom have ties to criminal elements. They are nearly as dangerous as the horrors that we face in here." **If <6.2>** "These people have no scholarly interest. They wish to understand these powers, so that they can harness them." Captain sighs. "I wonder how soon it will be before we are fighting them too..." **If <6.3>** Captain glances at Private, still chiselling away at the idols, and lowers his voice. "The trouble is, we don't really know that what we do has any effect. But the higher-ups think it might help, so when we have time, we do what we can." **If <6.4>** Captain shakes his head. "Nothing here will help us. This is the domain of the Demon, and everything is on their side." "No, our best option is to stop them being used by anyone else. Used against us."	
Demon	"She," Captain corrects you. "Although, demons mostly ignore the whole concept of gender, so it doesn't really matter." "Kalvash is one of fifteen known demons, though we expect there are more. She typically convinces people to help her open Gates in populated areas, so she can steal their bodies and syphon their souls. It's a fate worse than death, truly."	
DemonHub		**a** **b** **c**
DemonHelp	"Oh, on the contrary. Kalvash's offers of power can always find willing people." "Strength, wealth, a demon's blessing can bestow many gifts, at great risk though. Besides the havoc that you are helping the Demon wreak." "Demonic servants technically retain free will, but they always return to their masters for more power in the end."	**7.1** **7.2** **7.3** **7.4**

DemonHelp2	**If <7.1>** Captain sighs. "I doubt it. These blessings exist only to enslave and manipulate. There would be no value otherwise." **If <7.2>** Captain sighs. "I doubt it. Demons are devious and manipulative. Their blessing will be the same." **If <7.3>** Captain looks thoughtful. "I suppose. These Demons are devious though. I suspect they will have prepared for that." Captain regains his determined composure. "I'd rather not find out though. Let's hope we don't meet her on the way. **If <7.4>** Captain smiles sadly. "Truly, nothing is more foolish."	
DemonVengeance	"Dozens of times, yes. Always the same. Mass abduction in a populated area, for whatever horrific purpose Kalvash designs."	**8.1** **8.2** **8.3**
DemonVengeance2	"Her lair is always the same. Demons have a strange consistency when it comes to interior decoration."	
DemonKill	"We had killed her a couple of times before we realised that it made no difference." Captain shrugs. "Now we focus on containment. It's all we can do."	**9.1** **9.2** **9.3**
	If <9.1> Captain looks angry. "Theres nothing we can do! We barely understand what is happening here!" He gazes at you imploringly. "We have to focus on closing the Gate. Can't you see thats more important!" Even as he says these words, his resolve seems to crumble. "I know that we're dooming dozens to a terrible fate, but this saves so many more. I have to believe that." **If <9.2>** "I told you, we tried to kill her, but she just keeps coming back. We don't understand enough to be able to defeat her completely. All we can do is try to stop even more from being taken." "I killed her once. Bullet right through the head." Captain sighs. "And she remembered." He gives you a wry smile. "Next time I saw her, she remarked how good my shot was. Not so much as a mark on her though." **If <9.3>** "The more we come here, the more we learn about her and the other Demons. Hopefully we will learn enough to stop her once and for all." Captain looks grim. "I'm not too hopeful though."	

If <5.1>
No content.

If <5.2>
Making sure that Private is looking the other way, you swiftly bend down a pick up the red idol. You feel a pleasant warmth in your hand as you hold it. Before the others notice, you quickly stow it in your pocket.

If <5.3>
You call out.
"Private! I found another of those idols."
He looks up, and walks over to you.
"Thanks, I might have missed that one." He begins to chip away at the hard material with his chisel.

"Go and join the others while I finish this," He says, focussing intently on the obliteration of the idol.

After Ifs
As you move towards the group at the doorway, you hear them arguing about the nature of the doorway. On the doorframe, there is a small device with two red lights.

"We need to get going!" exclaims the young Lieutenant, stamping her foot in frustration. "It may take us ages to find the keystone!"

"Running in unprepared is suicide. We have to be sure before we do anything," says Captain reasonably. "You should know by now the dangers that await the hasty in our profession."

"This is Kalvash we're talking about, not a Demon Lord! Anyone with half a brain and a decent weapon could get out of here," she replies angrily. "You just said how important it is to find the keystone quickly. Why are we waiting around?"

Captain looks to retort, but Corporal intejects. "Lieutentant, you need to calm down. We have no idea where this door could lead. We need to wait,"
Lieutenant looks mutinous. "Besides," continues Corporal, "We need to wait for Private to finish."

Lieutenant glances over at Private, still chipping away at the red idols, before repeating, "We're wasting time. We should be focussing on finding the Keystone!"

As you listen to their circular argument, you notice that Captain's blunderbuss is still leaning against the nearby wall...

Complete	**If <S>** Sick of waiting and listening, you move forward, grabbing Captain's gun as you pass. The others look at you with surprise, but before they can act, you push past them and walk through the doorway. **If <G>** "Enough!" says Captain, with a finality that stops Lieutenant mid-sentence. In the ringing silence that follows, the device on the doorframe beeps, displaying two green lights. Their argument forgotten, the group springs into action. "Private, lets go," calls Captain, as he secures the rope around his waist once more. As he collects his blunderbuss from the wall, he speaks to you. "You should probably come with us. It's not safe to be alone in here." "Try not to slow us down," says Lieutenant with a grin, and she walks through the doorway, disappearing into the darkness. Captain gestures towards the doorway, indicating that you should go next. With a deep breath, you straighten your shoulders and walk into the darkness.	

This appendix is designed to be used with Appendix B, which outlines the choices associated with each passage.

The **If** figure denotes content that only appears if a previous option was chosen. This allows for back and forth dialogue to occur.

The **After** figure denotes content that only appears after a number of other options in this passage have been chosen. This forces the player to complete each of the sub-passages before continuing.

Appendix C

Player Choices

Passage	Option	Destination	Power	Independence	Curiosity	Order	Saving	Idealism	Vengeance	Total	Dialogue
Start	a	Intro1									Ughh, my head.
Intro1	a	Intro2									I... I don't think so.
	b	Intro2									Where are we?
Intro2	a	Intro3									Hell?
Intro3	a	Hub1Display									Good to meet you.
Hub1Display		Hub1									
Hub1	a	Location									I still don't understand where we are...
	b	Keystone									Is the Keystone the only way to get back?
	c	Civilians									What about the others that were drawn in?
		Hub2Display									Continue?
Location	a	Location2									Another dimension...
Location2	1.1	Location3			1			1		2	So the demon Kalvash steals people? For what purpose?
	1.2	Keystone	1		1		1			3	And how do we get out? We need this Keystone?
	1.3	Location4							2	2	Sounds like this demon needs to be stopped.
Location3	2.1	Civilians						1		1	What about the others that were drawn in?
	2.2	Location4				1			1	2	Sounds like this demon needs to be stopped.
	2.a	Location4								0	Then let's get out of here before we become demon lunch as well.
Location4		Hub1									
Keystone	3.1	Keystone2		1	2					3	And how does the Keystone work?
	3.2	Keystone2				1				1	So we need to retrieve it as soon as possible then.
Keystone2		Hub1									
Civilians	4.1	Civilians2			1			2		3	Locking in everyone else in the process?
	4.2	Civilians2					1	3		4	You're not here to save people?
	4.3	Civilians2				2				2	I understand. The longer the Gate is open, the more people like me are drawn in.
Civilians2		Hub1									

Passage	Option	Destination	Power	Independence	Curiosity	Order	Saving	Idealism	Vengeance	Total	Dialogue
Hub2Display		Hub2									
Hub2	a	Artifacts									What exactly is he doing?
	b	Demon									You mentioned Kalvash? Who is he?
	5.1	Outtro			2	2				4	Ignore it, and move forward to join the conversation by the door.
	5.2	Outtro		1	1		4			6	Surreptitiously bend down and take the idol.
	5.3	Outtro				2	-2			0	Call the idol to Privates attention, so that he can destroy it.
Artifacts	6.1	Artifacts2					3			3	Wealthy collectors, you say...
	6.2	Artifacts2			2					2	I can understand a fascination with the unknown.
	6.3	Artifacts2					-1		2	1	Everything here is evil. Destroying them is the right thing to do.
	6.4	Artifacts2	2		1						They must have some purpose. Perhaps some power we could use?
Artifacts2		Hub2									
Demon		DemonHub									
DemonHub	a	DemonHelp									Surely people wouldn't help a demon.
	b	DemonVengeance									So she has killed like this before?
	c	DemonKill									If you know so much about her, why hasn't she been stopped?
		Hub2									
DemonHelp	7.1	DemonHelp2	1	1	1		4			7	The blessing of a demon? That sounds unique. And valuable.
	7.2	DemonHelp2	2	1				2		5	Couldn't you use that power for good?
	7.3	DemonHelp2	3		1				2	6	That blessing sounds very useful. Especially for killing Kalvash.
	7.4	DemonHelp2				2		2		4	Sounds like a fool's errand.
DemonHelp2		DemonHub									
DemonVengeance	8.1	DemonKill						3	2	5	Mass abductions? She cannot be allowed to continue.
	8.2	DemonVengeance2			2					2	How do you know when its Kalvash?
	8.3	DemonKill				-1			1	0	Haven't you tried to stop her?
DemonVengeance2		DemonHub									

Passage	Option	Destination	Power	Independence	Curiosity	Order	Saving	Idealism	Vengeance	Total	Dialogue
DemonKill	9.1	DemonKill2		3				2		5	You should be focussing on preventing people being taken!
	9.2	DemonKill2		1					3	4	You can't just let Kalvash get away with this!
	9.3	DemonKill2			2	2				4	So you don't have a plan to stop Kalvash?
DemonKill2		DemonHub									
Outtro	S	Complete	2	5						7	Take the gun and rush through the door before anyone can stop you.
	G	Complete				3				3	Wait for a decision to be made.

Most rows consist of the passage where the choice is located, an identifier for the choice made, and the destination passage for that choice. The term passage is used by the Twine software used to define a page of text in the narrative. Each choice also has values for the seven motivators and the dialogue of that choice.

Blue rows are automatic progression. Usually, they are used once the player has completed all branches at a particular hub, to take the player to the next hub or choice.

Grey rows have no motivator content, and do not lead to new choice options. They only serve to progress the narrative.

Appendix D

Variation Events

Group Events								
Variation Description	**Name**	**Power**	**Independence**	**Curiosity**	**Order**	**Saving**	**Idealism**	**Vengeance**
Defeat Creature	GA1	1						2
Defeat and loot creature	GA2	2	1	1		2		2
Storage Room	GA3			2				
Storage Room Loot	GA4	1	1	2		2		
Find dead	GA5			1			1	1
Find survivors	GA6			1	1	1	2	
Become separated	GA7		1					
Find keystone	GK			2	2			
Kill Demon	GD1	1			2			3
Escape	GE1							
Escape with survivors	GE2				1		3	
Close Gate	GC				3			

Solo Events								
Variation Description	**Name**	**Power**	**Independence**	**Curiosity**	**Order**	**Saving**	**Idealism**	**Vengeance**
Defeat Creature	SA1	1	1					2
Defeat and loot creature	SA2	2	1	1		2		2
Storage Room	SA3			1				
Storage Room Loot	SA4	1		2		2		
Find dead	SA5			1			1	1
Find survivors	SA6			1	1	1	2	
Rejoin Group	SA7		-2					
Avoid Group	SA8		2					
Find keystone	SK			1	1	3		
Kill Demon	SD1	2	1		1			3
Speak with Demon	SD2	1	1	2				
Speak then Kill Demon	SD3	2	2	2				3
Demonic Bribe	SD4	3	2	1		1		
Rescue Group	SG		3			1	2	
Escape	SE1							
Escape with survivors	SE2				1	1	3	
Close Gate	SC		3		3			

Appendix E

Participant Information Sheet

Researcher:

My name is David Cowley, and I am an Undergraduate Honours student from Australia. I am studying Software Engineering at the School of Computer Science and Information Technology at the Australian National University.

Project Title: Planning a Story: Tracking Player Choices to Determine Player Goals

General Outline of the Project:

• Description and Methodology: The goal of this project is to determine whether player choices in interactive stories can be used to predict the level of enjoyment for particular events in that story. This will involve users completing a short web-based interactive story and providing feedback based on a personally generated conclusion to that story. This will test both the possibility of such a system and the validity of my chosen method.

• Participants: The number of participants is variable, with more participants resulting in better and more substantial conclusions. Participants will be recruited by the investigator personally, and via the website Interactive Fiction Database (ifdb.tads.org).

• Use of Data and Feedback: The data will be used to analyse the trends and therefore validate both my chosen narrative generation method and the possibility of other such methods. The conclusion drawn from these results, as well as the results themselves, will be available in thesis form on the study's website by December 2015. These conclusions will also be used to further tailor the design of the method, in order to increase its effectiveness.

Participant Involvement:

• Voluntary Participation Withdrawal: The participation in this project is entirely voluntary, and you may withdraw from the study at any time before the conclusion of the story. If you choose not to answer a question simply close the web browser to end your participation in the study. When you begin the game, a record of the current time will be taken, but no other information will be gathered until the conclusion of the game. Any incomplete records will be discarded upon the collection of the data at the end of the project. Due to the anonymous nature of the data collected, it will not be possible to remove specific information once the game is complete.

• What does participation in the research request of you? You will be asked to complete a simple interactive story, and provide answers to a few short questions. Your answer to each question will be recorded, as well as your feedback at the conclusion of the story. In addition, a record of the current time will be taken at the start and end of the game.

• No personal information will be gathered. All data collected will remain completely anonymous.

• The data will be collected by using a cookie, which is integral to the functionality of the project and will contain no information that can be used to identify any participant. Please ensure that cookies are enabled by your browser.

• Location and Duration: The participation in this project will take approximately 20-30 minutes, and can be completed any number of times. The URL for the Project is https://routineescape.herokuapp.com.

• Risks: This interactive story deals with elements of supernatural themes and references to violence and death. This may cause distress to some participants. If you experience any distress from participating, don't hesitate to call Lifeline Australia on 13 11 14, the National Suicide Prevention Lifeline USA on 1-800-273-8255, or your local crisis support service.

Using the ESRB standard for video game classification, I would rate this game as Teen (13+) due to Supernatural Themes and Violent References.

• Benefits: This research will allow the validation and development of a narrative system that can successfully predict the general motivations of the player. This will allow for a more focussed and immersive narrative in interactive stories which will provide the player with specific goals and obstacles based on their motivations. For example, if a player wishes their character to be immensely wealthy, this system would provide them with opportunities to accrue vast fortunes, rather than performing selfless tasks. The existing ideology in open-world games is to provide the player with a plethora of these opportunities, and force them to be selective with how they spend their time. This is usually unsuccessful, devolving the player character into someone who simply does everything because it is there. Creating a viable system that can provide a focussed narrative for every type of player or player character will ultimately encourage immersion and increase replayability. This research is vital in developing the proposed system into one that can reliably predict the player's motivations, and therefore provide a tailored story.

Confidentiality:

• Confidentiality: The results of this study may be shared or published in their entirety. However, due to the anonymous nature of the data collected, there will be no attribution of the data to the participants in any form. Therefore, participants will not be individually identified and their confidentiality will be protected as far as the law allows.

Data Storage:

• Where: The data will be stored on a cloud-hosted database provided

by the cloud application platform Heroku. The data collected from the participants will remain the property of the ANU, and only be used by Heroku for the sole purpose of enabling Heroku to provide you with the Heroku Services. For more information, see sections 6.2 and 8.1 of the Heroku Terms of Service https://www.heroku.com/policy/tos.

• How long: The data will remain on the cloud-hosted database for the duration of the study, after which it will be moved to a local digital copy in accordance with the ANU's Code of Research Conduct Policy https://policies.anu.edu.au/ppl/document/ANUP$_0$07403.*Asthedatacollectedmaybeusedinthec*

Queries and Concerns:

• Contact Details for More Information: Any concerns or requests for further information should be directed to me, David Cowley, or my supervisor Patrik Haslum.

David Cowley
Email: u5012568@anu.edu.au
Phone: 0429649151 (international charges may apply)

Patrik Haslum
Email: patrik.haslum@anu.edu.au

Ethics Committee Clearance:
The ethical aspects of this research have been approved by the ANU Human Research Ethics Committee. If you have any concerns or complaints about how this research has been conducted, please contact:

Ethics Manager
The ANU Human Research Ethics Committee
The Australian National University
Telephone: +61 2 6125 3427
Email: Human.Ethics.Officer@anu.edu.au

Appendix F

Results

Identifier	Best	Choice	Q1	A1	Q2	A1	Repeat
1	2	2	1,2	3	6,3	2	2
2	2	3	4,3	3	6,4	2	2
3	1	2	6,1	2345	7,4	2457	2
4	2	1	6,4	2	9,1	6	2
5	3	3	4,1	3	7,4	23	2
6	3	3	4,1	3	5,3	34	2
7	1	1	1,1	36	9,1	6	2
8	3	3	4,2	6	7,2	34	2
9	3	3	7,1	15	6,2	3	2
10	1	1	1,3	246	5,1	24	2
11	3	2	6,4	3	9,3	346	2
12	2	1	4,3	4	5,3	4	2
13	2	3	4,1	36	5,2	1235	2
14	1	1	1,1	3	8,2	3	2
15	1	1	9,3	4	7,4	26	2
16	2	3	4,3	4	7,4	3	2
17	2	2	8,2	3	5,1	4	2
18	2	2	4,3	35	5,2	235	2
19	3	1	4,1	36	8,1	36	1
20	3	1	4,3	2	6,3	6	2
21	3	1	3,1	3	6,4	2	2
22	2	1	4,3	3	5,3	4	2
23	1	3	8,2	35	5,1	345	2
24	1	1	7,4	3	8,2	3	2
25	1	2	1,2	34	8,3	34	2
26	2	3	1,2	2	8,2	3	1
27	1	2	8,2	34	5,2	35	1
28	3	1	6,4	3	5,1	4	2
29	1	2	3,1	3	7,2	3	2
30	2	1	3,2	4	9,3	3	2
31	2	1	9,3	3	5,1		2
32	2	3	7,2	23	5,2	25	2
33	3	3	4,3	4	8,2	3	2
34	1	2	4,1	346	5,2	345	2
35	1	3	3,2	34	5,1	24	1
36	3	3	9,3	35	5,3	4	2
37	3	1	4,2	3	8,3	3	1
38	3	3	2,1	3	7,4	3	1
39	3	2	4,2	34	5,2	125	1

Identifier	Scores	Path	Var1	Var2	Var3
1	11611-122	a a a a a a 1,2 3,1 c 4,3 a 6,3 b c 9,3 b 8,2 a 7,4 d 5,3 G	GA7?SA5?SK?SA4?SA1?SD4?SG?SE1?SC?	GA3?GA6?GK?GA1?GA7?SD2?SE2?SC?	GA5?GA2?GK?GA7?SA4?SD3?SE1?SC?
2	5199-222	a b a a b 3,1 a a 1,1 2,1 4,3 b b 8,2 a 7,3 c 9,3 d a 6,4 5,3 G	GA3?GA5?GK?GA4?GA2?GD1?GE1?GC?	GA4?GA3?GK?GA7?SA4?SD1?SE1?SC?	GA3?GA2?GK?GA7?SA1?SD2?SG?SE1?SC?
3	2754145	a b a a b 3,1 c 4,1 a a 1,3 a 6,1 b c 9,2 a 7,4 b 8,2 d 5,3 S	SA2?SA5?SK?SA7?GA3?GD1?GE1?GC?	SA2?SA6?SK?SA5?SA5?SD4?SG?SE2?SC?	SA4?SA3?SK?SA1?SA1?SD2?SG?SE1?SC?
4	4676451	a a a a c 4,3 b 3,1 a a 1,1 2,2 a 6,4 b a 7,2 c 9,1 b 8,2 d 5,2 G	GA4?GA4?GK?GA3?GA3?GD1?GE1?GC?	GA5?GA2?GK?GA7?SA4?SD2?SG?SE1?SC?	GA5?GA4?GK?GA4?GA7?SD3?SG?SE1?SC?
5	01109-250	a a a a b 3,1 c 4,1 a a 1,1 a a 6,2 b a 7,4 b 8,2 c 9,3 d 5,3 G	GA5?GA4?GK?GA7?SA1?SD1?SG?SE1?SC?	GA4?GA3?GK?GA3?GA3?GD1?GE1?GC?	GA6?GA3?GK?GA3?GA3?GD1?GE2?GC?
6	20710-250	a a a a a a 1,1 a c 4,1 b 3,2 b c 9,3 a 7,4 b 8,2 d a 6,4 5,3 G	GA3?GA7?SK?SA5?SA2?SD1?SG?SE1?SC?	GA4?GA3?GK?GA7?SA4?SD1?SE1?SC?	GA7?SA7?GK?GA6?GA3?GD1?GE2?GC?
7	41083-271	a b a a c 4,1 b 3,1 a a 1,1 2,2 b b 8,2 a 7,2 c 9,1 d a 6,2 5,3 S	SA8?SA5?SK?SA5?SA2?SD2?SG?SE1?SC?	SA7?GA6?GK?GA4?GA7?SD3?SE2?SC?	SA5?SA5?SK?SA7?GA2?GD1?GE1?GC?
8	71170670	a a a a c 4,2 a a 1,2 3,1 a 6,4 b a 7,2 c 9,1 b 8,2 d 5,2 S	SA5?SA5?SK?SA5?SA3?SD1?SG?SE1?SC?	SA8?SA5?SK?SA2?SA2?SD3?SE1?SC?	SA8?SA5?SK?SA4?SA2?SD4?SG?SE1?SC?
9	13116941	a b a a c 4,2 b 3,1 a a 1,1 2,2 b c 9,3 b 8,2 a 7,1 d a 6,2 5,2 G	GA6?GA7?SK?SA5?SA5?SD3?SG?SE2?SC?	GA7?SA4?SK?SA3?SA3?SD3?SG?SE1?SC?	GA3?GA7?SK?SA4?SA4?SD2?SG?SE1?SC?
10	21810022	a a a a c 4,3 b 3,2 a a 1,3 a 6,2 b b 8,2 c 9,3 a 7,2 d 5,1 G	GA3?GA4?GK?GA7?SA4?SD1?SE1?SC?	GA4?GA7?SK?SA5?SA5?SD3?SE1?SC?	GA5?GA3?GK?GA7?SA2?SD4?SG?SE1?SC?
11	4396561	a b a a c 4,2 b 3,1 a a 1,1 2,2 a 6,4 b c 9,3 b 8,2 a 7,2 d 5,2 G	GA7?SA6?SK?SA7?GA3?GD1?GE2?GC?	GA5?GA1?GK?GA5?GA5?GD1?GE1?GC?	GA5?GA2?GK?GA7?SA4?SD4?SG?SE1?SC?
12	5358-242	a a a a a a 1,1 2,1 4,3 b 3,2 a 6,4 b a 7,3 c 9,1 b 8,2 d 5,3 G	GA2?GA3?GK?GA7?SA1?SD1?SG?SE1?SC?	GA4?GA4?GK?GA7?SA8?SD1?SE1?SC?	GA7?SA5?SK?SA4?SA2?SD3?SE1?SC?
13	4793450	a a a a c 4,1 b 3,2 a a 1,1 a a 6,2 b c 9,3 b 8,2 a 7,2 d 5,2 S	SA8?SA8?SK?SA6?SA1?SD2?SE2?SC?	SA5?SA4?SK?SA4?SA3?SD4?SG?SE1?SC?	SA1?SA1?SK?SA7?GA6?GD1?GE2?GC?
14	23105560	a a a a c 4,2 a a 1,1 a b 3,1 a 6,2 b b 8,2 c 9,3 a 7,2 d 5,2 G	GA5?GA7?SK?SA4?SA4?SD4?SG?SE1?SC?	GA1?GA6?GK?GA7?SA6?SD4?SE2?SC?	GA3?GA4?GK?GA4?GA7?SD1?SG?SE1?SC?
15	22108451	a b a a c 4,1 b 3,1 a a 1,1 2,2 a 6,4 b c 9,3 b 8,2 a 7,4 d 5,2 G	GA6?GA4?GK?GA4?GA7?SD2?SE2?SC?	GA2?GA7?SK?SA8?SA1?SD4?SG?SE1?SC?	GA5?GA2?GK?GA1?GA7?SD4?SG?SE1?SC?
16	20612-230	a a a a b 3,2 c 4,3 a a 1,1 a a 6,4 b b 8,2 c 9,3 a 7,4 d 5,3 G	GA5?GA7?SK?SA5?SA2?SD2?SG?SE1?SC?	GA7?SA7?GK?GA4?GA3?GD1?GE1?GC?	GA6?GA3?GK?GA3?GA3?GD1?GE2?GC?
17	11119250	a a a a a a 1,2 3,1 c 4,2 a 6,2 b a 7,4 c 9,3 b 8,2 d 5,1 G	GA5?GA7?SK?SA5?SA1?SD1?SG?SE1?SC?	GA6?GA3?GK?GA3?GA3?GD1?GE2?GC?	GA7?SA5?SK?SA4?SA2?SD3?SE1?SC?
18	48104430	a a a a a a 1,1 a b 3,1 c 4,3 a 6,2 b a 7,2 c 9,3 b 8,2 d 5,2 S	SA4?SA6?SK?SA3?SA1?SD2?SG?SE2?SC?	SA8?SA4?SK?SA4?SA3?SD2?SG?SE1?SC?	SA8?SA5?SK?SA2?SA2?SD2?SG?SE1?SC?
19	1237566	a b a a c 4,1 b 3,2 a a 1,1 2,2 b b 8,1 9,2 a 7,1 d a 6,1 5,3 G	GA4?GA2?GK?GA1?GA7?SD4?SE1?SC?	GA4?GA7?SK?SA2?SA2?SD2?SG?SE1?SC?	GA1?GA7?SK?SA6?SA3?SD1?SE2?SC?
20	2658-224	a b a a b 3,1 a a 1,3 c 4,3 b c 9,3 b 8,2 a 7,4 d a 6,3 5,3 S	SA6?SA7?GK?GA4?GA2?GD1?GE2?GC?	SA5?SA5?SK?SA4?SA4?SD4?SG?SE1?SC?	SA3?SA7?GK?GA4?GA3?GD1?GE1?GC?
21	4287-160	a b a a b 3,1 c 4,2 a a 1,1 a a 6,4 b c 9,3 a 7,2 b 8,2 d 5,3 G	GA3?GA7?SK?SA1?SA1?SD3?SE1?SC?	GA7?SA1?SK?SA2?SA5?SD2?SG?SE1?SC?	GA6?GA2?GK?GA7?SA1?SD2?SE2?SC?
22	2289-222	a a a a c 4,3 b 3,1 a a 1,3 a 6,2 b c 9,3 b 8,2 a 7,2 d 5,3 G	GA5?GA4?GK?GA4?GA7?SD1?SG?SE1?SC?	GA3?GA4?GK?GA4?GA7?SD1?SE1?SC?	GA4?GA1?GK?GA7?SA6?SD2?SE2?SC?
23	51117024	a a a a a a 1,3 c 4,1 b 3,1 a 6,4 b c 9,3 b 8,2 a 7,3 d 5,1 G	GA4?GA3?GK?GA3?GA2?GD1?GE1?GC?	GA7?SA5?SK?SA4?SA2?SD3?SE1?SC?	GA1?GA5?GK?GA1?GA1?SD3?SE1?SC?
24	20613-231	a b a a a a 1,1 2,2 b 3,2 c 4,3 a 6,4 b c 9,3 a 7,4 b 8,2 d 5,3 G	GA7?SA7?GK?GA4?GA3?GD1?GE1?GC?	GA1?GA5?GK?GA1?GA7?SD3?SG?SE1?SC?	GA5?GA4?GK?GA3?GA2?GD1?GE1?GC?
25	71063141	a a a a a a 1,2 3,1 c 4,3 a 6,4 b b 8,3 9,1 a 7,2 d 5,1 S	SA7?GA2?GK?GA7?SA4?SD4?SG?SE1?SC?	SA2?SA6?SK?SA5?SA5?SD2?SG?SE2?SC?	SA2?SA8?SK?SA1?SA1?SD4?SG?SE1?SC?
26	5289-120	a a a a a a 1,2 3,1 c 4,3 a 6,4 b c 9,3 a 7,2 b 8,2 d 5,3 G	GA1?GA5?GK?GA1?GA1?GD1?GE1?GC?	GA4?GA4?GK?GA3?GA7?SD1?SE1?SC?	GA1?GA7?SK?SA6?SA1?SD3?SE2?SC?
27	3285834	a b a a a a 1,3 c 4,2 b 3,1 b c 9,3 b 8,2 a 7,3 d a 6,1 5,2 G	GA7?SA4?SK?SA4?SA2?SD3?SE1?SC?	GA5?GA2?GK?GA7?SA1?SD4?SG?SE1?SC?	GA7?SA5?SK?SA5?SA4?SD2?SG?SE1?SC?
28	50108032	a a a a b 3,2 c 4,1 a a 1,1 a a 6,4 b a 7,3 c 9,3 b 8,2 d 5,1 G	GA7?SA2?SK?SA2?SA2?SD1?SE1?SC?	GA5?GA7?SK?SA4?SA4?SD4?SG?SE1?SC?	GA4?GA3?GK?GA7?SA4?SD1?SE1?SC?
29	43105450	a b a a c 4,1 a a 1,1 a b 3,1 a 6,4 b c 9,3 a 7,2 b 8,2 d 5,2 G	GA5?GA4?GK?GA7?SA4?SD3?SG?SE1?SC?	GA7?SA6?SK?SA5?SA4?SD3?SE2?SC?	GA7?SA6?SK?SA4?SA3?SD1?SE2?SC?
30	4667322	a a a a b 3,2 c 4,3 a a 1,3 b c 9,3 b 8,2 a 7,2 d a 6,1 5,1 S	SA1?SA6?SK?SA6?SA6?SD1?SG?SE2?SC?	SA4?SA3?SK?SA7?GA4?GD1?GE1?GC?	SA4?SA5?SK?SA4?SA2?SD2?SG?SE1?SC?
31	51128033	a b a a b 3,1 c 4,1 a a 1,1 2,2 a 6,4 b a 7,3 b 8,2 c 9,3 d 5,1 G	GA4?GA7?SK?SA8?SA5?SD2?SG?SE1?SC?	GA5?GA4?GK?GA7?SA4?SD1?SE1?SC?	GA6?GA7?SK?SA6?SA6?SD3?SE2?SC?
32	6783460	a a a a a a 1,1 2,1 4,1 b 3,2 a 6,4 b c 9,3 b 8,2 a 7,2 d 5,2 S	SA8?SA2?SK?SA2?SA1?SD4?SG?SE1?SC?	SA5?SA4?SK?SA4?SA4?SD2?SG?SE1?SC?	SA5?SA8?SK?SA5?SA1?SD2?SG?SE1?SC?
33	4569-230	a b a a c 4,3 b 3,2 a a 1,1 a a 6,4 b c 9,3 b 8,2 a 7,4 d 5,3 S	SA1?SA6?SK?SA5?SA1?SD4?SG?SE2?SC?	SA2?SA8?SK?SA8?SA6?SD4?SG?SE2?SC?	SA8?SA7?GK?GA4?GA4?GD1?GE1?GC?
34	4483453	a a a a b 3,1 c 4,1 a a 1,1 a a 6,4 b b 8,2 a 7,2 c 9,2 d 5,2 G	GA5?GA4?GK?GA4?GA7?SD3?SG?SE1?SC?	GA5?GA4?GK?GA4?GA7?SD2?SG?SE1?SC?	GA7?SA8?SK?SA5?SA2?SD4?SG?SE1?SC?
35	4735027	a b a a b 3,2 c 4,3 a a 1,3 b a 7,2 c 9,2 b 8,2 d a 6,3 5,1 S	SA3?SA7?GK?GA4?GA3?GD1?GE1?GC?	SA3?SA7?GK?GA6?GA7?SD1?SE2?SC?	SA5?SA2?SK?SA7?GA7?SD1?SG?SE1?SC?
36	30611113	a a a a c 4,3 b 3,2 a a 1,1 2,2 a 6,1 b c 9,3 a 7,3 b 8,2 d 5,3 G	GA2?GA7?SK?SA8?SA6?SD4?SG?SE2?SC?	GA7?SA6?SK?SA4?SA3?SD3?SE2?SC?	GA7?SA7?GK?GA4?GA4?GD1?GE1?GC?
37	2276-171	a a a a a a 1,1 2,1 4,2 b 3,1 a 6,2 b b 8,3 9,3 a 7,2 d 5,3 G	GA3?GA7?SK?SA6?SA2?SD3?SE2?SC?	GA5?GA3?GK?GA7?SA2?SD3?SE1?SC?	GA5?GA5?GK?GA7?SA4?SD2?SG?SE1?SC?
38	23410-260	a b a a a a 1,1 2,1 4,3 b 3,2 a 6,4 b a 7,4 c 9,1 b 8,2 d 5,3 G	GA4?GA4?GK?GA7?SA8?SD1?SE1?SC?	GA7?SA4?SK?SA7?GA3?GD1?GE1?GC?	GA7?SA7?GK?GA7?SA6?SD3?SG?SE2?SC?
39	6186632	a b a a a a 1,2 3,2 c 4,2 a 6,4 b c 9,3 a 7,3 b 8,2 d 5,2 G	GA3?GA6?GK?GA1?GA7?SD2?SE2?SC?	GA3?GA7?SK?SA6?SA1?SD1?SE2?SC?	GA4?GA7?SK?SA4?SA4?SD1?SE1?SC?