ABSTRACT

BAHAMÓN, JULIO CÉSAR. A Computational Model for The Portrayal of Personality Traits in Planning-Based Narrative Generation. (Under the direction of Dr. R. Michael Young and Dr. David L. Roberts.)

Storytelling is an essential component of human culture. Humans use narratives to describe, understand, and relate to events of the world in which they live. Narrative plays a key role as a means to transfer knowledge. This is one of the principal motivations for Artificial Intelligence research that centers around the development of techniques and architectures to automate the generation of narrative content. Computer-generated narratives can be applied in multiple domains, such as training simulations, activity visualizations, instructional videos, and digital games.

One of the key elements that can improve the effectiveness of a story is the presence of interesting and compelling characters. Well-developed characters have features that enable them to significantly enhance the believability and quality of a narrative. In my research, I focus on the development of a computational model aimed at facilitating the inclusion of compelling characters in narrative that is automatically generated by a planning-based system. The model centers on the use of an intelligent process to express character personality. In this model, personality is operationalized as behavior that results from choices made by a character in the course of a story. This operationalization uses the taxonomy defined in the Five Factor Model (FFM) and results from behavioral psychology studies that link behavior to personality traits. I hypothesize that the relationship between choices and the actions they lead to can be used in narrative to produce the perception of specific personality traits in an audience.

The design of my narrative generation model is also influenced by the theory of human affect proposed by Lazarus. This theory is of particular relevance because I use it to simulate the mental process that a fictional character goes through as she deliberates on a course of action to follow. Affect theory informs the mechanism that is used to compare and contrast multiple courses of action that achieve a specific character intention, but that could have either beneficial or adverse effects for other characters in the story. The mechanism quantifies effects as being adverse or beneficial in terms of whether they help or prevent characters from achieving their intentions (things they want to accomplish). An example of a character intention can be to obtain wealth. The mechanism that I designed informs the work of the narrative generation algorithm to favor the creation of stories with actions and action sequences that highlight character personality traits. To achieve this, the mechanism evaluates characters' actions within the context of their intentions and those of other characters in the story.

The system that I designed, named *Mask*, has its foundation on the use of state-space

planning to generate narratives where characters act intentionally. My implementation uses the Glaive narrative planner that was developed by Ware and Young. The version I use has been significantly modified and enhanced to include the functionality described above. In contrast to a traditional narrative planner where a uniform planning process handles the construction of a story, in choice-based narrative generation, planning is interleaved between a macro-planner and a micro-planner. The macro-planner is responsible for constructing the authorial view of the global story and its causal coherence. The micro-planner is a restricted version of a planning system, designed to simulate the character's decision-making process as she works toward accomplishing a goal.

I conducted an initial evaluation with human subjects using handcrafted stories that were created following the algorithm I designed. Results from this evaluation were encouraging yet inconclusive. As a result, I conducted a formative study after revising my protocol and in particular the discourse method used to present the stories to the audience. Results from this study were significant enough to reject the null hypothesis and support the claim that *an audience presented with a set of alternate action sequences for a story character will select personality trait ratings that have significant correlation with the choices made by such character.* Additionally, the data collected from the formative study informed the fine-tuning and implementation of my narrative generation model. An evaluation of the completed *Mask* narrative generation system was conducted using automatically generated stories that were produced in accordance with the principles described above. Results from this evaluation were comparable to those from the formative study, i.e., the computer-generated stories elicited the perception of specific character personality traits on the audience that experienced such stories.

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A Computational Model for The Portrayal of Personality Traits in Planning-Based Narrative Generation

by
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DEDICATION

To Janneke, my wonderful wife, without whose unconditional love and support this project would have been essentially impossible.

BIOGRAPHY

Julio César Bahamón was born in Bogotá Colombia to Mario Bahamón Dussán and Gilma Bustamante. From a very early age, Julio had a keen interest in computers and programming in particular. This was inspired by countless hours spent playing games on an Atari 2600, which was followed by writing small programs in Basic on a TRS-80 Color Computer. He wrote his first program at the age of 11 and has been coding ever since. His desire to obtain a college education led him to move to Texas, where he attended the Computer Science program at Texas A&M University - Kingsville. Upon graduation, he moved to Tallahassee, Florida, where he attended Florida State University and obtained a Master of Science in Computer and Information Sciences. This enabled Julio to live in Jacksonville, Florida, where he worked in the IT industry for several years, in multiple capacities. Eventually, the desire to complete what felt like an unfinished project and fulfill his goal of teaching at the university level became too much to ignore and he applied to graduate school. North Carolina State University offered an opportunity that was too good to ignore, so he enrolled in the Ph.D. program at the Department of Computer Science, where he worked in Serious Games and Artificial Intelligence. When he is not teaching, doing research, or writing code, Julio spends his time with his family, reading, watching Netflix, or practicing the sport of Triathlon.

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does not make any sense (although I hope that some day it will).

I would like to thank my parents for teaching me that we can be as successful as our own ambition and desire to work hard allow. From my days in kindergarten to these last few weeks, I have received nothing but encouragement from you. I don't really know whether having someone who believes in you really matters, but to me it does. Thank you for always being there for me, for teaching me my work ethic, and for giving me the foundation for my moral compass.

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Chapter 1

Introduction

The presence of interesting and compelling characters is an essential element of narrative composition [36, 15]. Effective characters enable the audience to form a clear mental model of their beliefs, desires, intentions, and morality. This understanding of the characters can lead to a better understanding of the entire story and to a more effective delivery of its content. Moreover, well-defined characters add to the complexity of a story, enhance its discourse, and are vital for the realization of crucial story elements, such as events and dialog [15, 36, 49]. Several factors contribute to the effective definition of a character; some of these include: physical attributes, talents, emotions, beliefs, and personality. Characters should portray these factors in an interesting and believable manner. In particular, the depiction of a distinguishable personality is one of the key features that makes a character interesting and compelling.

Characters also play an essential narrative role as agents of change. Change can result both from a character's actions and from her reactions to the actions of others [15, 49]. Therefore, actions are one of the main techniques used by creative writers to define and describe fictional characters [36, 12, 49]. Further consideration of narrative structure, specifically plot points where a story could branch into alternate versions [9], indicates that a character's act of considering multiple courses of action before choosing to pursue one in particular has a direct impact on the role that she plays in a story. Additionally, the choices that a character makes may be linked to specific personality traits, an idea supported by research in behavioral psychology that has found correlation between people's actions and their personality [23, 47].

In this work, I posit that the link between choice and personality can be used in narrative generation to enable the perception of specific personality traits. An audience that is made aware of the existence of multiple choices that are available to a character will form an opinion of such character's personality based on the available choices, the choice selection, and the events that provide a context to the choice. The proposed approach is based on the development of a computational model that operationalizes personality as behavior that results from the choices

made by characters in the course of a story.

1.1 Motivation

The automatic generation of character behavior in planning-based narrative generation is an area where much work is still possible. This is particularly true if it is taken into account that incorporating character behavior can greatly increase the burden placed on the human author. As narrative delivery mechanisms, such as digital games and virtual training environments become more complex and detailed, the effort needed to create characters that have distinct features increases in its difficulty. Additionally, providing users with higher degrees of agency also adds to the need for characters that better adapt to user choices and to changing conditions in the story world.

In the area of narrative generation, the ability to create character behavior that adjusts in response to user actions or changing story conditions has not been fully addressed by researchers. Although models have been developed to direct character interactions [65], compose stories using predefined character models [38, 50], generate dialog based on personality traits [42], and control facial and physical gestures to express emotion in intelligent virtual agents (IVA) [41, 1, 18], none of these approaches focus specifically on controlling character behavior over time to elicit the perception of a distinct and well-defined personality. Additionally, the character personality models that are addressed in existing research efforts tend to focus on very specific subsets of character actions, such as utterances in dialog [42, 62]. My research focuses on another class of actions –physical actions– and the role that this class plays in the construction of the mental model that the reader forms when experiencing a story.

1.2 Thesis Statement and Hypothesis

This dissertation focuses on the incorporation of compelling characters in automatically generated narrative. The approach is based on the development of a computational model that enables fictional characters to have distinct and well-defined personalities. In this model, character personality is founded on the thesis that choices that lead to character actions in a story can significantly influence a character's perceived personality. However, the goal of this research is not to create a model that fully recreates all known factors of human personality but rather one that enables the representation of a general subset with enough detail to elicit a predictable cognitive response by the audience[1]. Furthermore, the subset represented by the model

[1]Although this work has its foundation on studies about human behavior and human psychology, it is not the intent of the author to develop a comprehensive computational model of human personality. The focus of this research is on a model specifically designed to produce fictional characters with distinguishable personality traits, not to produce characters with the personality of a real human being.

is specifically geared toward personality traits that are suitable for their use in the portrayal of character roles commonly found in fictional stories (e.g. villains vs. heroes). The computational model could enable authors to achieve specific goals, such as ensuring that audiences can clearly differentiate evil characters from non-evil ones based on how they behave, i.e., characters are defined by their choice of actions in the course of the story.

The narrative generation approach that I present deals with character personality as a fundamental component of story composition; to accomplish this, I focus on the story as a whole and in particular on the use of choices made by fictional characters as a means to portray their personality. In this approach, the planning-based mechanism that generates the story treats choice as a first class object; consequently, the actions performed by characters in the course of a story are selected based on their potential to highlight the existence of a choice, while demonstrating specific personality traits. Instead of the non-deterministic action selection mechanism that is typically used, action selection is informed by a micro-theory of characters' means-ends deliberation that operationalizes specific aspects of human personality in terms of the effects that a fictional character's actions have upon other characters in the story. The micro-theory is modeled on the taxonomy defined by the Five Factor Model (FFM) [26] in conjunction with results from studies on goal-directed human behavior [16] and a simplified model of affect theory [37], which are discussed beginning in Section 2.5. The resulting narrative generation system, named *Mask*, is designed to enable the automatic creation of stories that contain characters with distinguishable personality traits, as perceived by a human audience. Furthermore, the system is designed to be easily extensible and to scale to diverse story domains of varying complexities.

My research centers on the design and evaluation of the computational mechanism used in the implementation of the *Mask* planning-based narrative generation system. This mechanism constructs stories where characters act intentionally, in a manner that highlights their personality traits. To this effect, the narrative generation mechanism utilizes a *macro-planner* to implement the main story generation algorithm and a *micro-planner* to inform the story construction process. The micro-planer is a highly-specialized component that focuses on exploring the multiple ways in which a character can accomplish a goal that she has adopted. Additionally, the micro-planner considers the effect that specific courses for action have on the emotional response of other characters in the story. An evaluation mechanism uses this information to compare and contrast the set of alternate courses for action and select the two that provide the highest degree of contrast between behavior that is consistent with the character's personality and behavior that is not consistent. The information returned by the micro-planner is then used to guide the structure and contents of the plan-based story representation that is produced by the system. Consequently, the thesis statement that guides my research is as follows: **An audience presented with a set of alternate action sequences generated**

for a story character by the *Mask* planning-based narrative generation system will select personality trait ratings that have significant correlation with the choices made by such character.

An essential component of the research presented here is the use of the micro-planner mechanism to represent the mental process that a character undergoes when considering multiple alternatives to accomplish a goal. In contrast to a traditional narrative planner where a uniform planning process handles the construction of a story, in choice-based narrative generation, planning is interleaved between a macro-planner and a micro-planner. The macro-planner is responsible for constructing the authorial view of the global story and its causal coherence. The micro-planner is a restricted version of a planning system, designed to simulate the character's decision-making process as she works toward accomplishing a goal. The micro-planner incorporates elements from a model of human personality in conjunction with a micro-theory of human behavior to approximate a character's decision process. In addition, a simplified version of affect theory enables the micro-planner to evaluate each of the alternatives being considered and select those that best enable the system to portray the personality of the character who is making the choice.

The effective presentation of a story can be affected by its discourse. Therefore, another component important to my approach, although not the focus of this research, is the use of a discourse mechanism to present the story to the audience. The discourse mechanism must successfully convey the existence of choices for a character's actions, as well as the contents of these choices and the context in which they take place. Some of the methods that could be applied to address this component include techniques such as the use of a third-person narrator who describes the collection of choices that a character is considering or the use of an internal monologue where the character enumerates the available alternatives. A more detailed description of the discourse methods that were used to address this challenge is presented in Section 5.11.

I implemented the completed model as part of a narrative generation system named *Mask* and conducted a formal evaluation of the types of stories that it produces. The evaluation relied on the use of human subjects to test following hypothesis:

> IF the *Mask* system produces a story where a given character portrays a specific personality AND an effective discourse mechanism is used to present such story THEN readers will select personality trait ratings that have significant correlation with the choices made by the character in the course of the story.

1.3 Document Structure

In the following section, I summarize the previous research that has been done in this area. The related work section is followed by an introduction to planning-based narrative generation, where I describe how these algorithms operate, focusing on the narrative theory behind them. This section is followed by a high-level overview of the narrative generation approach that I designed. After the overview, I provide a formalization of the elements used to incorporate the approach for choice-based personality that was previously described into a planning-based narrative generation mechanism. The formal definitions are followed by a detailed description of an algorithm for the implementation of the approach, along with the discussion of multiple scenarios that illustrate the operation of the algorithm during story generation. Next, I discuss results from three experiments that were conducted as part of this research: a preliminary evaluation of the principles discussed earlier, a formative study that evaluated design changes prompted by the preliminary evaluation and validated the key ideas on which this research is founded, and an evaluation of the completed system in the context of the stories that it produces. Finally, I discuss the broader impacts of my research and propose potential areas of future work.

Chapter 2

Related Work

Overview

One of the principal motivations for work in the area of automatic narrative generation is the importance of storytelling in human culture. Humans use narrative to describe, better understand, and relate to events of the world in which they live [43]. Furthermore, computer-generated narrative can be applied in various domains to assist in the transfer of knowledge, such as training simulations, activity visualizations, instructional videos, and digital games [48, 73, 66]. In this section, I describe technologies and architectures used for the generation of narrative content and character behavior. The included work provides either a theoretical or practical foundation for the narrative generation model that I describe in this dissertation. Additionally, I introduce work that is highly-relevant to my research even though it is not in the field of Computer Science.

2.1 AI Planning

Planning is an artificial intelligence technique used to solve problems by finding a sequence of actions to achieve a goal state from a given initial state [84, 70]. A classical planning problem is represented by three inputs: an initial world state description, a description of a desired goal state, and a set of available actions that enable transitioning between world states [84]. One of the applications of AI planning is the automatic generation of narrative, which is of particular relevance to the work presented in this document.

A planning domain is typically described using a STRIPS-like representation [22]. The initial world state contains a conjunction of ground atoms. A goal state is a conjunction of positive or negated literals. Actions contain two parts, a list of preconditions and a list of effects. The preconditions define the states in which an action may be executed. The effect list defines the

result of executing the action.

Classical planning algorithms in general are designed following one of two search-based approaches [84]: search through state space and search through plan space. A description of each approach is provided below.

2.1.1 State Space Search

In this approach, search tree nodes represent different world states and edges represent transitions between world states caused by the execution of an action [70]. Search through state space starts with the initial world state. The algorithm invokes a *choose*() function, which non-deterministically selects an action that is satisfied by the world state. The algorithm returns failure if a choice is not possible, otherwise the search continues until a path that achieves the goal state from the initial state is found [70]. The narrative generation algorithm that I use in my research is based on this type of approach.

2.1.2 Plan Space Search:

In this approach, search tree nodes represent partially ordered unfinished plans and edges represent plan refinements [84]. The planning algorithm maintains a partially ordered sequence of actions and a list of causal links [72, 84] that indicate when the effect of an action is required to establish the precondition of another. The planning process starts with a null plan, where the *start* action has no preconditions, and its effects are the literals in the initial state. The *goal* action has as its preconditions the literals in the goal state and does not have any effects. The algorithm non-deterministically selects an open precondition and chooses an existing or new action that establishes it [84]. When a new action is added to the plan, ordering constraints and causal links are updated if necessary. Additionally, the algorithm must deal with the concept of threats. A threat occurs when the effects of an action interfere with one of the causal links in the plan. For example, consider an action a_1 that establishes p, which is a precondition for action a_2. Action a_t threatens the causal link between a_1 and a_2 if one of its effects is $\neg p$. Threats are usually resolved either by demotion or promotion, i.e., a_t can be either demoted by ensuring that it is ordered before a_1 or promoted by ensuring that it is ordered after a_2. The algorithm succeeds when all preconditions have been satisfied and all the threats have been resolved and fails when no action exists to establish an open precondition or a threat cannot be resolved [84].

Planning Approach Used by *Mask*

Several narrative generation algorithms that are relevant to the research described in this dissertation use the plan-space search approach (e.g. *Longbow* [87], IPOCL [68]). However, after carefully exploring both planning approaches (state-space search vs. plan-space search), and

initially considering the use of plan-space search, I have adopted an approach that uses a state-space search algorithm. The principal reason to design my narrative generation algorithm around a such an approach is that in choice-based narrative generation it is necessary to guarantee that a character's choices for action are applicable, i.e., all the necessary preconditions for their execution have been established. The least commitment binding mechanism that is utilized by the plan-space approach is unable to guarantee that preconditions are fully established at the time when a character's choice is being considered, i.e., when a step is newly instantiated. I proposed a method to address this challenge in my earlier work [8]; however, after considering recent narrative generation approaches based on state-space planning [83] it became clear that following a state-space approach would provide a much simpler, efficient, and straight forward method to handle the problem. In the state-space planning approach, when a step is newly instantiated the current state does not contain unbound variables, hence all the necessary preconditions are fully established.

2.2 Planning-based Narrative Generation

The use of AI planners to automatically generate stories was first introduced in systems such as Tale-Spin [46]. Considerable effort has been dedicated since then by AI researchers to the development and improvement of techniques, algorithms, and architectures to enable the application of the problem solving capabilities of AI planners to the automatic generation of narrative that is both interesting and coherent [66]. More recently, the IPOCL planning algorithm by Riedl and Young [68] focused on character intentionality by identifying goals that explain a character's actions. Two extensions to the IPOCL algorithm were later introduced that enable it to explore a bigger narrative space: Initial State Revision (ISR) and recommendations [67]. These extensions are designed to produce stories that are not specifically defined in the description of the story world that is provided by the planning domain. ISR enables the author to leave some elements of the initial state in an indeterminate state (i.e., neither true nor false); the planner can later choose a specific state that it commits to as part of the plan-space exploration. Recommendations are similar to action preconditions; however, it is up to the planner whether to enforce them during plan construction. Recommendations can be used as part of a mechanism where actions can be engineered to correspond with a character's personality attributes; however, the algorithm can generate stories where actors sometimes behave *out of character*. The authors contend that narratives produced by the enhanced version of IPOCL have the potential for being more creative yet still coherent.

Several systems and algorithms have been developed as a result of research in planning-based narrative generation. These include work by Cavazza et al. [13] that focuses on a character-based approach to interactive storytelling. In their methodology, Hierarchical Task Networks planning

(HTN) is used to describe the roles of characters in an initial story line. The system allows user interaction at any point during story progression, which results in narrative variations that emerge when operations such as re-planning and action repair occur to address the effects of user input. Two types of mechanisms are used to deal with the consequences of interactions that create situations not handled by plan-based behaviors: situated reasoning and action repair. The first mechanism deals with interrupting the execution of the current plan in order to deal with a specific situation. The second mechanism deals with either restoring the conditions that allow an action to execute, or using an alternate action to achieve the same result. Given the emphasis on character roles, main story characters have top-down plans for their pre-defined story actions and can also react to specific events. Additionally, actions associated with a character can be categorized based on various factors, such as personality traits and interpersonal relationships. Narrative variations may also be produced by the interaction of multiple characters plans. Their implementation assumes a total ordering of actions, subtask independence, and the absence of delete lists in all primitive action definitions [70]. Charles et al. discussed and compared the use of a Hierarchical Task Network (HTN) with an approach that uses Heuristic Search Planning (HSP) in interactive storytelling (IS) [14]. Following a character-based approach in their implementation, HTN planning is used to describe the role of individual characters. The plot is generated dynamically, as the result of character interaction. Also, the ability to support interleaving of planning and execution is essential for their target area of application; therefore, characters need to be able to generate actions in real-time in an environment where they interact with each other. Furthermore, in this formalism the different levels in the hierarchy of an HTN can be used to describe multiple layers of narrative representation, such as the main story line, various scenes, and individual actions within a scene. However, the use of HTN assumes that tasks are decomposable and totally ordered (decomposability implies the lack of positive or negative interactions between tasks), which imposes restrictions on the variety of the narratives that can be generated. A STRIPS-like representation of actions that uses HSP planning is proposed as a method to address the limitations imposed by HTN. This approach also provides more flexibility in terms of re-planning, more variations to the baseline story, as well as the ability to create more complex settings. One of the advantages proposed by the authors is the support that the HSP-based approach provides for the generation of comedic scenarios in a narrative.

Bae and Young applied a plan-based narrative generation architecture to create flashback and foreshadowing in automatically generated stories [4]. The architecture centers on the use of *Prevoyant*, which is a computational model of flashback and foreshadowing designed to produce surprise on the audience. Prevoyant is a plan-based model of reader understanding that is built as a story is read. The architecture also uses Zócalo [81], a web-based component service that enables the resulting narratives to be presented in a virtual 3D environment. Stories

are generated by *Longbow*, a partial-order causal link planner that also handles hierarchical decomposition of actions (DPOCL) [87]. Stories are represented by a planning structure that includes plan steps, binding constraints, ordering constraints, causal links, and decomposition links. Candidate flashback events are selected by identifying significant story events and their corresponding initiating events, allowing the presentation of the significant event prior to the events that initiate it. Events are chosen for their use in flashback based on a measure of the level of surprise that the omission of their initiating event(s) creates on the reader. Foreshadowing is achieved by ensuring that specific characters, events, or partial details of an initiating event are presented early in the story. The computational model was later enhanced to add the ability to generate surprise endings as a means to create narratives that maintain the sense of suspense in the audience [5]. This approach was based on utilizing the disparity of knowledge that can exist between what an audience knows about story events and what story characters know about the same events.

An approach that uses state trajectory constraints as a means to control the existence and ordering of essential story events in planning-based narrative generation for IS was developed by Porteous and Cavazza [54]. State trajectory constraints are a feature introduced in the PDDL3.0[1] specification; they provide various modal operators used to specify conditions that must exist in the complete sequence of steps that are explored in the execution of a solution. Constraints are specified independently from the rest of the domain description. A principal motivation for this work is that planning-based approaches are designed to produce efficient and correct solutions, which is not ideal in the context of IS. The authors propose that state trajectory constraints can be leveraged to generate stories that have a preferred narrative structure. Additionally, the partial ordering of events imposed by the constraints can be used to decompose the problem into multiple sub-problems whose solutions are appended to achieve the goal state. This methodology is based on the *landmarks* technique introduced by Hoffman [29]. Porteous and Cavazza suggest that constraints can also be used to introduce narrative effects, such as conflict, suspense, causality, and pace variation. A similar method, based on the planning concept of *islands* [28], was proposed by Riedl as a means to preserve authorial intent in story generation mechanisms that use an approach based on partial-order planning [64].

A mechanism for the off-line adaptation of plotlines in role-paying games (RPG) was developed by Li and Riedl [40]. Their approach uses a player model, a library of quests, a plan-based narrative representation, and an adaptation algorithm that utilizes plan refinement techniques. The narrative representation uses partial-order plans to describe the events that may occur in the game world as a result of player actions, physical events, or the actions of non-player

[1]The Planning Domain Definition Language (PDDL) is used to describe planning problems and their corresponding planning domain. PDDL is used in the International Planning Competition (IPC) to standardize the description of the set of problems that are used to test and evaluate participant entries.

characters. Additionally, hierarchical action decomposition is used to describe narrative subsequences, such as quests. One of the advantages of the plan-based representation is that it facilitates ensuring that a plot's narrative is sound and coherent. According to Li and Riedl, sound narratives are those where all of the necessary preconditions for an event are true at the moment of its execution. Similarly, coherent narratives are those where a directed acyclic graph (DAG) of the narrative events shows a path from every event to an important outcome, i.e., there are no dead ends. The adaptation algorithm applies partial order planning techniques (POP [84]) to rewrite a complete plotline in order to match a set of plot requirements, which specify the types of quests that the player prefers. The algorithm also uses a library of event descriptions and a set of decomposition rules to rewrite elements of the plotline.

A method for the automated extension of planning-based narrative domains was developed by Porteous et al. [56]. The method focuses on the identification of essential narrative elements in the story domain that when negated prevent the progression of the story. These elements are used as the basis for the creation of additional narrative actions, which enable the generation of new story content by introducing alternate transitions that are not already in the domain. To make the automatically-generated alternate actions human readable, antonyms for the labels used in the original actions and properties are retrieved from lexical sources, such as WordNet [20]. Porteous et al. are also developing a narrative generation system that uses a computational model of social networks to control the types of plans that are produced [55]. Their approach enables a plan-based narrative generation system to increase the diversity of the stories that are created. The system includes a graphical interface that enables authors to specify relationships between story characters, such as friendship and antagonism. The information provided by the social networks is used in conjunction with specially engineered planning operators to create narratives that change when the relationships specified in the network are modified.

The computational model of narrative used in this research is based on a modification of the Glaive state-space planning algorithm developed by Ware and Young [83]. Additionally, my work has its foundation on previous research conducted by Young and his colleagues on the use of planning algorithms for narrative generation [85, 66, 27, 68]. It is important to note that the work presented in this document follows an approach distinct from that used by Riedl and Young in the IPOCL planning algorithm [68]. IPOCL centers on character intentionality without considering the character's personality. In contrast, the approach described in this document focuses on the selection by a character of specific action sequences to achieve the character's goals as the means for the system to portray the character's distinct personality traits. It is envisioned that both approaches can be complementary as part of a solution aimed at producing more coherent and interesting narratives.

2.3 Drama Management Systems

Some of the approaches for the automatic generation of narrative have focused on systems that direct the interaction among characters. Work by Assanie on the extension of synthetic characters based on the Soar QuakeBot environment [35] dealt primarily with providing synthetic agents with the ability to adjust to changing goals provided by an external narrative manager [3]. One of the design objectives of this system was the implementation of characters able to exhibit behavior that would resemble improvisational actors. The system was designed to ensure that agents could accept directives from an external narrative manager and use them to adjust their behavior in a manner that would appear believable while at the same time be responsive to the newly given directives. This was accomplished by enabling the agent to reason about the directive in the context of its own goals in order to find a set of intermediate goals, which could then be mapped to a hierarchy of operators designed to achieve them. The purpose of the intermediate goals was to enable a coherent transition between the agent's current goal and the new goal set by the directive. An important part of the reasoning process was an evaluation of different sets of intermediate goals and their comparison with a direct transition that would essentially abandon the current goal and pursue the one indicated by the new directive.

Work by Riedl and Stern on drama managers focused on semi-autonomous agents that have the ability to *fail believably* [65]. The system is designed to ensure that agents avoid situations that are in conflict with the goals set by the drama manager and also to behave in a way that justifies agent failure due to conflict with a goal. The authors note that an agent's ability to fail is necessary to preserve the narrative plot line while still accommodating user actions and agent autonomy. In this approach, plots are represented as partially-ordered plans, which contain causally-connected graph of plot points. The only agent actions that require it to adapt are those that could prevent the successful execution of the drama manager's plan. Two methods are used to ensure that the drama manager's goals are preserved while ensuring the agent's believable behavior. The first method enables agents to determine whether their current set of goals are compatible with new directives issued by the drama manager and adjust their behavior as needed using one of three approaches: merge the new goal with its current goal, complete the current goal and immediately move on to the new goal, and abandon the current goal in favor of the new goal issued by the drama manager. The last approach depends upon the use of various transition behaviors that are previously scripted and that could be informed by the agent's personality traits. The second method deals with the agent's ability to avoid specific states of the story world because these are proscribed by the drama manager, such as performing actions that are in conflict with the drama manager's plot. Two approaches are used to address the need to avoid conflicting goals: plan coordination and plan restoration. Plan coordination uses the synergy algorithm [17] to identify conflicting goals among multiple agents

plans' and apply restrictions to prevent them from conflicting with each other. Plan restoration deals with conflicts that occur once a plan's execution is in progress; in this case behavior is implemented to enable agents to adjust when conflicting goals are identified in a manner that explains an agent's abandonment of a current plan in order to restore a goal set by the drama manager. Drama management systems are relevant to the research that I present in this document because they use computational models to create virtual characters that can adjust to changing situations in a manner that incorporates personality traits. However, these type of systems do not fully address character personality as an integral part of the story generation process.

2.4 Story Composition Using Predefined Character Models

The work of Lebowitz on the UNIVERSE system [38] focused on the generation of stories using a plan-based approach combined with predefined character models designed to promote story extensibility while maintaining consistency and coherence. Characters are modeled using three components: (1) stereotypes that describe elements such as occupation and personal background, (2) past events that motivate and justify behavior not consistent with a character's stereotypes, and (3) information about a character's interpersonal relationships. Stereotypes provide information on a character's physical and personality traits (e.g. self-confidence) and typical goals (e.g. become famous); this information is used to guide character selection when a new plot is created. The system also uses author goals to control the story-generation mechanism and character goals to ensure the coherence and consistency of the generated stories, i.e., character actions reflect their personality and backgrounds. The use of character goals is dependent on the definition of detailed character models, which are primarily based on the concept of stereotypes. Additionally, in order to maintain the consistency and coherence of the stories that are generated, UNIVERSE keeps track of the relationships between characters, the story events that influence such relationships, and characters' motivations. In contrast with the approach used in UNIVERSE, the model that I designed uses a declarative representation of character personality that enables the system to dynamically select the types of actions that are representative of a character's traits.

2.5 The Five Factor Model of Personality

In order to design a planning-based story generation mechanism that can create characters with distinct personalities, I am developing a computational model of behavior based on personality traits. The model is based on the Five Factor Model (FFM), or Big Five, defined by Goldberg [26]. The FFM provides a taxonomy for the classification of personality using the five

factors listed below. Note that within each classification there are distinct bi-polar personality traits, e.g. honesty vs. dishonesty.

1. **O**penness (or Culture).
2. **C**onscientiousness (or Dependability)
3. **E**xtroversion
4. **A**greeableness
5. **N**euroticism (or Emotional Stability)

Each factor is linked to specific personality traits that can be mapped to a set of behavioral manifestations. According to results obtained by social psychologists Mehl *et al.* [47] and Funder and Sneed [23], there is high correlation between personality traits and specific, observable, behaviors [45, 23, 47, 80]. A sample mapping is shown in Table 2.1. Study results indicate that witnessing a certain behavior can elicit the perception of a personality trait associated with it.

Of the five personality factors, I focus on Agreeableness and Conscientiousness because these are commonly used to describe *good* versus *evil* and *strong-willed* versus *weak-willed* personalities [45, 44]. These personalities are typically utilized in the portrayal of character types and themes frequently used in narrative. For example, Alexei in Dostoyevsky's *Brothers Karamazov* exhibits high agreeableness, Alex in Burguess' *A Clockwork Orange* exhibits low agreeableness, Antigone in Sophocle's play exhibits high conscientiousness, and Oscar Madison in Simon's *The Odd Couple* exhibits low conscientiousness [44].

Table 2.1: Big-Five Factors Mapped to Observable Behavior. Based on An alternative "Description of Personality": The Big-Five Factor Structure (Goldberg, 1990).

Factor	**Likely Behaviors**	**Unlikely Behaviors**
Agreeableness	Honesty	Aggression
	Responsibility	Confrontation
	Interaction	Lack of Interaction
	Ambition	Sabotage
	Empathy	Irritability
	Generosity	Selfishness
Conscientiousness	Organization	Impulsiveness
	Dutifulness	Lack of ambition
	Self-discipline	Mischief
	Achievement	Procrastination
	Reliability	Anti-social
	Risk avoidance	Criminal

2.6 Expressive Characters with Personalities

A number of research efforts have been aimed at the operationalization of personality models, in particular the FFM [26], to create richer and more expressive characters. André *et al.* [1] worked on the development of lifelike characters as a means to improve interaction between humans and virtual characters by focusing on modeling personality and emotion to control the affective state of a virtual agent when it communicates with humans. Their approach utilizes the FFM and the OCC theory of emotion [51]. The OCC theory of emotion is used to generate emotional states that influence the agent's planning mechanism and physical expressions. Physical expressions are in turn implemented using the GRETA agent architecture [52]. Application of this architecture in different environments shows that it is well suited for the representation of stereotypical responses for simple emotion types. The work of Doce *et al.* [18] applied the FFM to create distinguishable personalities in virtual agents by using personality traits to affect specific cognitive and behavioral processes (e.g. coping mechanisms, bodily expressions). Work by Bouchet and Sansonnet [11] applied the FFM and a model of cognition to implement a system in which rational agents make decisions after reasoning about goals that are modulated by pre-assigned personality traits.

Research by Loyall [41] focused on the creation of believable agents, defined as autonomous agents with a rich personality and properties similar to those of characters in the traditional arts (e.g. film). The *Hap* architecture was developed to achieve this goal. Hap provides a language that enables authors to describe agent personality in terms of goals and behaviors, the latter mainly used to indicate activities that an agent can enact to achieve a goal. Additionally, an *Active Behavior Tree* (ABT) is expanded at run-time to keep track of the goals being pursued by an agent; nodes in the tree may include subgoals and primitive actions, such as "close eyes." Additionally, behaviors may have preconditions that must be true for their execution; however, the Hap architecture does not include a planning component. Finally, the contents of the ABT are updated when an action completes execution or when there are changes in the environment.

Although these systems incorporate robust psychological models, they do not consider story generation as a whole and instead focus on the immediate reactions of virtual agents. They do not fully address the ability to generate rich character behavior that can adjust to a changing set of authorial goals or to changing story conditions.

2.7 Virtual Agents and Character Dialog

Recent work in the area of virtual agents has focused on a specific subset of character actions: utterances in dialog [42, 62]. Of particular interest to my research is the work of Mairesse and Walker on PERSONAGE [42], a natural language generator that can be configured to generate

dialog that meets a predefined set of personality requirements. PERSONAGE is built on an architecture that uses the Five Factor Model [26] to create a mapping between personality traits and dialog utterances. Experimental results showed that the system parameters could be configured to generate dialog that was correctly perceived as extroverted. The PERSONAGE system was also used as part of the SpyFeet Role-Playing Game (RPG) to generate dialog for game characters based on author-provided personality traits [62]. Wok on these systems thus provides relevant evidence to support the applicability of the FFM on a computational system. Furthermore, results from their evaluations support the idea that a computational system can create narrative content that elicits on an audience the perception of a pre-selected personality factor.

2.8 Creative Writing Principles

The solution that I presented in this document relies on the operationalization of creative writing principles for the automatic generation of stories. While there are a number of principles that are relevant to the support of an automatic story generation system, I focus on the importance of character personality for the development of fictional characters. To accomplish this objective, I incorporate established principles and techniques that have been refined from creative writing teaching methods and best practices [15, 12, 36]. Among these, I focus on the principle of *character definition*, which deals with the essential role that well-defined characters play in the composition of a story. I focus on this principle not only due to the importance of compelling characters in storytelling but also because of the crucial role that characters play as agents of change in a story. Characters are an essential component of narrative, vital for the realization of essential story elements such as events and dialog [15, 36, 49].

Narrative composition principles can potentially be operationalized into computational processes that provide assistance at critical junctures where human subject matter knowledge is essential but computational power can dramatically reduce the time and effort needed to create a story. The resulting computational processes can then be used to assist human authors of interactive or static narratives and to enhance the capabilities of narrative generation systems. For instance, when validating the consistency of a story plot, rather than depending on the author to manually review all the story events, an intelligent process could analyze the causal chain of events and algorithmically measure their coherence.

Enhancing the ability to automatically generate stories that are interesting and coherent is of particular relevance to my research. One way in which this could be accomplished is by supporting and improving the ability to use narrative elements that strengthen the expressiveness of the narrative in a manner that has a predictable effect on the mental model of the story that is elicited on the audience. For instance, characters that are intended to be heroes behave in a

manner that is in fact perceived as heroic by those who experience the story.

In order for characters to contribute to the effectiveness of a story, they should be well-defined, i.e., they should have rich and detailed features that make them interesting and compelling. Among the factors that contribute to the effective definition of a character creative writers typically include: physical attributes, talents, emotions, beliefs, and personality. Characters that portray these factors in an interesting and believable manner are considered round; characters that fall short of this expectation are considered flat. This poses a challenge for narrative generation systems because it places additional requirements on the structure and content of the stories that such systems produce.

Personality is a key component of what makes a narrative character round. A character's personality can make her more believable and compelling, consistent yet capable of surprising the audience. A character's lack of personality can create the perception of being flat, thus detracting from the story and reducing its effectiveness. For the purposes of this research, I center my efforts on the personality factor as one of the key defining characteristics of well-defined narrative characters. The computational model that I present in this document is thus designed to enable the automatic generation of stories where characters are portrayed as having a distinguishable personality.

2.9 Hierarchical Taxonomy of Human Goals

The narrative generation model that I designed must reason about the effects of character behavior on the goals of other characters. Such reasoning can be informed by the use of a hierarchical taxonomy of human goals and their relationship with personality traits. The hierarchy I utilize is derived from the work of Chulef, Read, Walsh and Miller on the study and simulation of human behavior [61, 16]. Their research suggests that many personality traits are goal-based structures [61]. Furthermore, they propose the grouping of traits based on the similarity of the goals that are associated with them. In the context of their work, traits are composed of four key elements: (1) goals, (2) plans formed to achieve such goals, (3) resources needed to complete the plans, and (4) beliefs associated with the trait. They also established that factors of the FFM [26] have conceptual relationships with specific clusters of human goals (e.g. teaching and helping others, ethics and idealism) that were identified during experimental studies. Based on this, given a set of personality traits, we can establish a link to a cluster of goals that will be held with higher regard by individuals possessing such traits. For example, a highly agreeable personality will assign a higher priority to goals in the areas of Friendship, Teaching and Helping Others, Positive Social Qualities, Social Awareness, and Ethics and Idealism [16].

2.10 Affect Appraisal Theory

One of the key problems that this research deals with is that of assigning valence to story events. Instead of statically labeling every possible action as being positive or negative, I use a model that dynamically assesses the effects of specific choices for action on the affect of other story characters. The design of this mechanism is based on a simplified version of the appraisal theory introduced by Lazarus [37]. In this theory, human emotions are considered in the context of the elements that motivate them: values, goals, commitments, intentions, and plans. Appraisal is an essential element of human emotions. It constitutes an evaluation of the personal significance of what occurs in an encounter between a person and the surrounding environment.

The model of affect that I use is an approximation. Emotions can be very complex; however, in their simple form they can be seen as a person-environment relationship that involves either harm or benefit. Hence, for the purposes of this research, I use a simplified valence indicated by either positive or negative affect, as assessed in the context of character choices and how these affect the goals of other story characters. The affect model is described in Section 4 of this document.

2.11 Summary

A considerable body of research has been dedicated to the development of narrative generation systems and intelligent virtual agents. Among these, several approaches have focused on the portrayal of personality traits. However, these and similar efforts tend to deal primarily with characters as individual agents who are able to react to their immediate environment or to the actions of other agents. Although existing methods have proven successful at specific aspects of narrative generation [68], drama management [65], portrayal of emotions in virtual agents [1], and natural language generation [42], they typically handle very specific and localized elements of narrative without reasoning about the story in its entirety. In contrast, the research presented in this document aims at considering characters in the context of an entire story. Rather than focusing on immediate and localized reactions to events, my objective is to develop a narrative generation system that reasons about the story as a whole, while placing an emphasis on the effect that a character's actions have on the mental model that the audience forms of the story. Specifically, the resulting narrative generation mechanism will be designed to ensure that character actions are chosen to elicit the perception of a specific and predictable personality factor (e.g. conscientiousness).

Chapter 3

A Brief Introduction to Planning-Based Narrative Generation

Overview

In this section, I provide an introduction to the methods and techniques that are used to create stories through the use of automated processes. Several of the efforts in this area aim at the creation of stories in a completely automated manner (e.g. [68]), freeing the human author from being directly involved in all of the details of the story creation process. However, there is also much work being done that focuses on enhancing or augmenting what the human author can do through the introduction of intelligent tools that enable human-machine collaboration using mixed-initiative techniques [21], such as the Wide-ruled authoring tool [75]. Here, I focus on the technical aspects of the first set of efforts, i.e., those that deal with algorithms that can produce narrative content in an unattended manner.

3.1 Background

Planning-based narrative generation has its foundation of the use of AI planning methods to design algorithms that can produce story content [87, 85]. The basis of a planning algorithm is in the use of a search mechanism to find a sequence of steps that when executed will transform an initial state into a goal state [70]. This process utilizes a formal representation of the world in which an agent operates, a formal description of actions that are legal in such a world, and a formal description of the desired goal state. The formalisms typically use Logic, specifically first-order logic in the case of several of the current systems.

Planning mechanisms use an operationalization of a means-ends analysis of a problem [74]. In such an analysis, search is applied in order to find a solution in a state-space or in a plan-space. The key idea being that if such a solution exists, the planning system will find it—achieving completeness—and that the solutions found will be correct—achieving soundness—.

3.1.1 Search

Search as an AI problem is essential to the study and implementation of AI planners. The use of search algorithms is at the heart of classical planning because search is essential to achieve a planning mechanism's objective of finding the solution to a problem by applying sequences of operators, each of which may provide a piece of such solution [70].

The essential idea behind search in AI is that a given goal can be achieved by an agent through the execution of a sequence of actions [74]. The ability to find such actions depends on the assumption that the world where the agent operates is known, observable, and deterministic. Search algorithms take as input a problem and return the specific set of actions that when executed in sequence will provide a solution.

A commonly used example of a problem that can be solved using search is the 8-puzzle. The 8-puzzle consists of a 3 by 3 grid in which eight of the squares contain a number and one of the squares is empty. The objective of the game is to achieve a specific ordering of the squares, such as the one shown in Figure 3.1.

	1	**2**
3	**4**	**5**
6	**7**	**8**

Figure 3.1: Standard 8 Puzzle Problem

The group of sliding-block puzzles, to which the 8-block puzzle belongs, is known to be NP complete [70]. The 8-block puzzle, which is easy to solve, has $9!/2 = 181,440$ possible states [70].

There are also problems with more practical applications, such as the Traveling Salesperson Problem (TSP), an NP-complete problem. Other applications include the design of Very Large Scale Integration (VLSI) circuits and robot navigation. In the case of interactive narrative, search can be used to find a path through a virtual world for computer-controlled characters, and it can also be used to generate narrative content in response to user commands or actions [88].

3.1.2 Formal Definition of a Problem in Search

A problem in search is formally defined using five elements:

1. An initial state of the agent.
2. A set containing the actions that are possible in the environment.
3. A transition model that describes the effect of each action, i.e. the resulting state. The transition model can be represented using a directed graph where the nodes represent states and the links between them represent actions.
4. A goal test used to decide whether a reached state constitutes the achievement of a goal.
5. A function to measure the cost of following a given path. Paths on the graph indicate a sequence of actions with their corresponding resulting states. Search algorithms apply a cost function to help find the path that achieves the goal at the lowest cost, hence providing the optimal solution.

3.1.3 The Search Process

Search algorithms look for a solution using a search tree, where the root node represents the initial state of the problem, branches represent actions, and subsequent nodes represent different possible states in the problem space.

The search algorithm starts by verifying that the initial state does not itself constitute a solution, i.e., it is not a goal state. The algorithm then proceeds to select a valid action from the set of actions that connect to the initial node and expands those actions. Expanding consists of generating the set of states that result from the execution of an action. A state is then chosen from this new set and the process is repeated. The process continues until a solution is achieved or the set of unexpanded states is empty.

3.1.4 Types of Search

The technique used to select the state that is expanded next is one of the main differentiating factors between different search algorithms. The selection method or strategy can have a profound influence on the performance of the algorithm as well as on the efficiency of the solution that is found. Here I present some of the more commonly used search algorithms.

Breadth-first Search

The breadth-first search strategy starts with the root node and expands all of the states that immediately follow it. It then expands all the nodes at the next level and continues to do this

until a solution is reached. The main idea is that a given level is expanded in its entirety before the algorithm moves to the next level.

Depth-first Search

The depth-first search strategy works by expanding the current deepest expanded node in the graph and expanding its successors. The algorithm stops when no more successors are found and then returns to the next deepest node and expands its successors.

3.1.5 Heuristics

The tremendous time and space requirements of search algorithms make it a necessity to apply optimization techniques. The use of heuristics in particular has proven to be very beneficial. Heuristics use a relaxed version of the problem that the search process is trying to solve, one whose solution can be computed much faster. The solution to the relaxed version of the problem is then used to guide the search process in the selection of which nodes to expand next.

A* Search

Heuristics are used in the A* algorithm, which is commonly known as best-first search. The A* algorithm uses a cost function to determine which node to expand next. The main idea is to select the node that is cheapest to reach and that in turn provides the least expensive path to the goal, as illustrated by the following equation:

$f(n) = g(n) + h(n)$, **where**

1. $f(n)$ is the cost function for node n.
2. $g(n)$ is the cost of the path to reach node n from the initial node.
3. $h(n)$ is the estimated cost of the least expensive path from n to the goal state.

3.1.6 Complexity Analysis

The performance of search algorithms is primarily affected by the number of nodes that must be accessed and expanded in the search tree in order to find a solution. However, other factors such as memory requirements also deserve consideration. In general, the complexity of a search algorithm can be expressed using the following factors:

1. b - The branching factor, given by the maximum possible numbers of successors of a node in the tree.
2. d - The depth of the goal state that is closest to the root node.

3. m - The maximum possible length of a path in the tree.

In the case of breadth-first search, the time complexity is $O(b^d)$ [70]. It is important to note that this complexity is present both in terms of time and space required to solve the problem. It is easy to appreciate that the use of this algorithm is only practical for problem spaces of a small size.

In the case of depth-first search, the time complexity of the algorithm is $O(b^m)$ [70]. The space complexity can be $O(m)$ or $O(b \cdot m)$ depending on how the algorithm implements returning to unexpanded nodes when all the successors of a given node have been expanded.

The A^* algorithm is a much better solution than breadth-first search and depth-first search; however, its time and space requirements are also steep. The complexity of A^* is $O(b^\epsilon \cdot d)$, where ϵ is the relative error of the heuristic used to find the solution, $\epsilon \equiv (h^* - h)/h$ and h^* is the actual cost incurred in reaching the goal state from the root of the tree.

3.2 Classical Planning

Planning is an artificial intelligence technique used when a sequence of actions can be ordered appropriately to achieve a goal [84]. Classical planning is represented by three inputs: an initial world state, a goal state which is the desired state of the world, and a set of actions that transition between world states [84]. The problem consists of finding a set of actions, and an ordering of such actions, needed to transition from the initial world state to the goal state. This technique is particularly important for intelligent agents where it is often necessary to find logical sequences of actions to achieve specific goals [84]. In the case of narrative generation, the same technique can be applied by framing the story generation problem as one of finding a chronological sequence of events that can transform an initial story context into a desired outcome. In the case of stories, the events in the solution set represent what narrative theorists refer to as the *fabula* [58] of the story.

Planning can be considered in two different ways [84]:

1. Search through world space.

2. Search through plan space

In both cases the main underlying method used to plan is search as described in the previous section. In the case of world space search, the search tree nodes are different world states, and the edges are transitions between world states caused by the execution of one action [84]. In the case of plan space search, the search tree nodes are partially ordered unfinished plans, and the edges are plan refinements [84]. The research described in this document uses a technique that is based on search through the world space, also described as state-space search.

3.2.1 Knowledge Representation

Planning data is generally represented using a STRIPS-like formalism [22]. The initial and goal world states are described by a conjunction of positive literals. Actions contain two parts, a list of preconditions and a list of effects. The preconditions are also a list of positive literals which must be true in order to apply the action. The effect list, on the other hand, can contain both positive and negative literals. The goal is then to match preconditions of actions to literals already in the world state. These actions are said to be satisfied by the current world state, and are possible additions to the plan. Any literals not explicitly described in the initial state of the story world are assumed to be false (closed-world assumption [70]).

World Space

Search through world space begins with the initial world state, followed by a non-deterministic call to a *choose*() function to get the next action which is satisfied by the initial world state. The algorithm then adds the effects of the chosen action to the world state [84]. The process continues, recursively choosing and adding actions until the goal state is achieved or failure is detected. To turn this non-deterministic approach into a deterministic one, search can be used to find the correct actions to add. The algorithm for a world space planner, taken from [84], is presented in Algorithm 1.

Algorithm 1 *ProgWS(world-state, goal-list, Λ, path)*

```
1: if world-state satisfies each conjunct in goal-list then
2:     return path
3: else
4:     Let Act = choose from Λ an action whose precondition is satisfied by world-state:
5:
6:     if no such choice was possible then
7:         return failure
8:     else
9:         Let S = the result of simulating execution of Act in world-state
10:        return ProgWS(world-state, goal-list, Λ, Concatenate(path, Act)
11:    end if
12: end if
```

Plan Space

Search through plan space is different from world space in that it does not maintain a total ordered list of actions. Instead, it maintains partially ordered incomplete plans. The knowledge representation needs to change slightly to accommodate this. The algorithm maintains a list of actions currently in the plan, a partial causal ordering of these actions and a list of causal links indicating which of the effects of the action caused it to be chosen [84]. We also need to introduce the concept of threats. An action causes a threat to a causal link if the effects of the action negate what the causal link establishes [84]. For example, let us suppose that there is an action a_1 which has the effect of q, which is in turn a precondition of a_2. Action a_3 would threaten this causal link if its effects include $\neg q$. To resolve this, a_3 is either promoted (forced to come after the causal link), or demoted (forced to come before the causal link). The planner starts with a null plan, where the start state and goal state are represented by dummy actions. The start action has no preconditions, and its effects are the literals in the initial state. The goal action has as its preconditions the literals in the goal state and no effects. The planner then non-deterministically calls a *choose*() function to fill in open preconditions [84]. Before the first call to *choose*(), the only preconditions that exist are those causally linked to the goal action. Note that in this process, actions that are ordered later in the plan may be chosen before ones that are ordered earlier. This process is performed recursively, until either all of the preconditions have been satisfied or an inconsistent state is detected. The plan is considered complete when all preconditions have been satisfied and there are no threats to causal links the plan [84]. This plan may be partially ordered. The pseudo-code for the POCL algorithm [85, 87, 68], which implements this type of search is shown in Algorithm 2.

3.2.2 Complexity Analysis

There are several things to consider when analyzing the complexity of planning. First, whether or not the algorithm is sound and complete; that is, will the plan that is found work correctly? Also, if there is a plan that satisfies the goal, will it be found? The world space search algorithm described above is both sound and complete [84]. The complexity of deterministically searching through world space to find a sound and complete plan is $O(b^n)$ [84], where:

1. n is the number of *choose*() calls the algorithm needs to make.
2. b is the number of possible choices at any given *choose*() call.

The partial order planning algorithm presented is also both sound and complete [84]. The running time is $O(cb^n)$ [84], where:

1. n is the number of non-deterministic *choose*() calls that are made.

Algorithm 2 POCL($\langle S, B, O, L\rangle$, F, Λ) (by Riedl and Young)

(taken from [68])

The first parameter is a plan. On the initial call to POCL, there are only two steps in S – the dummy initial step whose effect is the initial state and the final step. F is a set of flaws. On the initial call, F contains an open condition flaw for each goal proposition in the goal situation. $B = L = \emptyset$. Λ is the set of action schemata. Output is a complete plan or *fail*.

I. Termination.

If O or B is inconsistent, fail. Otherwise, if F is empty, return $\langle S, B, O, L\rangle$.

II. Plan Refinement.

1. Goal selection.

Select an open condition flaw $f = \langle s_{\mathsf{need}}, p\rangle$ from F. Let $F' = F - \{f\}$.

2. Operator selection.

Let s_{add} be a step that adds an effect e that can be unified with p (to create s_{add}, non-deterministically choose a step s_{old} already in S or instantiate an action schema in Λ). If no such step exists, backtrack. Otherwise, let $S' = S \cup \{s_{\mathsf{add}}\}, O' = O \cup \{s_{\mathsf{add}} < s_{\mathsf{need}}\}, B' = B \cup B_{\mathsf{new}}$ where B_{new} are bindings (e.g., assignments of ground symbols to variables) needed to make s_{add} add e, including the bindings of s_{add} itself, and $L' = L \cup \{\langle s_{\mathsf{add}}, e, p, s_{\mathsf{need}}\rangle\}$. If $s_{\mathsf{add}} \neq s_{\mathsf{old}}$, add new open condition flaws to F' for every precondition of s_{add}.

3. Threat resolution.

A step s_{threat} threatens a causal link $\langle s_j, e, p, s_k\rangle$ when it occurs between s_j and s_k and it asserts $\neg e$. For every used step s_{threat} that might threaten a causal link $\langle s_j, e, p, s_k\rangle \in L'$, non-deterministically do one of the following.

Promotion. If s_k possibly precedes s_{threat}, let $O' = O'\{s_k < s_{\mathsf{threat}}\}$.

Demotion. If s_{threat} possibly precedes s_j, let $O' = O'\{s_{\mathsf{threat}} < s_j\}$.

Separation. Let $O' = O' \cup \{s_j < s_{\mathsf{threat}}, s_{\mathsf{threat}} < s_k\}$ and let $B' = B' \cup$ the set of variable constraints needed to ensure that s_{threat} won't assert $\neg e$.

III. Recursive invocation. Call POCL($\langle S', B', O', L'\rangle$, F', Λ)

2. b is the number of choices possible at each *choose*() call.

3. c is the time it takes to process a node in the search tree, which encompasses dealing with causal links and threats.

3.3 Using Planning to Generate Narratives

Narrative is a very important form of communication [68]. It is used not only in literature, movies, TV, and other forms of entertainment, but also in education and training [68]. Because of this, narrative has a key role in the production of digital content, including digital games. Furthemore, an artificial intelligence that can reason about narratives will be better positioned to communicate ideas to humans in a more natural manner [43, 68]. Stories in digital games and other interactive media should be both interesting and coherent to be effective.

Planning is not only useful for problem solving but also applicable to narrative generation [86]. Planning uses actions to achieve a goal in a world state, which maps directly to the idea of generating *fabula* [58] that encompasses the events of a story [58, 86, 85]. Many narrative generation and interactive narrative systems use AI planners to create their story content. In these types of systems, the start state represents the beginning of the story, the goal state represents the outcome of the story, and the actions of the plan correspond to the events that take place in the course of the story. Planning, however, is not a perfect fit for narrative generation [68]. Classical planners only reason about the causality of actions. That is, a planner may generate a plan that works and is causally accurate, but that makes absolutely no sense from a narrative perspective. The opposite is also true, a planner may produce a very simple and sensible plan, which tells a story that is very boring or inconsequential. In narrative, stories not only need to be causally accurate, but also have believability of events and character actions, as well as interesting events [68]. The need to address narrative composition requirements, coupled with the inherent limitations imposed by classical planning have led to the development of planners specifically designed for narrative generation. Examples of such planners include *Longbow* [87, 68] and *Glaive* [83]. Systems such as these incorporate a planning algorithm that has been significantly modified to incorporate a process that is based on story composition principles, such as ensuring that a character's actions always have a motivation as a means to ensure that they behave in a coherent and believable manner [68].

3.3.1 Intentional Planning

One type of planning system that is specifically designed for narrative generation is the Intent-driven Partial Order Causal Link (IPOCL) planner [68], designed by Riedl and Young. In addition to keeping track of causal links between actions, the planning mechanism also reasons

about the motivations that lead characters to take their actions. In *IPOCL* planning, every action must have an intention that justifies it before such action can be a valid part of the plan. For example, if a character is going to drive a car, that character needs to have something happen to cause him to need to drive the car, not just have the keys needed to turn it on. The planner does this by using actions that have been enhanced to include the specification of the character who is carrying out the action [68]. Using this information, Frames of Commitment [68] are created for any goal that a character has committed to achieving. The Planner searches through plan space like a classic partial order planner; however, the algorithm also keeps track of the character who executes an action and adds these actions to the frames of commitment for the character. The planning process is finished when there are no open preconditions or threats, and when all actions are justified within a frame of commitment [68]. Experimental evaluation of the planner was shown to create narratives that were more believable than ones created with a classic partial order causal link planner [68]. The running time of this algorithm is $O(c(b(e+1)^a)^n)$, where:

1. n is the depth of the search tree.
2. b is the number of permutations of action bindings(i.e., which things in the world space are bound to the variables in the action).
3. e is the number of effects in an action.
4. a is the number of characters involved in an action.

3.4 Using Plans to Represent and Generate Stories

Using a STRIPS-like formalism, we can create schemata that describe the various types of actions that may take place during a story, such as traveling, fighting, and picking up items. Examples of action schemata are shown below:

```
(action
   :action-type travel
   :variables ?character - person ?from - place ?to - place
   :preconditions (and (not (= ?from ?to))
           (alive ?character) (at ?character ?from))
   :effects (and (not (at ?character ?from))
           (at ?character ?to)))
```

```
(action
   :action-type meet
   :variables ?character1 - person ?character2 - monster
          ?location - place
   :preconditions (and (not (= ?character1 ?character2))
          (alive ?character1) (alive ?character2)
          (at ?character1 ?location) (at ?character2 ?location))
   :effects (knows-of ?character2 Granny))

(action
   :action-type eat
   :variables ?aggressor - monster ?victim - person
          ?location - place
   :preconditions (and (not (= ?aggressor ?victim))
          (alive ?aggressor) (alive ?victim)
          (at ?aggressor ?location) (at ?victim ?location))
          (not (eaten ?victim))
   :effects (eaten ?victim))

(action
   :action-type pick-up
   :variables ?character - person ?item - object
          ?location - place
   :preconditions (and (not (has ?character ?item))
          (at ?character ?location) (at ?item ?location)
          (alive ?character))
   :effects (has ?character ?item ))

(action
   :action-type fight
   :variables ?aggressor ?victim - person ?location - place
   :preconditions (and (not (= ?aggressor ?victim))
          (alive ?aggressor) (alive ?victim)
          (at ?aggressor ?location) (at ?victim ?location))
   :effects (injured ?victim ))
```

Let us suppose that we want to represent an excerpt of the *Little Red Riding Hood* fairy

tale [53]. In this portion of the story, Little Red Riding Hood leaves her house in town to go visit Granny, runs into the Wolf at the forest, and eventually meets her demise along with Granny at the hands of the wolf. Typically, the initial step would be the description of the initial and goal states of the story using a conjunction of first-order logic literals, as shown below:

Initial State:

```
(alive Wolf) (alive Red) (alive Granny)
(at Red town) (at Wolf forest) (at Granny cabin)
```

Goal State:

```
(alive Wolf) (eaten Red) (eaten Granny)
```

We would also need to provide a library of action schemata that describe the set of actions that are possible in the context of the story. For the story domain that we have chosen, these would include actions such as traveling, meeting other characters, and being eaten by a monster.

The information about the initial and goal states in conjunction with the library of action schemata could then be used as the input to a planner, which would produce a sequence of steps that when executed would transform the initial state into the goal state. The plan steps for a possible solution are shown below and in Figure 3.2.

Story Plan:

```
(start)
(travel Red forest)
(meet Red Wolf)
(travel Wolf cabin)
(eat Wolf Granny)
(travel Red Cabin)
(eat Wolf Red)
(end)
```

3.5 Summary

Narrative is a very important part of communication between humans. We use storytelling to better understand our world and share ideas about it. Consequently, the use of AI techniques to automate the creation of stories has the potential to have a significant impact in the development and enhancement of intelligent systems that can be used to disseminate knowledge (e.g. training simulations, visualizations). It is also important to note that narrative can have a key role in areas such as virtual worlds and entertainment games (e.g. Second Life, Mass Effect, World

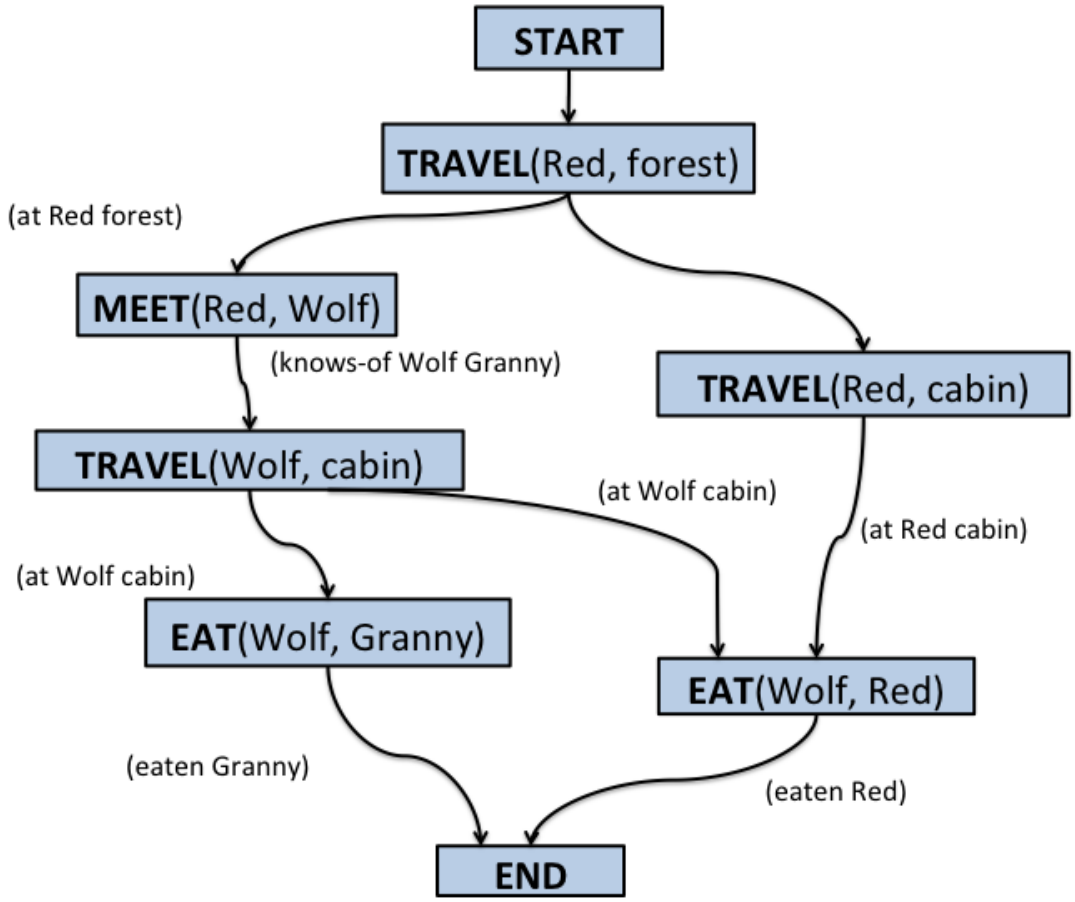

Figure 3.2: Sample Story Plan - The rectangular boxes indicate steps in the plan. Time flows roughly vertically downward. Solid arcs from one step to another indicate a causal link between the source step's effects and the destination step's preconditions.

of Warcraft). The continued economic success of the entertainment games industry [19] and the use of game-based technologies as a platform for the implementation of intelligent tutoring systems [69] further justifies the importance of this research area.

AI planning is one of the principal methods used for the automatic generation of narrative content. Planning is a technique used to solve problems by finding a sequence of actions that achieve a goal state from a given initial state. A classical planning problem is represented by three inputs: an initial world state description, a description of a desired goal state, and a set of available actions that enable transitioning between world states. The plot-lines of stories can be represented using plan-based data structures, which makes it possible to use AI planners to automatically produce story content based on a set of specifications provided by a human author. Recent planning-based narrative generation approaches have focused on producing stories that are interesting and coherent. The research described in this paper focuses on the development of AI techniques that facilitate the portrayal of character personality traits. My goal is to further the field of AI by developing algorithms and techniques that produce stories that are made more compelling and interesting by the presence of well-defined characters.

Chapter 4

A Computational Model of Character Personality

Overview

In this section, I provide a general overview of the narrative generation approach that I developed. This approach was implemented in a system named *Mask*, which uses a state-space planing algorithm that has been modified to ensure that characters behave intentionally, i.e., their actions in the course of the story are justified by a frame of goal adoption and action sequences that are performed in pursuit of such goals. The *Mask* system utilizes the intentional behavior of characters and a micro-theory of character behavior to produce stories where fictional characters not only act intentionally but also behave in a manner that is consistent with preassigned personality traits. Construction of stories that meet this criteria is achieved through the use of a sub-module—a micro-planner—that reasons about different possible courses of action and the impact that their enactment has on the story participants. Figure 4.1 shows a high-level view of the system.

I begin by considering structural elements of story composition that narrative theorists regard as key in the depiction of character personality features. I then focus on a subset of these elements and describe a method for their operationalization into a mechanism that uses a plan-based story representation and a model of aspects of human personality to guide the structure of the stories that are created. The model, which is based on psychological research, utilizes the relationship that exists between personality traits and goal-related behavior to inform the selection of character action sequences during narrative construction. Finally, I introduce the theory of Alternative Possible Worlds [71] and a micro-theory of human behavior that facilitate the implementation of my model.

The research described here focuses on character actions as one of the key elements that

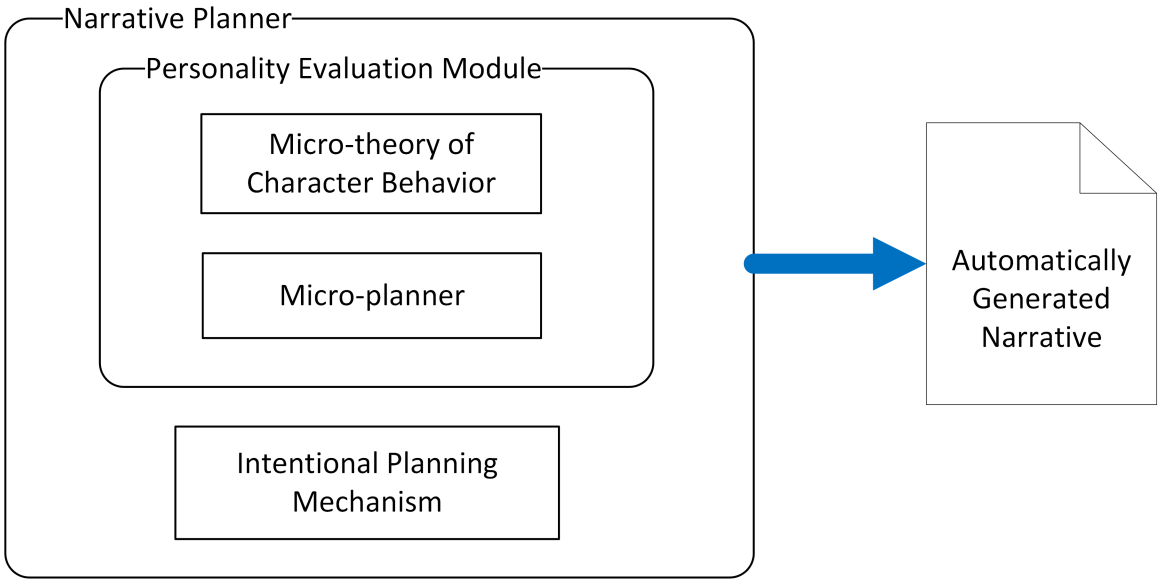

Figure 4.1: The Mask System

define personality in the audience's mental model of the story. The central problem addressed is the selection of character actions taking into account their properties such as goals, motives, and moral traits. Additionally, we may consider that characters can be shaped by their reaction to story events, in particular the effect that such events can have on the choices they make.

4.1 Choice and the Expression of Personality

Considering the structure of a story, specifically plot points where branching occurs [9], audiences intuitively expect the existence of plot point instances when actions follow a choice. For example, in *The Iliad*, Achilles must choose whether to help the Greeks in the Trojan War. From an analysis of such a structure, it may be deduced that choices made by characters can have a direct impact in determining the actions they perform. Furthermore, we can argue that choices may be linked to specific personality traits. This idea is supported by research in behavioral and social psychology that has found correlation between people's actions and their personality [23, 47]. The work presented in this paper relies on these empirically-validated principles. I have used such principles to inform the design of a computational model of character behavior that is based on the operationalization of personality traits, guided by results from research focusing on the behavioral manifestations of personality [26, 23].

I posit that the link between choice and personality can be used in narrative generation

to enable the perception of specific personality traits. An audience that is made aware of the existence of multiple choices that are available to a character will form an opinion of such character's personality based on (1) the choices made and (2) the context in which the choices take place.

As a starting point, I identified two specific story aspects where choice and character personality intersect:

1. Stories can be constructed to include choices that express a character's personality, i.e. characters make choices that are consistent with their assigned personality traits. For instance, a highly *agreeable* character only makes choices that result in honest behavior.
2. Stories can be constructed to include events that justify or explain a choice that does not agree with a character's personality. This type of structure may be used to show more complex or surprising characters. For instance, a highly *agreeable* character makes a choice that results in dishonest behavior after multiple failed attempts to engage in honest alternatives.

For this research I have focused on aspect (1), under the assumption that once it is computationally modeled, aspect (2) will be an extension that can be derived from it. My approach addresses choice as a character-centric event that can be directly linked to a character's personality traits.

4.2 A Narrative Example

Let us consider the following story with two alternate endings:

> *Amos is a farmer whose son has fallen gravely ill. His son may die unless he undergoes a very expensive surgery. Amos must obtain a large amount of money soon if he expects to save his son. Amos considers his options for obtaining the money, such as asking his friends for help, getting a loan from the credit union, selling his only tractor, or even robbing the local bank.*

Alternate Ending 1:

> *After careful consideration, he decides to sell his only tractor even though that means that his work at the farm will be much harder from now on. Selling the tractor provides enough money to pay for the operation and save his son.*

Alternate Ending 2:

> *After careful consideration, he decides to grab his shotgun and goes to local the bank. He robs the bank and obtains enough money to pay for the operation and save his son.*

Both story endings have the same set of choices available to the main character, Amos. However, the choice made in Alternate Ending 1 shows a clear attempt to resolve the crisis through what could be characterized as honest behavior. In contrast, in Alternate Ending 2 the character engages in behavior that could be characterized as dishonest. I contend that it is the specific choice made by the character, when considering the available alternatives, that characterizes his behavior as honest or dishonest. This distinct choice is what enables the expression of a specific personality trait. The personality trait in turn supports the portrayal of a corresponding personality factor, in this case *agreeableness*.

4.3 Computational Approach

The approach that I have pursued centers on the development of a computational model that enables the representation of distinct character personality traits in the context of a story world. The model is intended to provide authors with the ability to create fictional characters that have a rich set of behaviors that can be adjusted based on authorial goals and in response to story events or user interaction. The model works under the premise that narrative characters can be distinguished or classified by the visible manifestations of their personality, i.e., their choices, actions, and dialog.

Previous approaches have primarily addressed character personality by considering behavior at a very fine-grained level of representation. That is, these approaches focus on a character's immediate reaction to stimuli. Additionally, none of the current models address characters' physical actions and their impact on audience comprehension. In contrast, my research focuses on the story as a whole and in particular the use of choices made by characters as a means to express their personality. I have designed a model focused on physical actions and the role that these play over the course of a narrative in the construction of the mental model that the audience forms when experiencing a story. In particular, how this model is affected by the choices made by characters and the context in which such choices take place.

The focus of my work is on the creation of an intelligent process that enables the automatic generation of behavior that matches personality traits assigned to story characters. In this model, personality is expressed in the form of actions linked to choices. Actions are determined by individual elements such as goals, beliefs, moral traits, and personality. Characters are further shaped by their reaction to external events or by the effect that these have on them. For example, let us consider a character's reaction to a stranger's act of aggression against a friend; an agreeable character may respond by helping the victim in a non-confrontational manner whereas a non-agreeable character may respond with assistance that also punishes the stranger.

A simplistic approach to the development of a computational model of behavior would

be to annotate the actions in the action library of a planning-based story generator (e.g., Riedl and Young [66]) with specific personality traits. Actions are then chosen by the planner during narrative generation using the annotations as part of a filter mechanism. However, this approach would not adequately achieve the stated purpose for several reasons. First, it requires a labor-intensive process. Every time actions are added to the planning library, it is necessary to update their annotations to indicate the specific personality traits to which they apply. More significantly, actions may need to be further annotated to indicate every situation in which it is appropriate to use them. When we consider that there could be many situations that justify or preclude the validity of an action it is evident that the work for the author would increase exponentially.

Rather than hard-coding trait labels on relevant action definitions, my approach uses a declarative representation of action in which a character's personality traits are used to dynamically determine the set of personality-consistent actions that she should perform. Such a method would scale to complex domains and generalize to narrative generation applications beyond simple test cases or academic story generators.

4.4 The *Mask* Narrative Generation Mechanism

The *Mask* narrative generation mechanism has its foundation on a character-centric model of action selection. Within this model, we work under the assumption that story characters act intentionally and consider multiple courses of action as they pursue their goals. Consequently, we use an operationalization of character intentionality based on the one defined by Riedl and Young for the IPOCL algorithm [68] and later expanded by Ware and Young for the CPOCL algorithm [82]. In these approaches, sub-plans called *intention frames* explicitly mark the adoption of a new goal by a character, the action in the story that gives rise to the new goal, the steps that the character takes in pursuit of that goal and the point in the story at which the sub-plan to achieve the goal ends execution.

In contrast to a traditional narrative planner where a uniform planning process handles the construction of a story, in choice-based narrative generation, planning is interleaved between a macro-planner and a micro-planner. The macro-planner is responsible for constructing the authorial view of the global story and its causal coherence. The micro-planner is a restricted version of a planning system, designed to simulate the character's decision-making process as she works toward accomplishing a goal. To represent the character's process of considering multiple plausible courses of action to achieve her goal, the micro-planner generates the set of possible intention frames that allow the character to achieve such goal and then evaluates them utilizing a simplified model of affect appraisal theory. This facilitates the implementation of a process where character choice is treated as a first class object, and as such it guides the

construction of the story. Because generating the entire set of alternatives may not be tractable, our mechanism limits the number of alternatives explored to a preset threshold. Determining the optimal number of intention frames to generate, or deciding which ones to generate is an area where the algorithm could be improved in future versions.

The determination of a character's choice for action is triggered when a character forms an intention to achieve a new goal. When this occurs, the micro-planner generates, evaluates, and ranks the set of intention frames that can be constructed to achieve the character's intention. It is important to note that in our model not all new intentions will result in a choice. For example, even though multiple possible intention frames for achieving a character's new goal may exist, their effects on the affective response of other story characters may not have measurable differences relative to one another. When this condition occurs, one of the intention frames is chosen non-deterministically. Additionally, an important distinction between IPOCL [68], Glaive [83], and my approach is the categorization of story characters. In Choice-Based narrative generation, story characters are divided in two general categories: *principal role* and *supporting role*. Characters in the supporting role category do not have a personality factor assigned to them, hence the micro-planner is not used to evaluate choices for their actions.

We say that a choice occurs just when a character adopts a new intention whose achievement requires the character to chose between at least two contrasting intention frames. The process of choosing between the alternate intention frames is done by using a simplified version of the appraisal theory proposed by Lazarus [37] to characterize each alternate. Of particular relevance to my research is his study of human emotions and in particular the assessment of the personal significance assigned to events. The model that I have developed represents the impact that a character's choice for action has on the emotions of other characters in terms of the beneficial or harmful appraisal of its effects.

When a choice is identified, i.e., when two or more contrasting courses of action to achieve the same goal exist, two distinct intention frames are selected: the *choice*, which is the intention frame that the character will execute, and the *contrast*, which is the intention frame that is used to highlight what the character could have done but chose not to do. Steps in the *choice* intention frame are returned to the macro-planner to specify the course of action it then constructs for the given character, merging these actions into the global story structure it generates. Steps in the *contrast* intention frame are not added to the plan, but are recorded to support discourse devices that communicate the deliberation process that the character went through. A detailed and formal description of *Mask* is provided in Chapter 5.

4.5 Intelligent Action Selection

The process used by *Mask* aims at enabling the intelligent selection of actions considering the context in which they execute and without requiring extensive hand-annotation of actions in the planning library. In this approach, the execution context determines the appropriateness of actions for specific story characters. For example, the action `(kill attacker victim)` may only be appropriate for a highly agreeable character if the context indicates either that she is behaving in self defense or that the target is an evil enemy who must be defeated. However, the same action may always be valid for a disagreeable character. The action selection process used by *Mask* chooses actions after analyzing the current execution context and evaluating the space of possible story plans that each alternative produces.

4.6 The Execution Context

The execution context used to evaluate multiple alternatives for action is derived from the current state of the story world, the properties of the story character who is making the choice, the individual goals of other story characters, and the set of open goals that are yet to be achieved in the plan. The specific story elements analyzed by the action selection process may include:

1. The causal chain of events that precedes the plot point where an action is needed.
2. The character's personality traits.
3. Previous actions that the character has performed.
4. Future actions that the character may perform.
5. The character's relationships, e.g. friends, enemies.
6. The set of choices that the character has already made.
7. An evaluation of the past and possible future consequences of choices made by the character.

Information obtained from the analysis of the execution context is used to advise the planning process on the selection and placement of actions, to produce desired behaviors. To this effect, I focused on a mapping between observable behaviors and personality traits using empirical results from social psychology [23, 32]. The objective was to operationalize the mapping as a set of plan structure characteristics that when present result in specific character behavior.

4.7 Model of Character Behavior

As part of this work, I introduce a computational model to generate character behavior through a declarative approach. The technique is partly based on the hierarchical relationship that exists between human goals and personality traits, as identified by Chulef, Read, Walsh and Miller during their study and simulation of human behavior [61, 16]. Their research suggests that many personality traits are goal-based structures [61]. Furthermore, that traits can be grouped by the similarity of the goals associated with them. In the context of their work, traits are composed of four key elements: (1) goals, (2) plans formed to achieve such goals, (3) resources needed to complete the plans, and (4) beliefs associated with the trait. They also established that factors of the FFM [26] have conceptual relationships with specific clusters of human goals (e.g. teaching and helping others, ethics and idealism) that were identified during experimental studies. Based on this, given a set of personality traits we can establish a link to a cluster of goals that will be held with higher regard by individuals possessing such traits. For example, an individual with a highly agreeable personality will assign a higher priority to goals in the areas of Friendship, Teaching and Helping Others, Positive Social Qualities, Social Awareness, and Ethics and Idealism [16].

The model used in the design of the *Mask* system replaces the oracle function described in my earlier work [8], which was responsible for assisting in the evaluation of actions by focusing on their effects upon other story participants. The model described here utilizes a mechanism that evaluates multiple choices for action to gauge their consistency with specific personality traits. The model uses a declarative approach to enable the portrayal of personality traits with enough detail to elicit a predictable attribution of personality traits from the audience. In this model, character properties inform the selection of the actions they perform in the course of a story.

An essential component of my approach is the behavior that results from the observable (e.g. physical) actions that characters perform during the course of a story, a mechanism to ensure that the actions chosen by characters are consistent with specific personality traits is essential to its realization. The evaluation mechanism reasons about the effects of characters' actions upon themselves and on other story characters to produce a ranking of multiple applicable alternatives for action. The ranking informs the planner during action selection to promote the use of actions that are more in accordance with a character's personality traits. It also ensures the viability of contrasting choices that make their existence clear to the audience.

The approach used in the development of *Mask* operationalizes the trait-to-behavior link described above through the implementation of a process that explores and compares the space of story versions that are possible given multiple alternatives for action for a character at specific points in the story. I use the notion of Alternative Possible Worlds defined by Ryan [71]

to facilitate an evaluation of the set of stories that may result when characters make specific choices. This notion is defined below.

4.7.1 Alternative Possible Worlds

Typical narratives may describe or imply events that have not yet or that may never occur [71]. These events can be the result of a character's choice whether or not to perform a specific action. Points in the narrative structure where multiple options for character action exist create the possibility of alternate versions of the story, which are represented by different branches of the search space explored by the planner as it generates such story. In the context of this work, an alternate version of the story that results from a specific character choice constitutes an Alternative Possible World (APW) [71]. APWs represent different versions of a story that share the same initial steps, those that occur between the beginning of the story and the plot point where a choice exists. Typically, events that occur after the choice is made tend to be different, particularly in how they affect various characters in the story.

The concept of Alternative Possible Worlds provides the theoretical basis to support key components of the Glaive narrative planner [83]. Glaive provided the initial code base for my implementation. An APW represents the state of the story world that would result from the execution of a specific action or action sequence. Glaive uses APWs to explain the actions that characters perform in the course of a story. Furthermore, a key component of my approach focuses on establishing and presenting to the audience not only what a character does but also what she could have done. In the latter case, I leverage the concept of APW to justify that at the point in the story where a character made a choice there exists an alternate course of action where a contrasting option is a valid possibility, i.e., both the chosen action and its contrasting alternative make sense within the story context.

4.7.2 Personality Evaluation Module

The personality evaluation module focuses on gauging a set of choices for action within the context of a character's personality. The evaluation of an action is done in terms of its implications for character choice, based not on its immediate effects, but on the space of story plans that it enables. Each possible plan can potentially result in a different story context given by the class and placement of the effects in the plan structure. For example, let us consider the case of Bilbo Baggins in *The Hobbit* [78]. We could have two different versions of the episode where Bilbo is lost in a cave and trying to escape from Gollum: (a) one version in which Bilbo Baggins kills Gollum in order to escape and (b) a version in which he escapes by jumping over Gollum while incurring a personal risk. In the second version of the story, note that Bilbo's jumping in itself does not tell us anything about his personality; however, the fact that he accepts the

possibility of getting hurt or dying in order to spare Gollum makes it an example of highly agreeable behavior.

4.7.3 Knowledge Micro-Theory of Character Behavior

The evaluation of character actions in relation to the effects they produce utilizes a knowledge micro-theory of character behavior. The main objective of the micro-theory is to facilitate a procedural mechanism capable of establishing the existence or lack of contrast among multiple alternatives for action. The micro-theory uses a procedural approach in which a set of behavior patterns is evaluated over a given story context. The story context is provided by the effects present in a possible story plan and in particular their valence, i.e., positive/negative/neutral with respect to self/other. This idea of considering story events in terms of the valence of an action's effects is inspired by the work of Lehnert on plot points as part of a method for narrative summarization [39].

The micro-theory also takes into account the collection of character intentions and related goals that are affected by the execution of actions as the story progresses. Character intentions play an essential role in the evaluation of multiple viable alternatives for action. These can help establish contrast among multiple choices and also identify how consistent a given action is with the character's personality. Reasoning about the goals held by characters could be further refined through the use of a hierarchical taxonomy, such as that identified by Chulef et al. [16] to help identify goals that have a greater importance or a higher priority.

An evaluation module that uses a micro-planner to explore the alternate story versions that can be constructed between the point where a choice exists and the point where a story goal is achieved handles evaluation of the story context produced by an action. The module takes into account that story goals may be achieved by a single action or by a sequence of causally linked actions. The evaluation is based on the set of choices available to a character and the application of the micro-theory described above. This enables the narrative generation mechanism to identify elements of the plan structure indicative of behavior patterns such as self-sacrifice, cooperation, and aggression. For example, in the case of Bilbo Baggins mentioned earlier, the evaluation module would detect that there is a dichotomy in version (a) of the story; in this version, Gollum dies whereas Bilbo does not. Conversely, version (b) includes *risk-causing* effects on Bilbo but nothing of the sort on Gollum; these effects can be detected in the existence of APWs where Bilbo either dies or gets hurt, which would prevent him from achieving his individual goals. The evaluation module can detect the contrast present in the space of possible plans and use it to determine that Bilbo's actions are indicative of a *self-sacrificing* (thus agreeable) behavior pattern.

4.7.4 Implementation

The behavioral model enables the ranking of a set of viable alternatives, taking into account the character's personality traits and the context where a newly instantiated plan step will be used. The evaluation of the viable alternatives results in a ranked list, where multiple choices for action are ordered from least representative to most representative of a character's personality factor, such as conscientiousness. Ideal choices are those at the extremes of the scale, which extreme is most desirable depends on the polarity of the factor assigned to the character, e.g. high agreeableness vs. low agreeableness. The ranking is also dependent on the effects of the action on the affect of other story characters. Finally, it is important to note that in the initial version of the model, I have focused on two of the FFM factors: Agreeableness and Conscientiousness because these two represent character types and themes frequently used in narrative [45].

Chapter 5

The *Mask* System

Overview

In this chapter, I provide a formal description of the *Mask* narrative generation system. *Mask* uses a mechanism that focuses on the role that actions performed by characters play over the course of a narrative in the construction of the mental model of the story that the audience forms when experiencing a story. In this model, the mechanism that generates the narrative is designed to ensure that the story structure and its contents promote the existence of choices for characters' actions. It also makes such existence evident to the audience by including contrasting options that are available to the character. The actions that characters perform are chosen by an intelligent mechanism that reasons about their consistency with the personality traits assigned to the character by a human author prior to story generation.

The *Mask* narrative generation mechanism has its foundation on a character-centric model of action selection. In this model, story characters act intentionally [68, 82] and consider multiple courses of action as they pursue their goals. Sub-plans called *intention frames* explicitly mark the adoption of a new goal by a character, the action in the story that gives rise to the new goal, the steps that the character takes in pursuit of that goal and the point in the story at which the sub-plan to achieve the goal ends execution.

In contrast to a traditional narrative planner where a uniform planning process handles the construction of a story, in choice-based narrative generation, planning is interleaved between a macro-planner and a micro-planner. The macro-planner is responsible for constructing the authorial view of the global story and its causal coherence. The micro-planner is a restricted version of a planning system, designed to simulate the character's decision-making process as she works toward accomplishing a goal.

The determination of a character's choice for action is triggered when a character forms an intention to achieve a new goal. When this occurs, the micro-planner generates, evaluates, and

ranks the set of intention frames that can be constructed to achieve the character's intention. We say that a choice occurs just when a character adopts a new intention whose achievement requires the character to chose between at least two contrasting intention frames. The process of choosing between the alternate intention frames is accomplished using a simplified version of the appraisal theory proposed by Lazarus [37] to characterize each alternate.

5.1 Definitions

In this section I provide a set of definitions that are necessary for the formal description of the *Mask* narrative generation system. These definitions are used in the algorithms for choice-based character personality that are part of the macro-planner and the micro-planner. I work within the context of a planning-based narrative generation system, where a plan data structure is used to represent the events of a story and the temporal and causal relationships between them [85, 68]. Informally, a plan is a sequence of steps that describes how a world transitions from an initial state to a goal state [74].

5.1.1 Notation

The definitions given below use the following symbols:

Action Schemata: $a, a_1, a_2, \ldots$
Story Characters: $c, c_1, c_2, \ldots$
Variables: $i, j, i_1, i_2, \ldots, j_1, j_2, \ldots$
Problem: P
Preconditions: $p, p_1, p_2, \ldots$
Effects: $e, e_1, e_2, \ldots$
Character Goals: $g, g_1, g_2, \ldots$
Intention Frames: $I, I_1, I_2, \ldots$
Plan Steps: $s, s_1, s_2, \ldots$
Plan: Π

5.1.2 Planning-based Narrative Generation

I use a state-space plan-based story representation based on that utilized in the Glaive algorithm [83]; however, I extend it to incorporate elements specific to the action-selection mechanism described earlier in this document. In particular, I make a distinction between the representation of general elements of the story world and that of elements directly related to the choices for action that characters make.

Definition 1 (State) *A state is a conjunction of literals used to describe what is true and what is false in a story world.*

Any literals not explicitly described in the initial state of the story world are assumed to be false (closed-world assumption [63]).

Definition 2 (Character Name) *A character name is a unique constant symbol that represents a story agent.*

Definition 3 (Character Goal) *A character goal is a tuple $\langle c, g \rangle$ where c is a character name and g is a literal used to represent that character c intends goal g in the current state.*

Character goals represent something that a character intends to achieve in the course of the story.

Definition 4 (Action Schema) *An action schema is a template for an action possible in the story world, described by a tuple $\langle \mathsf{ActionType}, \mathsf{Pre}, \mathsf{Eff}, V, \mathsf{MainChar} \rangle$ where* ActionType *is a unique identifier for the action,* Pre *is a set of literals that must be true prior to executing the action (preconditions),* Eff *is a set of literals established by the execution of the action (effects), V is the list of variables used in the template, and* MainChar *is one of the variables in V that designates the story character who performs the action. The value of* MainChar *can be null ($\emptyset$).*

I use a STRIPS-like representation [22] to describe the set of actions that are available in the story world. Preconditions are represented as a conjunction of all-positive literals, whereas effects may be a conjunct of both positive and negative literals. For example, the plan step used to represent the story event "the knight kills the evil wizard" is an instance of the following action schema:

```
(:action kill
   :parameters ?attacker ?victim - person
   :main-character ?attacker
   :precondition (and (has sword ?attacker) (alive ?victim))
   :effect (not (alive ?victim)))
```

It is important to note that not all story actions require the participation of a character, in which case the MainChar variable will be set to null. This type of actions are referred to as *happenings* [57].

Definition 5 (Planning Domain) *A planning domain Λ is the set of all action schemata available in the story world.*

Definition 6 (Planning Problem) *A planning problem P is a tuple $\langle \Lambda, S_0, S_G, C \rangle$ where Λ is a planning domain, S_0 is a set of literals that specify an initial state of the story world, S_G is a set of literals that specify a goal state, and C is a set of character names available in the story.*

Definition 7 (Binding Constraint) *A binding constraint on a variable/constant pair (u, v) indicates that u and v must unify in any well-formed formula. A negated pair $\neg(u, v)$ indicates that u and v must not unify in any well-formed formula.*

For example, the following set of binding constraints could be used to represent two characters that take part in a story event:

$\beta = \{$(?kidnapper, the-dragon), (?victim, the-princess)$\}$

Definition 8 (Step) *A step describes a ground instance of an action schema that occurs in a plan. A step is a tuple $\langle$*ActionType, StepID, Pre, Eff, $\beta\rangle$*, where* ActionType *is the unique identifier of an action schema,* StepID *is an identifier for a step that is unique within the plan in which the step occurs,* Pre *is the set of step preconditions,* Eff *is the set of step effects, and β is a set of binding constraints to which the step's parameters are bound.*

Definition 9 (Causal Link) *A causal link is denoted $s_i \xrightarrow{p} s_j$, where s_i is a plan step with an effect p and s_j is plan step with a precondition p. Causal links are used to keep track of dependencies between actions that exist when one action establishes a literal that is a precondition for another.*

Definition 10 (Plan) *A plan Π for a planning problem P is a tuple $\langle S, L \rangle$ where S is a totally ordered, fully-ground set of steps and L is a set of causal links.*

A plan Π produces a solution to a problem P if the execution of the steps in S transforms the initial state S_0 into the goal state S_G.

Definition 11 (Intentional Operator) *An intentional operator is a tuple $\langle$*ActionType, Pre, Eff, V, MainChar, IntChars$\rangle$ *where* ActionType *is a unique identifier for the action,* Pre *is a set of literals that must be true prior to executing the action (preconditions),* Eff *is a set of literals established by the execution of the action (effects), V is the list of variables used in the template,* MainChar *is one of the variables in V that designates the story character who performs the action, and* IntChars $\in V$ *is a set of story characters who must consent to the execution of that action.*

Intentional operators are used during plan construction to create instances of intentional steps, i.e., steps that require not only the participation of one or more characters but also their consent to the execution of the action.

Definition 12 (Motivating Step) *In the context of a plan* Π *and a planning problem P, a motivating step for a character c and a goal g is an instance of an intentional operator whose effects contain the motivation (intends c g).*

Motivating steps are used to describe the story event when a character adopts a new goal. For example, the motivating step for a dragon's intended goal of kidnapping a princes would include the effect `(intends dragon (kidnapped princess dragon))`.

Definition 13 (Intention Frame) *In the context of a plan* Π *and a planning problem P, an intention frame for a character c and a goal g is an alternating sequence of n steps and n propositions* $\{s_1, p_1, s_2, p_2, ..., s_n, g\}$ *such that the following is true:*

- *g is a goal that character c intends to achieve through the execution of the steps in the sequence.*
- *Character c must consent to all steps.*
- *`(intends c g)` is true before step* s_1 *and true until step* s_n*.*
- *Step* s_n *has effect g.*
- *For i from 1 to* $n-1$*, there exists a causal link* $s_i \xrightarrow{p_i} s_{i+1}$*.*
- *No proposition appears twice.*
- *The sequence never contains a proposition and its negation.*

An intention frame, describes the sequence of steps that a character takes in order to accomplish a goal. Note that in this definition, characters do not abandon their intentions. Once an intention is formed, it remains open until either the macro-plan is complete or the intention is achieved. Additionally, characters do not overcommit. In this document, I sometimes refer to intention frames as *character sub-plans*.

Definition 14 (Explained Step) *We say that a step s is explained if and only if:*

- $\forall$ *consenting character c,* $s \in$ *an intention frame for c.*
- *All other steps in the intention frame are also explained.*

Definition 15 (Valid Intentional Plan) *We say that a plan* Π *for a problem P is a valid intentional plan just when the following is true:*

- *Each step's preconditions are satisfied immediately before the step is executed.*
- *After all steps are executed, the goal state (*S_G*) is satisfied.*
- *Every step is explained in some possible world.*

5.1.3 Character Choice

The definitions in this section are based on an analysis of the creative writing principles and narrative structure elements described earlier. I use these definitions to extend the plan-based representation of a story in a manner that enables the implementation of an intelligent action selection mechanism that models the choices for action made by characters during the course of a story. In the following discussion, let us assume that a plan Π is a totally ordered, possibly partial, plan serving as a story being constructed.

Definition 16 (Viable Alternative) *A viable alternative over state σ is a tuple $\langle \Pi, P, \sigma, s_i, c, g, I \rangle$, where Π is a plan that addresses a planning problem P, σ is the current state, s_i is a motivating step, $c \in C$, g is a character goal, and I is an intention frame for character c and goal g. We say that I is a viable alternative for c over state σ in plan Π just when the following is true:*

- *I is an intention frame for a motivation (intends c g) established by the motivating step s_i.*
- *All of the preconditions of the first step in I are true in σ.*

A viable alternative describes a specific course of action that a character may follow in order to accomplish a goal that she is pursuing. The narrative generation algorithm, which is described below in Section 5.3, works under the assumption that story characters act intentionally and consider multiple courses of action as they pursue their goals.

Definition 17 (Choice Point) *In the context of a plan Π for a planning problem P, a choice point CP is a tuple $\langle \mathsf{VA}, b, c_i \rangle$ where VA is a set of viable alternatives for the current state (σ), b is an identifier for a newly instantiated step that is unique within the plan in which it occurs, and $c_i \in C$. We say that CP is a choice point in plan Π just when the following is true:*

- *$\exists\ \mathsf{VA}' \subset \mathsf{VA}$, which contains two or more unique intention frames that achieve the same goal.*
- *All of the intention frames in VA' are performed by the same character (c_i).*
- *All of the intention frames in VA' differ from each other in one or more steps.*
- *The current state (σ) can be expanded by a new step (s_b), which is an instantiation of exactly the first step in any intention frame $I \in \mathsf{VA}'$.*
- *s_b is causally linked to a motivating step $\in \Pi$.*

A choice point is an abstraction that represents a character's act of choosing to perform a specific action sequence, out of a set of multiple applicable options. A choice point exists when there are two or more intention frames that: (1) are applicable in the current state, (2) are performed by the same story character, (3) achieve the same goal, and (3) differ in one or more of their steps. Choice points are used to keep track not only of what a character chooses to do, but also of her alternative courses of action.

Definition 18 (Choice) *In the context of a plan* Π*, a planning problem* P*, and a state* σ*, a choice* $\langle \mathsf{CP}, i, c_i \rangle$ *designates a specific intention frame (*I*), performed by character (*c_i*), starting at the choice point (*CP*).*

A choice is an intention frame that has been selected for inclusion in the plan that is being constructed. A choice represents a specific action sequence, from a number of applicable options, that a character chooses to perform in order to achieve one of her adopted goals. Steps in the choice are merged into the plan by the macro-planner, thus ensuring their inclusion in the global story.

A single choice could potentially produce more than one plan; however, in my algorithm I only use the first plan that is found. As part of future work, I may fine-tune the algorithm to ensure that the first plan returned has specific properties (e.g. plans that include a particular cast of characters). Also, note that the narrative generation mechanism described in this document is not designed to focus on the immediate effects produced by the execution of a single action, but rather on the collection of effects that occur in the version of the story that such execution creates.

Definition 19 (Alternative Possible World) *An alternative possible world (*APW*) is a tuple* $\langle \Pi, P, \sigma, \mathsf{CP}, S', s_b, \sigma' \rangle$*, where* Π *is a plan that addresses problem* P*,* σ *is the current state at choice point* CP*,* S' *is a totally-ordered sequence of* n *steps* $\{s_1, s_2, ..., s_n\}$*,* s_b *is the first step in* S'*, and* σ' *is a new state that can be achieved by executing the steps in* S' *starting at the current state (*σ*).*

I use the term Alternative Possible Worlds (APWs) to refer to the collection of distinct story versions that could be created by each one of the alternatives for action that are available to a character at a specific choice point. The pursuit of a given course of action creates a new and distinct version of the story state, a possible story world. Consequently, an APW is used to describe the state of the story world that results from the execution of a specific choice and the sequence of steps that follow it. The sequence of steps ends either at the goal state of the planning problem or at an intermediate state delimited by the completion (last step) of an intention frame.

5.2 Narrative Generation Algorithm Overview

The *CB-Glaive* narrative generation algorithm presented here is based on a modification of the Glaive algorithm [83], using a technique based on my previous work [8], to include a mechanism that evaluates the effect of a character's actions on the individual intentions of other story characters. This represents the character's process of considering multiple plausible courses of action to achieve a goal. Instead of using a non-deterministic method to select action schemata during plan construction, the mechanism utilizes individual character intentions and the personality traits of the protagonist to guide the selection. Additionally, this mechanism treats the goals defined in the planning problem differently from the individual goals of story characters.

The mechanism first identifies when a character forms a new intention, i.e., adopts a new goal to pursue, and determines if there exist multiple ways for such goal to be achieved. When this is the case, a choice point exists and the alternate versions of the story produced by each viable course of action are explored and analyzed. The result is a ranking of each alternate version based on how consistently the effects of steps included in each story version portray the personality of the character who is making the choice. Only step effects that are unique to each story version with respect to the common set of steps present in all possible story versions are considered. The story version whose effects most consistently depict the personality of the character is selected and the action schemata that it contains are selected to be added to the plan after the choice point. Additionally, the mechanism also makes sure that a story version whose effects are least consistent with the personality of the character is a possible path that the story could follow. Finally, the planner records information about the alternate but not followed path for later use by a discourse manager; this is designed to help ensure that the information necessary to convey the existence of a choice can be presented to the audience.

5.2.1 Data Structures

The choice-based process described here requires the enhancement of the planner's data structures and knowledge representation that describe the story world in order to: (1) enable reasoning about who performs an action, (2) maintain the information necessary to determine the context in which actions execute, and (3) keep track of plan steps where choices exist. These enhancements support the use of a personality model and character intentions to guide the structural properties of the story plan as it is constructed. It is also necessary to introduce a procedural mechanism for the evaluation of the plan structure in the context given by such knowledge; this mechanism is described in the following section.

5.2.2 The Character Repository

The character repository (CR) is a data structure of global scope. The CR contains a collection of objects whose static and dynamic attributes describe the characters that participate in the story, including:

1. Character name
2. The character's role: either *principal* or *support*.
3. The personality factor assigned to the character by the human author, e.g., agreeableness.
4. The polarity of the personality factor: high or low.

5.2.3 Story Actions

The representation of actions in the planning domain is augmented to enable the distinction of actions that require character participation from those that do not. Furthermore, actions that require the participation of a character must include a variable named `main-character`, which may only be bound to objects in the character repository. Additionally, instantiated action schemata (plan steps) include the variables `choice` and `contrast-set`, which are used to identify steps where multiple choices are viable and the alternative courses for action that were available to the character.

5.3 The Choice-based Narrative Generation Algorithm

In order to incorporate choice in a planning-based story generation process, a preliminary version of a modified planning algorithm was previously introduced [7, 8]. An updated and expanded version —CB-Glaive— is presented in this document (see Algorithm 3). The current version is based on a modification of the Glaive state-space planning algorithm developed by Ware and Young [83] to ensure that choice is treated as a first-class object during narrative generation, i.e., the story structure and contents promote the existence of choices and make such existence evident to the audience. This approach also builds on prior narrative generation research by Young and his colleagues [85, 66, 27, 68].

5.3.1 Algorithm Description

In conventional state-space planning algorithms, actions are chosen nondeterministically to reach the next state until a complete plan is constructed or the process fails [70]. In the approach introduced by this research, specific actions may be added to the plan to facilitate the depiction of a personality factor previously assigned to a character, e.g., agreeableness. Furthermore, the plan is built to support the ability to replace such actions with alternatives that

depict contrasting personality traits. Other aspects of the planning process work as expected, including: state update, causal link tracking, failure detection, and the recursive invocation of the algorithm. Details of the functions that implement modified processes are provided in the following sections.

5.4 Operationalization of Personality

The generation of personality for fictional characters is operationalized as a process that finds, evaluates, and selects a story version from a collection of related story world states or Alternative Possible Worlds (APWs) [71]. Each APW represents the version of the story that results from a character's choice to perform a specific action or causally-related sequence of actions from a set of applicable alternatives. As part of the story generation process, a micro-planner explores the set of plans relative to a character's beliefs that can be constructed using: the current plan, the current state, and the instantiation of each of the alternatives as steps in a distinct new plan. Once a set of APWs is found, its members are evaluated to detect structural properties that indicate the presence of patterns of behavior exhibited by the character who is making the choice for action. Behavior patterns may result from the effects of single character actions or from the cumulative effects of action sequences within one APW.

Evaluation of the behavior patterns found in a set of APWs hinges on two key elements: (1) characters' individual goals in a context of intentional behavior and (2) the effect of single actions or action sequences upon such goals. Actions and action sequences provide an insight into the structural properties of the APWs under evaluation. These properties and the story events that they represent enable the planner to reason about the implications of a character's choice for action with respect to her personality. The mechanism used to operationalize and identify behavior patterns is described in the following sections.

5.5 Overview of The Choice-Based Narrative Generation Mechanism

The narrative generation mechanism described in this document has its foundation on a character-centric model of action selection. Within this model, we work under the assumption that story characters act intentionally and consider multiple courses of action as they pursue their goals. Consequently, we use an operationalization of character intentionality based on the one defined by Riedl and Young for the IPOCL algorithm [68] and later expanded by Ware and Young for the CPOCL algorithm [82]. The definition and handling of intention frames, as well as motivating steps, is addressed just as it is done in CPOCL. Additionally, because the story gen-

eration mechanism also utilizes a heuristic state-space search algorithm, the planning process uses fully-ground planning operators (or action schemata).

In contrast to a traditional narrative planner where one planning process recursively handles the construction of a story, in choice-based narrative generation, planning is interleaved between a macro-planner and a micro-planner (MP). The macro-planner is a modified version of Glaive [83]. The micro-planner is a special-purpose mechanism based on a restricted and highly customized version of a heuristic state-space planner. The use of a micro-planner facilitates the implementation of a process where character choice is treated as a first class object, and as such it guides the construction of the story.

One important distinction between IPOCL, Glaive, and my approach is the categorization of story characters. In Choice-Based narrative generation, story characters are divided in two general categories: *principal role* and *supporting role*. Characters in the supporting role category do not have a personality factor assigned to them. Moreover, only characters in a principal role form intentions.

Choices are evaluated when a character forms a new intention, i.e., right after a motivating step is added to the plan. When this occurs, a micro-planner generates, evaluates, and ranks the set of intention frames that can be constructed to achieve the goal in the character's intention. The process used to evaluate and rank a set of intention frames, which is based on a simplified model of affect appraisal theory, is described below. It is important to note that in our model not all new intentions will result in a choice. It is possible that in some cases there exists only one possible intention frame for a given intention. When this condition occurs, the micro-planner will stop its process and return control to the macro-planner. The macro-planner will then continue the construction of the plan using a traditional story generation mechanism that does not consider character choices. Another case when choices are not considered is when the character who is adopting an intention does not have a personality factor assigned to her. When this condition occurs, the micro-planner is not invoked at all. Instead, a traditional story generation mechanism is used. Finally, there is the case where there are multiple possible intention frames but no contrast exists among them, i.e., their effects on the affective response of other story characters have no measurable differences. When this condition occurs, one of the intention frames is chosen non-deterministically. The micro-planner will then return control to the macro-planner, where plan construction continues using a traditional story generation mechanism that does not consider character choices.

The more interesting case that my mechanism handles (and the main focus of this work) is that when a choice is identified, i.e., two or more contrasting courses of action to achieve the same goal exist. In this case, two distinct intention frames are chosen, as follows:

1. Choice: is the intention frame that the character will execute, the steps it contains will

eventually become part of the macro-plan. The macro-planner uses a special-purpose mechanism that merges the steps from the micro-plan into the macro-plan. This mechanism keeps track of the steps in the *choice* intention frame, which enables the heuristic function to identify steps that are linked to a character's chosen course of action. CB-Glaive uses a modified version of the heuristic that examines steps being considered for addition to the macro-plan that is being constructed and ensures that steps in a *choice* intention frame are given a higher priority, i.e., they are favored for addition to the macro-plan.

2. Contrast: is the intention frame that is used to highlight what the character could have done but did not. Steps in this intention frame are not added to the plan. They are added to a different data structure which is later used to support discourse devices designed to communicate the mental process that the character went through. This could be as simple as an internal monologue where the character enumerates the alternatives she is considering or a third-person narrator who is omnipresent. It could also be something more sophisticated; however, the development of a complete discourse mechanism is beyond the scope of this research. Steps in the *contrast* intention frame are not merged into the macro plan. Additionally, CB-Glaive does not handle the case where later story events create a state that no longer matches that which the character considered when she made a particular choice. Just as it often happens in fiction, characters can change their mind or find new ways to achieve their goals.

The implementation of a specific discourse mechanism to convey contrasting options presented an important challenge that needed to be addressed for the successful completion of this research. The approach that I used is described in Section 5.11.

5.6 Character Intentions

The story generation mechanism must be able to deal with multiple character intentions. Additionally, intentions can be overlapping or interleaving. Furthermore, as characters commit to multiple intentions, multiple micro-plans are built to achieve the associated goals, i.e., each character has one micro-plan (sub-plan) for each intention they adopt. This ensures that contrasting intention frames take into account steps that the character already committed to executing.

The planner also needs to do the necessary bookkeeping to ensure that multiple intentions are handled in a manner that results in coherent plans. It is of the utmost importance to preserve completeness and soundness, which is achieved using the following techniques:

1. The macro-planner maintains a graph of the actions that each character has committed to execute in service of her intentions. These are stored in a database of intentions that all processes, including the micro-planner, can access.

2. When the micro-planner constructs a new intention frame, a sub-graph is produced which is merged by the macro-planner into the plan that is being constructed. The merge process ensures that actions that are part of a character's chosen course of action become part of the macro plan. Additionally, the correct placement of these actions in the macro-plan is also considered to prevent threats and ensure causal consistency. This is a step-wise process that occurs as part of the process used by the macro planner to explore the state space during plan construction.

Finally, my approach does not use a mechanism to preserve contrasting intention frames. Contrast is only evaluated by the micro-planner and only considered relevant at the point when its corresponding choice was made. Potentially, the initial state required by a micro-plan can be modified by the very next step. The micro-planner does not consider previous contrasting intention frames; the contrast graph generated when considering a potential choice is only used by the micro-planner while considering a set of multiple choices and then discarded. However, the intention frame that provides the most contrast with respect to the choice is stored with the choice. Contrasting intention frames are used by the discourse generator to help ensure that the audience is aware of an alternate course of action for a character who is deliberating about a choice.

5.6.1 Character Goals

In my approach, characters do not abandon their goals. Once they adopt an intention, they will continue to act on it until the associated goal is achieved or a plan that achieves all the authorial goals is constructed. However, it is important to note that the planning process only results in a failure condition if the completed plan does not achieve all the goals specified by the author, i.e., not all of the goals adopted by characters need to be achieved for the story generation process to succeed.

5.7 Story Generation Algorithm: Macro-Planner

CB-Glaive takes into account the multiple courses of action that may be available to a character when she pursues a goal in service of an intention. To accomplish this, CB-Glaive invokes a micro-planner that generates and evaluates the set of multiple intention frames that can be constructed to achieve a character's goal. This mechanism represents the character's mental

process of considering multiple alternative courses for action before performing an action in the course of a story.

CB-Glaive maintains a database of current intention frames. The information in this database is used to guide plan construction and also to inform the reasoning mechanism utilized by the micro-planner to consider choice alternatives. Additionally, every time that a choice is identified, CB-Glaive stores the information needed to support the use of a discourse manager when the story is presented to an audience. The information recorded about every choice includes: (1) the step in the macro-plan where the choice was identified, (2) the *character name* that represents the story character who made the choice, (3) the intention frame that was selected by the micro-planner as most consistent with the character's personality, and (4) the intention frame that was selected by the micro-planner as least-consistent with the behavior exhibited by the character in (3). It is important to note that this additional bookkeeping is only done when a choice is detected. A formal description of the macro-planner mechanism is provided in Algorithm 3.

The initial invocation of CB-Glaive is similar to that of Glaive [83]. The values in $\langle \Pi, P, \sigma, G, X, \mathsf{Choices} \rangle$ are initialized to represent the initial and goal states for the planning problem, the set of story characters, the initial set of character goals (which may be empty), and the set of unexplained steps, which is initially empty. Note that character goals may be assigned by the author or adopted as the story is constructed. Additionally, Choices is initialized to $\{\{s_0, \emptyset\}, \{s_G, \emptyset\}\}$, to indicate the lack of choices before the initial plan step and after the final plan step. On subsequent invocations of the algorithm, if all of the author's goals have been satisfied and there are no unexplained steps, the process succeeds and a plan is returned. Otherwise, CB-Glaive selects a potentially motivated step (s) whose preconditions are satisfied in the current state (σ) and adds it to the plan. The selection method uses a heuristic that favors steps which are present in a character's chosen course of action, i.e., they are part of a *choice* intention frame previously evaluated and selected by the MP as most consistent with a character's personality factor. If the newly added step adds a new character goal in one of its effects (it establishes a new intention) and the main character who adopts the goal has been assigned a personality factor, the MP will be invoked. The MP will evaluate the different courses of action that the character can choose to accomplish the goal and whether these exhibit any contrast with respect to her personality. If at least two contrasting frames are found, these are stored in Choices for later use by the heuristic and the discourse generator. From this point on, CB-Glaive operates in the same manner as Glaive, which mainly includes keeping track of steps that require explanation in the form of character intentions and the bookkeeping needed to keep track of such intentions.

Assumptions

The operation of CB-Glaive depends on the following assumptions:

1. The planning process uses fully-ground planning operators (or actions schemata).
2. Intentionality is handled as defined in the CPOCL algorithm [82].
3. Planning is interleaved between a macro-planner and a micro-planner (MP).
   (a) The macro-planner is a modified version of Glaive [83], unless indicated otherwise it operates as Glaive does.
   (b) The micro-planner is a special-purpose mechanism based on a restricted and highly customized version of a heuristic state-space planner.
4. Motivating steps are handled as defined in the CPOCL algorithm.
5. Story characters are divided into two general categories: *principal role* and *supporting role*. Characters in the supporting role category do not have a personality factor assigned to them. Additionally, only characters in a principal role form intentions.

5.7.1 State-Space Search Heuristic

The heuristic used to guide plan construction takes into account the existence of alternative choices for action. When a choice and a corresponding contrasting intention frame are identified by the micro-planner, the heuristic is designed to favor the steps in the chosen intention frame to guarantee that these are included in the final plan. Steps in the contrasting intention frame do not require any special handling by the heuristic because these do not become part of the plan, instead the entire intention frame is stored for later use by a discourse manager. Furthermore, because we are using a totally-ordered plan, no additional processing needs to be done to guarantee that the contrasting intention frame is valid since it is already executable at the point in the story where the character makes the choice.

The macro-planner must use a heuristic that takes into account plans that include more expressive choices. Suppose that the space of plans includes a set of nodes $\{w_1, w_2, w_3, w_4\}$ that achieve the same intention with varying degrees of character personality expressiveness. Consequently, the macro-planner heuristic has been designed to favor plans that include the two (2) nodes with the most contrast. However, it is important to note that completeness should be preserved and for this reason the planner must be able to eventually generate all possible plans, even if they do not have the same level of contrast as those that the heuristic is designed to favor. The specific details of a modified heuristic to handle this requirement are part of the key challenges that were addressed for the successful completion of this research.

Algorithm 3 *CB-GLAIVE(*$\Pi, P, \sigma, G, X,$ Choices*)* – Macro-Planner

Where Π is a totally ordered, fully-ground plan, P is a planning problem $\langle \Lambda, S_0, S_G, C \rangle$, σ is the current state, G is the set of character goals, X is the set of unexplained steps, and Choices is the set of choices made by characters in the course of the story.

Nondeterministically choose a potentially motivated step s whose preconditions are satisfied in σ. Assign a higher priority to steps in Choices.

▷ **Update the plan**

Add step s to Π.
Apply the effects of s to σ.

for each effect of s like c *intends* g **do**
    Add a new character goal $\langle c, g \rangle$ to G.

▷ **Check if a choice exists**

    if c has been assigned a personality factor **then**
        Invoke the Micro-Planner (MP) to evaluate the character's choices for action
        Add the intention frame returned to Choices
        Store the contrasting intention frame returned (used by discourse manager)
    end if
end for

if any characters consent to s **then**
    Add s to X.
end if

for each character goal $g = \langle c, g \rangle \in G$ **do**
    for each intention frame I for c ending in g **do**
        Remove g from G.
        for each step $t \in p$ **do**
            if t is explained **then**
                Remove t from X for all nodes*.
            end if
        end for
    end for
end for
if any node* satisfies the author's goals and $X = \emptyset$ **then**
    return Π for that node. ▷ **Solution found**
else
    CB-GLAIVE($\Pi, P, \sigma, G, X,$ Choices*)* ▷ Recursive invocation
end if

5.8 Story Generation Algorithm: Micro-Planner

The Micro-Planner (MP) is a highly-customized and specialized version of a state-space planner. This component simulates the character's decision-making process as she works toward accomplishing a goal. To represent the mental process of considering multiple plausible courses of action that achieve the same goal, the MP generates the set of possible intention frames that allow the character to achieve such goal and then evaluates them utilizing a simplified model of affect appraisal theory. Because generating the entire set of alternatives may not be tractable, the mechanism limits the number of alternatives explored to a preset threshold. Determining the optimal number of intention frames to generate, or deciding which ones to generate is an area where the algorithm could be improved in future versions. Likely, this will require additional experimentation and work on the optimization of the Java code that is used in the implementation of *Mask*.

The evaluation performed by the MP considers the action's execution context, which includes the following elements: (1) a specific goal that the character has adopted, (2) the current state of the story world, (3) the intentions of other story characters, (4) the personality factor assigned to the character who is making the choice, and (5) the character's current set of intentions. The last element is particularly important because ensuring that a character's actions are consistent with their existing intentions helps preserve the coherence of the story and the portrayal of story characters as rational agents.

Intention frames are also used to place a boundary on the search process conducted by the micro-planner. These help define the place where the evaluation of possible choices for action begins and also where it ends. The macro-planner launches the MP when a motivating step is added to the plan, i.e., the effects of a newly instantiated plan step include the adoption of a character goal as one of its effects (e.g. `(intends Jane (not (hungry Jane)))`). We say that a choice occurs when a motivating step is added, which results in two (2) or more contrasting intention frames. Evaluation of a choice for action ends at the point where the intention frame that accomplishes the goal being pursued by the character is completed.

Finally, to further emphasize the attribution of actions related to a choice, all of the steps considered by the micro-planner must be performed by the character who is acting on an intention. To accomplish this, the MP will only generate intention frames where all the actions are performed by the same character who adopted the goal, except for the case of *happenings* [57], which are actions that do not require the intervention of a character. A formal description of the micro-planner mechanism is provided in Algorithm 4.

Algorithm 4 *Micro-Planner(c, g, σ, Λ, I)*

Where c is the character who is adopting the goal, g is the goal that the character intends to achieve, σ is the current state, Λ is the planning domain, and I is the set of current character intention frames.
▷ **Find out if there are multiple courses of action**
Let MAX_INT_FRAMES be the maximum number of intention frames explored
while there is a new solution that allows c to achieve g
    and MAX_INT_FRAMES has not been reached **do**
    Intention_Frames = Intention_Frames ∪ New_Solution
end while

if only one intention frame exists **then** ▷ There is no choice
    contrast = null
    return Intention_Frames[0], contrast
else ▷ **A choice exists, evaluate it**
    for each intention frame (i) in Intention_Frames **do**
        if i is consistent with c's current intentions **then**
            affect_score = evaluate the effects of i on the affective response
                of other story characters
                ▷ This yields a +, −, or 0 numeric score
        end if
    end for

    Sort the intention frames by affect score, in ascending order

    choice = select the intention frame that is most consistent with
        the FFM factor assigned to c. If more than one exists,
        nondeterministically select one.
    contrast = select the intention frame that provides the highest
        level of contrast with choice. If more than one exists,
        nondeterministically select one.

    return choice, contrast
end if

5.9 Evaluation of Intention Frames

Intention frames are evaluated and then tagged using a simplified model of affect based on the work of Lazarus [37]. Of particular relevance to my work is his study of human emotions and in particular the assessment of the personal significance assigned to events. The model used in the design of *Mask* represents the impact that a character's choice for action has on the emotions of other characters in terms of the beneficial or harmful appraisal of its effects. In the current version of the algorithm, this evaluation is based on whether a character's course of action supports or prevents other characters from accomplishing their own goals. I envision that later versions of the algorithm will include evaluation of additional criteria, such as taking into account the degree to which one character's actions assist other characters in the achievement of their goals and also considering how detrimental the negative impact a harmful action or action sequence is.

Evaluation of intention frames assumes omniscient characters, i.e., all story characters have full knowledge of each other's intentions. To make this possible, the macro-planner maintains a database of every character's current intentions. In this context, current intentions are those for which an intention frame has been generated by the MP, but which have not yet been fully merged into the macro-plan.

Once the MP generates the set of possible intention frames for a new intention, every intention frame is evaluated with respect to the following criteria:

1. Its effects on the current intentions of other characters.
2. Its effects on the current intentions of the character who is making a choice.
3. The personality of the character who is making the choice. For example, a non-agreeable character will be more likely to make choices that elicit a harmful affect appraisal on other story characters.

5.9.1 Current Intentions of a Character

In the context of this work, *current intentions* refers specifically to intention frames that are being created in the macro-plan, but that are not yet complete. In our current model, we manage this *simplistically* by assuming that each character has full knowledge of every other character's current intentions. Current intentions are stored in a database that is also accessed by the micro-planner during the evaluation of multiple alternate intention frames or choices for action. The database makes it possible to evaluates a potential choice for action by considering the effects that steps contained in its corresponding intention frame have on the intention frames that represent the goals that other characters are pursuing. Being able to consider both intention

frames enables the mechanism to reason about how the effects of the character's actions would be appraised by other story characters. Such appraisal thus provides key information needed to determine whether the consequences of the choice are consistent with the personality of the character who is making the choice.

Future versions of the algorithm may be expanded to use a more robust model, such as one based on character knowledge that is limited by her observations or that uses a belief system where characteristics such as incomplete or inaccurate knowledge play a role. In such a model, every character could potentially have their own version of the state of the story world, one which may not agree with other characters' versions and thus promotes the generation of narratives that are potentially more expressive.

5.9.2 Affect Tagging

Each new intention frame being considered as part of a character's choice is tagged to indicate its potential effects on the affective response of other story characters. This is based on how the state of the story world at the end of the frame would be appraised by the characters on whom it has an impact. Three tags are used: positive (+1), negative (-1), and neutral (0). A tag of zero (0), indicates that the effects of the intention frame produce a neutral appraisal on the affect of other story characters. A tag with a positive score indicates a beneficial appraisal and a negative score indicates a harmful appraisal. *Mask* uses a mechanism that evaluates whether a character's actions would be perceived as harmful or beneficial. This mechanism is described in the next subsection.

An additional consideration is that instead of tagging the entire intention frame, we may want to use a more granular approach that focuses on individual actions within the intention frame. Using this type of approach would facilitate the implementation of a model that supports characters with more finely detailed personality features and possibly lead to more expressive narratives. The current version evaluates an intention frame as a whole.

5.9.3 Affect Model

The model of affect use in the design of *Mask* is based on a simplified version of the appraisal theory proposed by Lazarus [37]. This model is utilized to assign valence to a character's choice for action and to its potential alternatives. The model operationalizes the emotional state of a character that results due to a sequence of story events; namely, the steps contained in a specific intention frame.

In this model, emotions stem from the relationships between a person and the environment that involve harm or benefit. For the purposes of this research, I generalize harm to be the inability or difficulty in achieving a goal, i.e., fulfilling an intention. There could be varying

degrees of harm; however, the current version of *Mask* focuses on whether such harm exists or not. Varying degrees of harm could later be evaluated using a model that takes into account the effort necessary to undo the damage (e.g. total steps, action cost, or some other plan-based metric) or it could also take into account whether recovery is at all possible. A case in point is that of irreversible effects, such as the death of a character.

In the current version of *Mask*, I generalize benefit to be the achievement of a character's goal or one or more of the conditions necessary to achieve it. The affect elicited by an intention frame is quantified in terms of the relationship between the effects that it produces and their relationship with the goals that other story characters are trying to accomplish and also the preconditions that are necessary to achieve such goals. Effects common to all the steps in a set of intention frames under evaluation are ignored because they do not provide information to help differentiate the alternatives from each other.

After the mental states of all other characters (those potentially affected by a choice) with respect to a character's choice is identified, these are aggregated to tag the intention frame as either harmful or beneficial. This idea is partially based on the concept of plot units as defined by Lehnert [39] and in particular the relationship that characters' actions have with the affective state that they produce. Consequently, *Mask* uses a mechanism that measures an approximation of affect in a plan-based story representation. The result of using this mechanism is a labeling of the affective state elicited by story events. In the context of this research, the events of concern are those directly related to a choice for action made by a character in pursuit of a goal. The events that are considered and labeled by the mechanism are those encompassed by the intention frame that represents such choice. A mechanism that uses the affect model described above to tag intention frames is presented in Algorithm 5.

The design and implementation of a mechanism that measures the effect of a specific intention frame on the affect of another character is one of the key challenges that were addressed as part of this research. Using this mechanism, *Mask* is able to evaluate multiple intention frames and calculate a score that serves as an indicator of how consistently each intention frame portrays behavior that matches the personality factors of the character who is making the choice. The score that is calculated for each intention frame enables their comparison and is thus crucial for the selection of the *choice* intention frame and of its *contrast*.

5.10 System Architecture

The mask narrative generation system is implemented in Java, using a multi-tier system architecture (see Figure 5.1). The system has the following components:

1. Narrative Planner: A modified version of the Glaive planner's codebase [83], this com-

Algorithm 5 *EvaluateIntentions*(c, i, I)

Where c is the character who is making a choice, i is the intention frame being evaluated, and I is the set of current character intention frames.

Let I_{other} = Subset of I where the character working on a goal is not c.
Let $\mathsf{TotalAffectScore} = 0$

for each intention frame (i_o) in I_{other} **do**
▷ Evaluate the influence of i on the affect of the
▷ character who is pursuing the goal associated with i_o
    Let $\mathsf{AffectScore} = 0.0$
    if i and i_o are overlapping intentions, i.e., i produces an effect that matches
        the goal (g) associated with i_o **then**
        if the effect achieves g **then**
            $\mathsf{AffectScore} = \mathsf{AffectScore} + 1.0$
        else
            if the effect negates g **then**
                $\mathsf{AffectScore} = \mathsf{AffectScore} - 1.0$
            end if
        end if
    end if
    for each precondition (p) required by a step $s_j \in i_o$ **do**
        if i produces an effect that achieves p **then**
            $\mathsf{AffectScore} = \mathsf{AffectScore} + 1.0$
        else
            if i produces an effect that negates p **then**
                $\mathsf{AffectScore} = \mathsf{AffectScore} - 1.0$
            end if
        end if
    end for

    $\mathsf{TotalAffectScore} = \mathsf{TotalAffectScore} + \mathsf{AffectScore}$
end for
return TotalAffectScore

ponent is where the main story generation mechanism is implemented. Throughout this document I use the term macro-planner to refer to this mechanism.

2. Personality Evaluation Module: A special-purpose mechanism used to ensure that character choices for action guide the story generation process. This component has the following modules:

   (a) A micro-planner designed to explore a segment (sub-problem) of the search space and generate a set of possible solutions. This module uses an implementation of the Alternative Possible Worlds theory, an operationalization of human goals with respect to personality, and the concept of character intentionality.

   (b) An affect evaluation process that implements a simplified model of affect appraisal theory.

   (c) A character repository that describes the role and personality factor of story characters.

   (d) A database of current character intentions.

   (e) A mechanism that evaluates the affective response that would be elicited by a character's course of action on other story characters

3. Discourse Manager: A component that utilizes the *SimpleNLG* [24] Java API to produce a natural language version of the stories generated by *Mask*. This component uses the story plan produced by the macro-planner, information about the story characters, and a collection of natural language templates.

5.11 Discourse Generation

In narrative discourse, according to Genette [25], there are five main concepts that are applied when the syntax of narratives is considered. These are:

- Order
- Frequency
- Duration
- Voice
- Mode

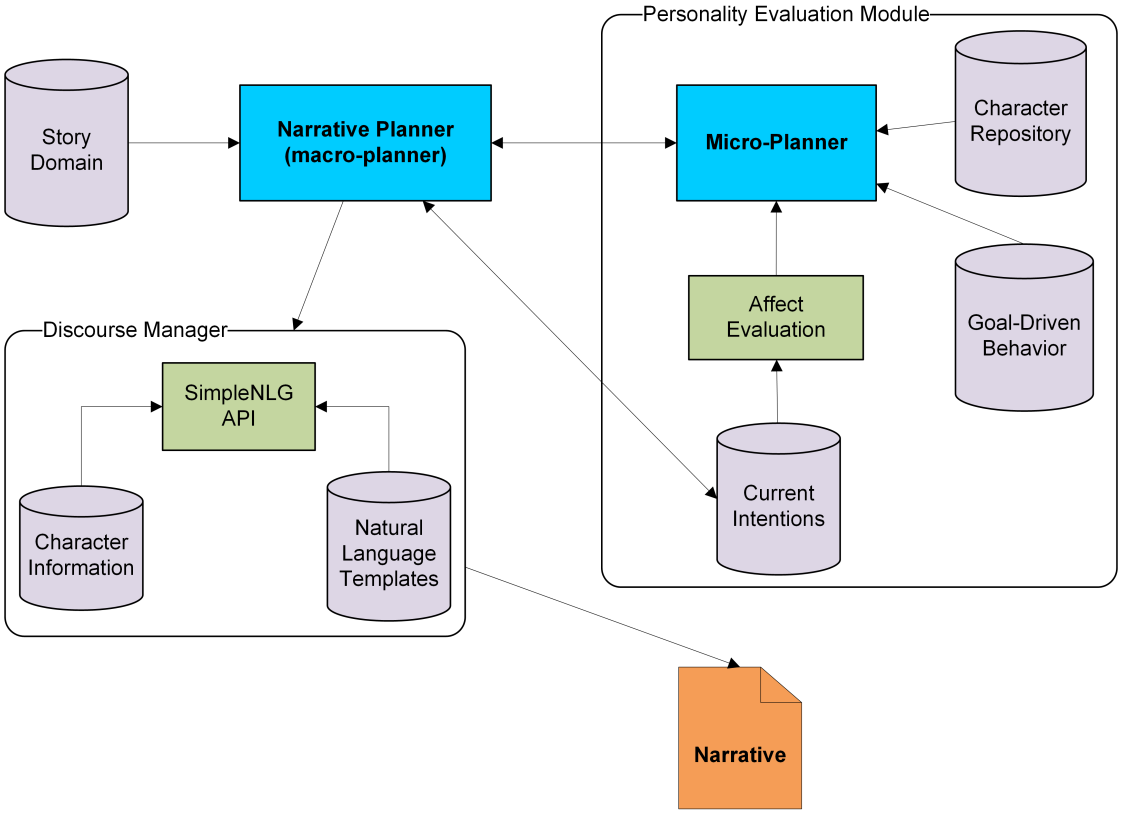

Figure 5.1: The Mask Narrative Generation System: Architecture

Voice refers to the speech or other overt means through which events and existents (characters that participate in the story) are communicated to the audience [25, 15]. Voice is also concerned with who narrates the story and from where. There are two major considerations in terms of voice: where the narration is from and whether the narrator is a character in the story. In the case of the former, narration can be either (a) intra-diegetic, which means that it is inside the text or (b) extra-diegetic, which means that it is outside of the text. The narrator's place in the story can be either (a) hetero-diegetic, which means that the narrator is not a character in the story or (b) homo-diegetic, which means that the narrator is a character in the story.

Narrative mode is dependent on the *distance* and *perspective* of the narrator and it is related to voice. The distance of the narrator changes with narrated speech, transposed speech and reported speech. The perspective of the narrator is called focalization. Narratives can be non-focalized, internally focalized or externally focalized.

In terms of discourse, according to Chatman [15], there is a dichotomy that results from how information is presented to an audience: statements can be directly presented to the audience, or they can be mediated. Mediation assumes the existence of a narrator. This is basically the same contrast observed between mimesis (showing) and diegesis (telling) [77]. The former requires no mediation whereas the latter does. Another important consideration is the point of view, which is the physical place, ideological situation, or practical life-orientation that narrative events are associated with. A point of view is in the story when it belongs to one of the characters. Typically, the narrator's conceptual point of view tends to override that of the character.

Records of Thought

An important application of discourse methods is the communication of a character's thoughts or feelings [25, 15]. Some of the techniques used in this area include: the soliloquy, the interior monologue, and the stream of of consciousness [31].

A soliloquy presents the psychic content and processes of a character directly to the reader. It does this without the presence of an author, yet it tacitly assumes the presence of an audience. The character explains or comments upon what is happening. Soliloquies must be tagged to ensure that they are recognized as speech or an expression of thought, e.g. "It is too late for apologies," said James.

Both the interior monologue and the stream of consciousness consist of the non mediated presentation of a character's thoughts and impressions. However, interior monologues (also described as direct free style) are not as mediation free as strict speech record. They require the transformation of perceptions into language verbalization. An interior monologue treats the character's thoughts as unspoken speech, is tagged, and presents the exact words of the character as "spoken" in her mind. Interior monologues have the following characteristics [25, 15, 57]:

1. If a character self-reference is used, it is in first person.
2. Discourse time equals story time. Verbs are in present tense.
3. The language utilized (idioms, diction, syntax) can be identified as that of the character.
4. References to the character's own experience have no further explanations besides any that may be needed in the character's own thinking.
5. It is assumed that there is no audience, other than the character who is doing the thinking.
6. Quotation marks are not used.
7. The narrator cannot make statements indicating that the character is thinking. The words used must convey this to the audience.

A stream of consciousness (also described as free association) is similar to an interior monologue [31]; however, one key distinction is that it includes "sense impressions" that are not the result of an internal analysis produced by a narrator. It goes beyond verbalized thoughts, but suggests that the words used are not words. A stream of consciousness typically has the following characteristics [31, 15, 57]:

1. May be marked by truncated syntax.
2. Includes a random ordering of thoughts and impressions.
3. The attention of the character's mind can shift from one object to another due to unexpected, sudden, or remarkable stimulus.
4. It has its own organizational principles, such as generalization, analysis, and exemplification.

Discourse Devices Used by Mask

For the purposes of this research, it was of the utmost importance to be able to evaluate the effectiveness of the choice-based narrative generation mechanism. Such effectiveness was measured in terms of the perception of character personality traits that stories generated by *Mask* elicit in an audience. However, any discourse devices used could potentially introduce a source of bias. Nevertheless, the first study that I conducted made it evident that the audience did not have enough information about the choices for action that were available to a character.

In order to present the choice information to the audience, while significantly reducing the possibility of bias, I implemented a very simple discourse generator that presented the story events in past tense, using active voice. Furthermore, I refrained from applying any techniques

that would have made embellished the language used. In essence, the discourse generated was as close as possible to a simple enumeration of events and facts. More precisely, the narration was intra-diegetic, the narrator was hetero-diegetic, and mediation was kept to a minimum and avoided whenever possible. In the specific case of presenting the choices available to a character, I used an approach based on the soliloquy technique that is described above. Examples of the English text generated by *Mask* are provide in the following section.

5.12 Sample Narrative Generation Scenarios

This section contains the description of a series of narrative generation scenarios used during the development and evaluation of the *Mask* system. Each scenario is discussed within the context of the choice-based mechanism that is designed to portray personality traits for fictional characters. Special attention is given to the process that the planner follows to select specific action and action sequences to ensure that they are consistent with a character's assigned personality factors. The stories used in each of the scenarios are either simplified versions of excerpts from literary works or based on themes typically found in popular fairy tales.

Complete sets of action schemata based on these scenarios, along with a problem description, and sample plans generated by *Mask* are presented in Appendix B.

5.12.1 Sample Scenario: Riddles in The Dark

In this section, I use a scenario based on an excerpt from *The Hobbit: Chapter 5 - Riddles in The Dark* [78] to describe the operation of the narrative generation mechanism described in previous sections. Some details of the story have been omitted or simplified, both for the sake of brevity and to facilitate the use of a plan-based story representation.

Story Argument

Bilbo Baggins has become separated from his traveling companions and is currently lost in a cave, under the misty mountains. He has the ability to become invisible, thanks to a magical ring that he found earlier, and he has in his possession a knife that he collected during his travels. He has met Gollum, a seemingly wicked creature who lives in an underground lake and has promised to help him find the exit out of the cave. After a while, Bilbo has realized that Gollum is only pretending to help and instead wants to hurt him. Consequently, he intends to escape from Gollum in order to regain his safety and be able to exit the cave. Meanwhile, Gollum is trying to grab Bilbo to kill him and he is also blocking the passage that leads to the cave's exit. Bilbo considers multiple alternatives that would enable him to escape from Gollum and exit the cave.

In this scenario, we consider Bilbo to be highly agreeable (as is typical of a Hobbit). Behavior that can be expected of him includes: honesty, responsibility, interaction, empathy, self-sacrifice, and generosity. Likewise, Bilbo is unlikely to exhibit behaviors such as aggression, sabotage, irritability, and selfishness. The story plan that is constructed by *Mask* for this scenario will include choices that show behavior consistent with these traits.

Scenario Alternatives

Consider a scenario where in order to escape, Bilbo faces a choice from three alternatives: (1) hurt Gollum to disable him, (2) kill Gollum to eliminate him, and (3) jump over Gollum to reach the passage. Each one of these alternatives results in a different sequence of actions that when added to the plan creates a different version of the story, i.e., an Alternative Possible World (APW). The contrast between the story produced by the chosen alternative and the possible versions that would result from the selection of the other alternatives is used to represent Bilbo's act of making a choice while considering its consequences. Furthermore, the selection of a specific alternative is determined by the personality factor that has been previously assigned to Bilbo, in conjunction with his own goals and those of Gollum.

Action Schemata

The following action schemata are used to implement the plan-based representation of the narrative scenario. Note that not all the actions used in the sample plan are included, just those with particular relevance to this discussion. A consolidated description of the schemata is shown in Table 5.1.

```
(:action sneak-up
      :parameters (?character - character ?from - place ?to - place)
      :main-character (?character)
      :preconditions (and (not (= ?from ?to))
               (alive ?character)
               (at ?character ?from)
               (or (next-to ?from ?to)
               (next-to ?to ?from))
               (has ?character ring-of-power)
      :effects (and (not (at ?character ?from))
               (at ?character ?to))
      :agents (?character))
```

Table 5.1: Action Schemata Used in the Sample Scenario

Action	**Preconditions**	**Effects**
sneak-up	The character is at the starting location, is alive, and has the *ring of power*. The starting and destination locations are different from each other and they are adjacent.	The character is no longer at the starting location and is now at the destination location.
jump-over	The character is at the starting location, is alive, and is able to jump over objects. The starting and destination locations are different from each other.	The character is no longer at the starting location and is now at the destination location.
stab-to-death	The character performing the stabbing is different from the victim, both the stabber and the victim are alive, the stabber has a weapon, and both stabber and victim are at the same location.	The victim is no longer alive.
stab-to-disable	The character performing the stabbing is different from the victim, both the stabber and the victim are alive, the stabber has a weapon, and both stabber and victim are at the same location.	The victim is now disabled and has a stabbing wound.

```
(:action jump-over
   :parameters (?character - character ?obstacle - object)
            ?from - place ?to - place
   :main-character (?character)
   :preconditions (and (not (= ?from ?to))
            (alive ?character)
            (at ?character ?from)
            (or (next-to ?from ?to)
            (next-to ?to ?from))
            (can-jump ?character))
   :effects (and (not (at ?character ?from))
            (at ?character ?to))
   :agents (?character))

(:action stab-to-death
   :parameters ?character - character ?victim - character
               ?weapon - weapon ?place - place
   :main-character (?character)
   :preconditions (and (not (= ?character ?victim))
            (alive ?character)
            (alive ?victim)
            (has ?character ?weapon)
            (and (at ?character ?place)
            (at ?victim ?place))
   :effects (not (alive ?victim))
   :agents (?character))

(:action stab-to-disable
   :parameters (?character - character ?victim - character)
               ?weapon - weapon ?place - place
   :main-character (?character)
   :preconditions (and (not (= ?character ?victim))
            (alive ?character)
            (alive ?victim)
            (has ?character ?weapon)
            (and (at ?character ?place)
            (at ?victim ?place))
```

```
:effects (and (disabled ?victim)
         (stabbed ?victim))
:agents (?character))
```

Story Generation Walkthrough

Consider the partial story plan shown in Figure 5.2, which shows the *Start* step of the plan. The figure shows the plan after the initial invocation of the algorithm has taken place and no steps have been added to the plan. Note that at the beginning of this scenario, Gollum has already formed the intention of staying alive; such an intention could be specified by the author in the initial state or be the result of earlier story events. After a few recursive invocations of CB-Glaive, we may have the totally-ordered, fully ground, partial plan shown in Figure 5.3. This plan is the result of the planner's search of the state-space, producing the addition of new steps that are applicable in the subsequent states. The plan represents a point in the story where Bilbo has become separated from his friends. He wanders around the cave and meets Gollum.He has asked Gollum for his help in finding a way out of the cave; however, he has realized that Gollum does not want to help him and instead wants to cause him harm. Bilbo knows that he is in danger and as a result forms the intention `(intends bilbo (not (in-danger bilbo))`. At this point the macro-planner creates a new intention frame for Bilbo. The new intention frame represents Bilbo's pursuit of his newly adopted goal and the steps that it will contain represent the course of action that he is going to follow to achieve it.

The next step taken by the macro-planner (CB-Glaive) is to invoke the micro-planner (MP). This invocation represents Bilbo's mental process of considering multiple applicable alternatives for achieving his goal and choosing one to enact. The MP generates the set of intention frames that enable Bilbo to achieve the goal `(not (in-danger bilbo))`; a subset of these is shown in Figures 5.4 to 5.6. Each intention frame represents a course of action that would achieve Bilbo's goal. As part of its process, the MP evaluates and ranks the intention frames to identify the one most consistent and the one least consistent with Bilbo's highly *agreeable* personality. Note that in Intention Frames 1 and 2, the outcome produced will elicit in a negative affective response on Gollum's part. This is due to the detrimental effect that they have on Gollum's intention of staying alive. Alternatively, the effects of Intention Frame 3 will elicit a neutral affective response on Gollum. This is the result of it not having any effect on Gollum's intentions.

The MP evaluates and ranks the intention frames using the simplified model of affect described earlier, the personalty factor that was assigned to Bilbo by the author (high agreeableness), and the global database of all character intentions. As a result of this evaluation, the MP assigns a negative affect score to Intention Frames 1 and 2; thus they are tagged as being *neg-*

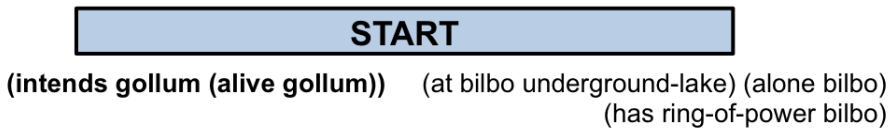

Figure 5.2: Sample Scenario - Beginning of Story Plan. In this figure, the rectangular boxes indicate steps in the plan. Time flows roughly vertically downward. Initially, the start step is the only step in the plan. The figure also shows the goal state specified by the author.

ative `(score=-1)`. Conversely, Intention Frame 3 is tagged as being *neutral* `(score=0)`. Since both negatively-tagged intention frames have the same score, the MP non-deterministically selects one of them. The end result in this process is the selection of Intention Frame 3 as the action sequence that Bilbo will enact in pursuit of his goal and of Intention Frame 1 as the option used to provide contrast. Intention Frame is used as Bilbo's choice for action because it is consistent with his highly agreeable personality. These two intention frames are returned to the macro-planner and constitute the contrast set for Bilbo's choice.

The complete plan is shown in Figure 5.7. This plan is produced after further expansion of the search tree, during which CB-Glaive favors the addition of steps contained in Intention Frame 3. Note that only the steps included in the chosen intention frame are added to the plan. However, the contrasting option is stored and linked to the choice that Bilbo made in order to achieve his goal. This additional bookkeeping makes the steps in the contrasting alternative available for their use by a discourse manager.

5.12.2 Sample Scenario: The Kidnapping of The Princess

In this section, I use a scenario based on a theme typically found in folk tales to provide further illustration of *Mask* and the choice-based process that is used to generate stories. Some details of the story have been omitted or simplified, both for the sake of brevity and to facilitate the use of a plan-based story representation.

Story Argument

A princess has gone from the royal palace to the forest. She enjoys her time in the forest, becomes distracted, and ends up attracting the attention of a dragon who lives in a cave nearby. The dragon decides to leave his cave and go to the forest, where he finds the princess and decides

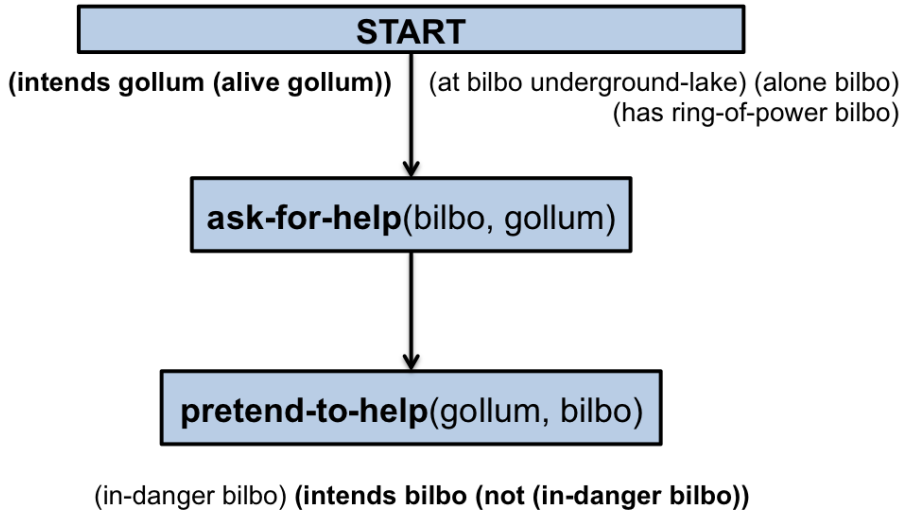

Figure 5.3: Sample Scenario - Partial Story Plan. In this figure, the rectangular boxes indicate steps in the plan. Time flows roughly vertically downward. Solid arcs from one step to another indicate a causal link between the source step's effects and the destination step's preconditions.

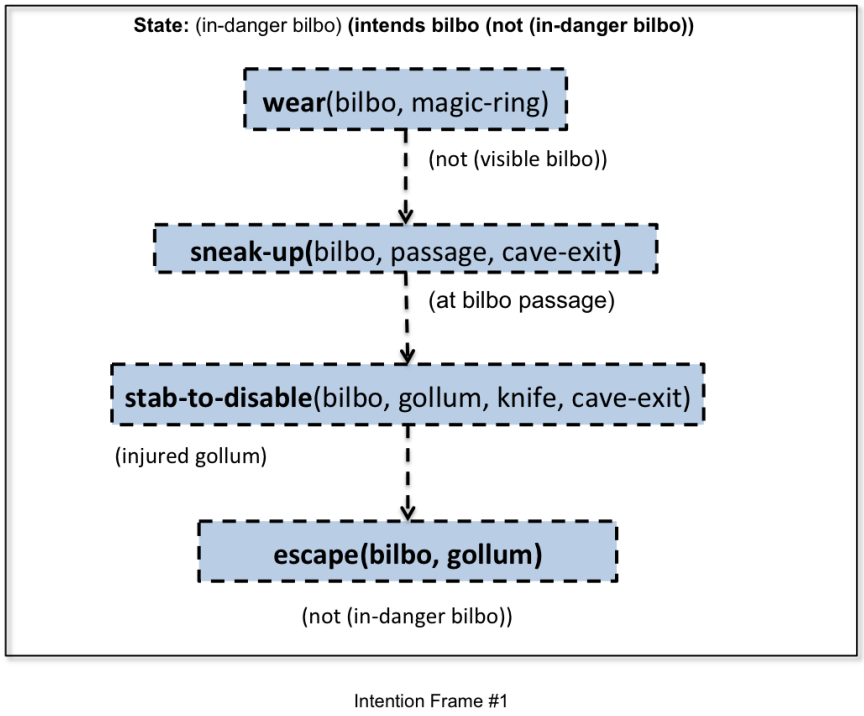

Figure 5.4: Sample Scenario - Intention Frame Generated by The Micro-Planner. In this figure, the rectangular boxes indicate steps in an intention frame. Time flows roughly vertically downward. Arcs from one step to another indicate a causal link between the source step's effects and the destination step's preconditions. Three (3) distinct intention frames for the goal `(not (in-danger bilbo))` are shown, out of several that the MP generates an evaluates.

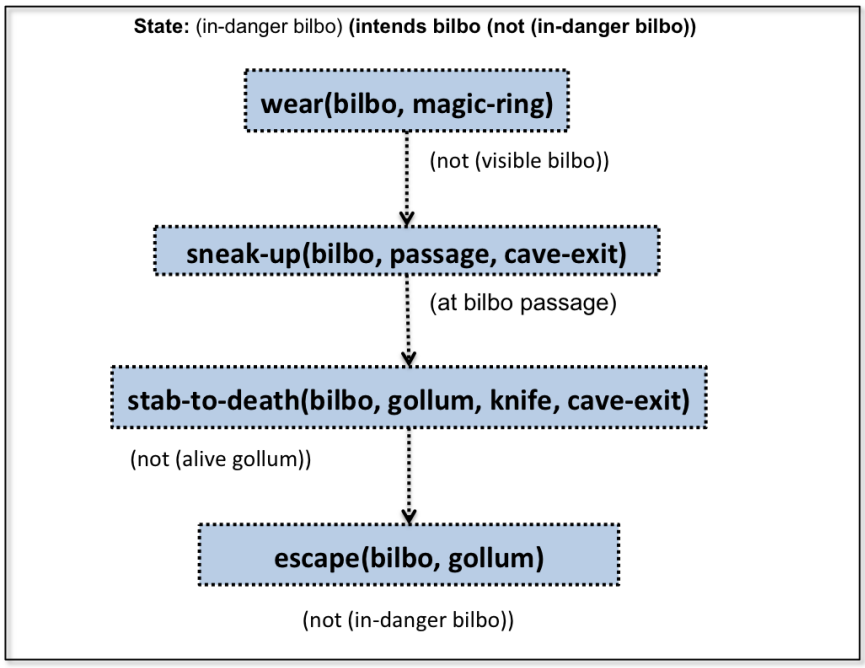

Figure 5.5: Sample Scenario - Intention Frame Generated by The Micro-Planner. In this figure, the rectangular boxes indicate steps in an intention frame. Time flows roughly vertically downward. Arcs from one step to another indicate a causal link between the source step's effects and the destination step's preconditions. Three (3) distinct intention frames for the goal `(not (in-danger bilbo))` are shown, out of several that the MP generates an evaluates.

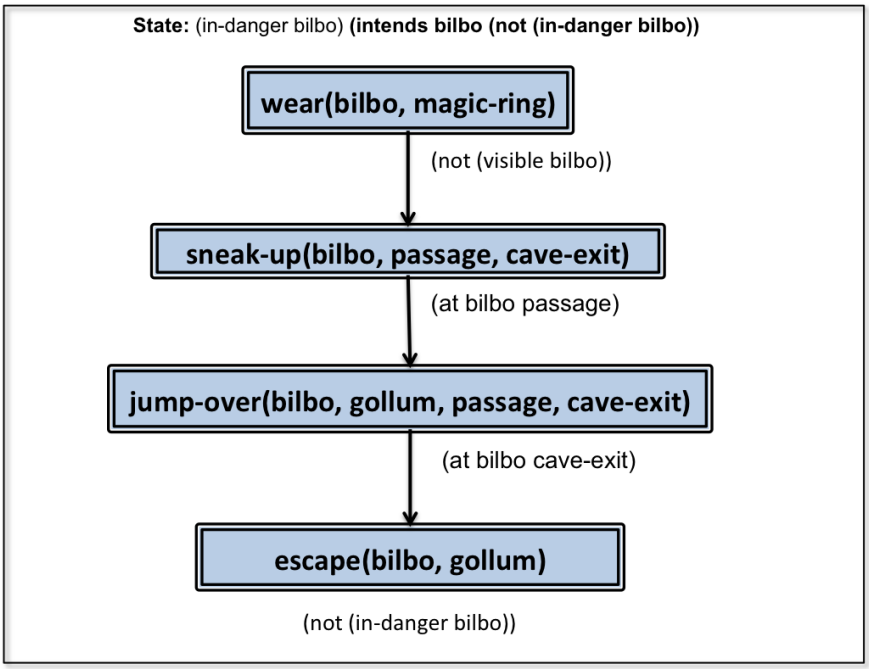

Figure 5.6: Sample Scenario - Intention Frame Generated by The Micro-Planner. In this figure, the rectangular boxes indicate steps in an intention frame. Time flows roughly vertically downward. Arcs from one step to another indicate a causal link between the source step's effects and the destination step's preconditions. Three (3) distinct intention frames for the goal `(not (in-danger bilbo))` are shown, out of several that the MP generates an evaluates.

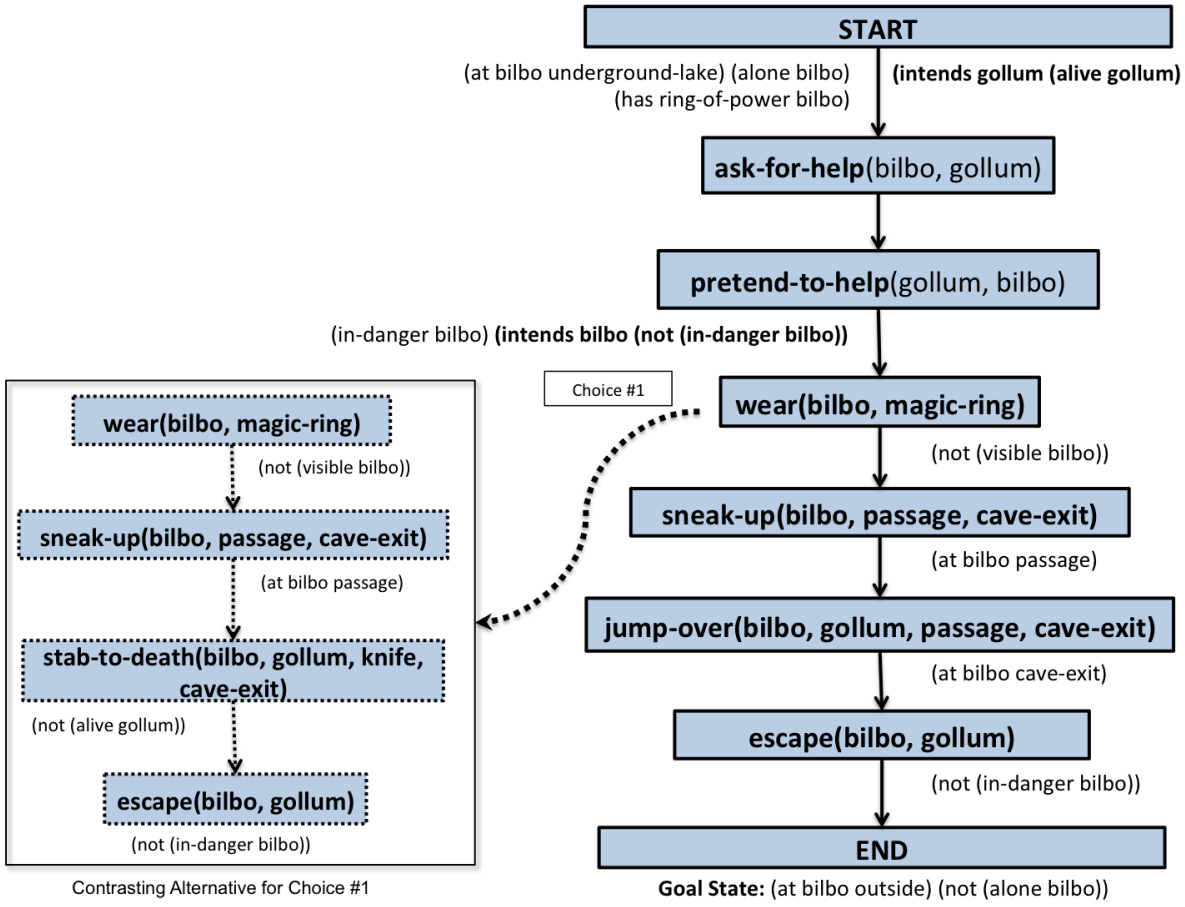

Figure 5.7: Complete Story Plan with Choice and Contrasting Alternative. In this figure, steps drawn with dashed lines indicate a contrasting alternative that is stored as part of the planner's bookkeeping but that is not used to construct the plan. Steps in this option are flagged as being linked of a choice, which makes it possible to use them during discourse generation to help convey the existence of such choice. A box with a double border indicates a step that results from a choice. A dotted line indicates a link between a choice and its contrasting alternative.

to kidnap her and take her to his cave. The princess in despair screams for help and gets the attention of a knight who lives in a cabin in the same forest. The knight decides to help the princess, but he is faced with a choice regarding the means that he will use to rescue her.

In this scenario, the knight has been tagged with a low agreeableness personality factor. Behavior that can be expected of him includes: aggression, sabotage, irritability, and selfishness. Likewise, the knight is unlikely to exhibit behaviors such as honesty, responsibility, interaction, empathy, self-sacrifice, and generosity. The story plan that is constructed by *Mask* for this scenario will include a choice that shows behavior consistent with the low agreeableness factor.

Scenario Alternatives

The knight considers his options and realizes that there are multiple ways in which he can free the princess. He could engage in a violent rescue where he fights and kills the dragon. Alternatively, he could also sneak into the dragon's cave and orchestrate an escape, leaving the dragon unharmed. Both alternatives achieve the goal of freeing the princess; however, the violent rescue is the option more consistent with the knight's low agreeableness. Hence, he chooses the rescue option, fights and kills the dragon and rescues the princess.

Action Schemata

The following action schemata are used to implement the plan-based representation of the narrative scenario. Note that not all the actions used in the sample plan are included, just those with particular relevance to this discussion. A consolidated description of the schemata is shown in Table 5.2.

```
(:action scream-for-help
   :parameters (?victim - person ?hearer - hero ?kidnapper - monster)
   :main-character (?victim)
   :precondition (and (kidnapped ?victim ?kidnapper)
            (not (= ?victim ?kidnapper)) (not (= ?victim ?hearer))
   :effect (and (intends ?hearer (not (kidnapped ?victim ?kidnapper)))
            (intends-rescue ?hearer ?victim))
   :agents (?victim))

(:action rescue
   :parameters (?rescuer - hero ?victim - person ?kidnapper - monster
            ?place - place)
   :main-character (?rescuer)
```

Table 5.2: Action Schemata Used in the Kidnapping Scenario

Action	**Preconditions**	**Effects**
scream-for-help	A kidnapping victim screams to get the attention of a hero. She has been kidnapped by a monster and would like to be rescued.	The hero hears the victim's plea and forms the intention to rescue her. From this point on, the hero will work on a course of action that achieves the princess' rescue.
rescue	A hero, a monster, and a victim are at the same location. The victim is currently kidnapped at such location.	The hero and the victim are at a different location, together, The victim is no longer kidnapped and is grateful to the hero. The monster is dead.
help-escape	A hero, a monster, and a victim are at the same location. The victim is currently kidnapped at such location.	The hero and the victim are at a different location, together. The victim is no longer kidnapped and is grateful to the hero. *Note that the monster is still alive.*

```
   :precondition (and (kidnapped ?victim ?kidnapper) (at ?rescuer ?place)
            (intends-rescue ?rescuer ?victim) (at ?victim ?place)
            (not (= ?rescuer ?victim)))
   :effect (and (not (kidnapped ?victim ?kidnapper))
            (indebted-to ?victim ?rescuer)
            (intends ?rescuer (at-home ?victim))
            (not (bound ?victim)) (dead ?kidnapper))
   :agents (?rescuer ?victim))

(:action help-escape
   :parameters (?helper - hero ?victim - person ?kidnapper - monster
            ?place - place)
   :main-character (?helper)
   :precondition (and (kidnapped ?victim ?kidnapper) (at ?helper ?place)
            (intends-rescue ?helper ?victim) (at ?victim ?place)
            (not (= ?helper ?victim)))
   :effect (and (not (kidnapped ?victim ?kidnapper))
            (indebted-to ?victim ?helper)
```

```
            (intends ?helper (at-home ?victim))
            (not (bound ?victim)))
    :agents (?helper ?victim))
```

Story Generation Walkthrough

Consider the partial story plan shown in Figure 5.8, which shows the first few steps for the plan that represents the scenario described above. The totally-ordered, fully ground, partial plan would have the structure shown after a few recursive invocations of CB-Glaive. The figure shows the plan after the princess has become distracted during her visit to the forest and as a result has attracted the attention of the dragon. The dragon has decided to kidnap the princess and take her to the cave where he lives. Note that the kidnapping event results in the princess forming the intention of not being kidnapped. As a result, the princess screams to attract the attention of the knight who lives in a cabin in the same forest. She wants him to rescue her, which results in the knight forming the intention `(intends the-knight (not (kidnapped princess dragon))`. This intention represents his goal of ending the princess' kidnapping. At this point the macro-planner creates a new intention frame for the knight. The new intention frame represents his pursuit of the newly adopted goal and the steps that it will contain represent the course of action that he is going to follow to achieve it.

The next step taken by the macro-planner (CB-Glaive) is to invoke the micro-planner (MP). This invocation represents the knight's mental process of considering multiple applicable alternatives for achieving his goal and choosing one to enact. The MP generates the set of intention frames that enable the knight to achieve the goal `(not (kidnapped princess dragon))`; a subset of these is shown in Figures 5.9 and 5.10. Each intention frame represents a course of action that would achieve the knight's goal. As part of its process, the MP evaluates and ranks the intention frames to identify the one most consistent and the one least consistent with the knight's low *agreeableness* personality factor. Note that in Intention Frame 1, the outcome produced will elicit a negative affective response on the dragon's part. This is due to the detrimental effect that its actions will have on the dragon's ability to participate in any future events in the story world. In this story domain, multiple action schemata include the character being alive as one of the preconditions. Consequently, if the dragon is no longer alive this will prevent the fulfillment of many of his current intentions, such as the continued kidnapping of the princess or moving from his cave to the forest and back. Alternatively, the effects of Intention Frame 2 will elicit a neutral affective response on the dragon. This is the result of it not having any of the detrimental effects just described, specifically because there is no effect on the dragon's life.

The MP evaluates and ranks the intention frames using the simplified model of affect de-

scribed earlier, the personality factor that was assigned to the knight by the author (low agreeableness), and the global database of all character intentions. As a result of this evaluation, the MP assigns a negative affect score to Intention Frame 1; thus it is tagged as being *negative* `(score=-1)`. Conversely, Intention Frame 2 is tagged as being *neutral* `(score=0)`. The end result in this process is the selection of Intention Frame 1 as the action sequence that the knight will enact in pursuit of his goal and of Intention Frame 2 as the option used to provide contrast. Intention Frame is used as the knight's choice for action because it is consistent with his low agreeableness personality factor. These two intention frames are returned to the macro-planner and constitute the contrast set for the knight's choice.

The complete plan is shown in Figure 5.11. This plan is produced after further expansion of the search tree, during which CB-Glaive favors the addition of steps contained in Intention Frame 1. Note that only the steps included in the chosen intention frame are added to the plan. However, the contrasting option is stored and linked to the choice that the knight made in order to achieve his goal. This additional bookkeeping makes the steps in the contrasting alternative available for their use by a discourse manager.

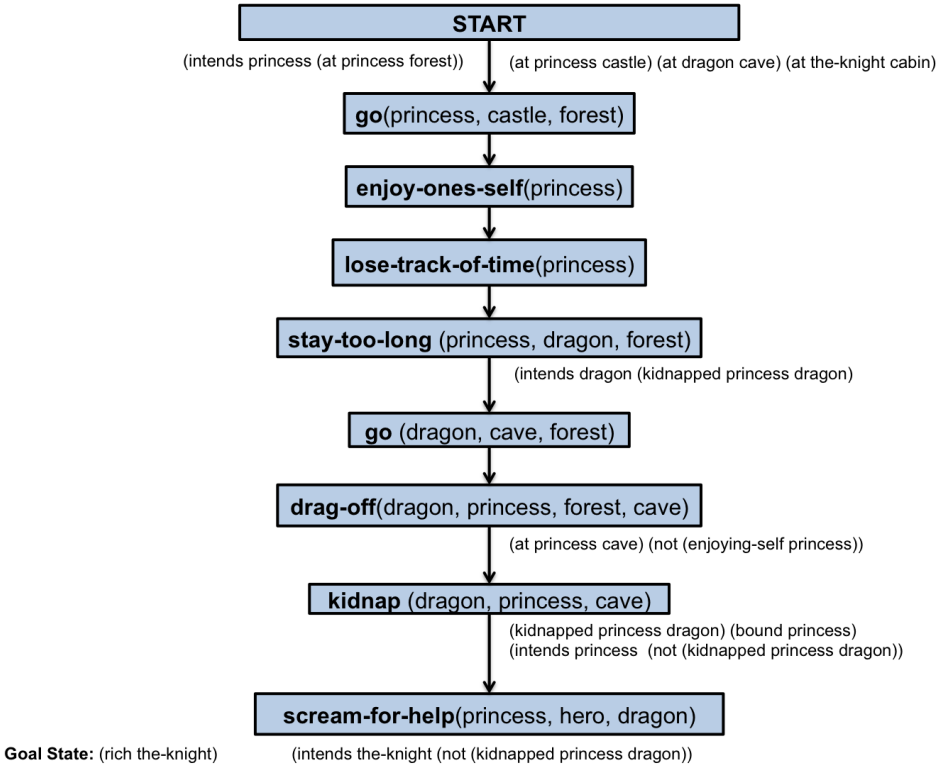

Figure 5.8: Sample Scenario - Partial Story Plan. In this figure, the rectangular boxes indicate steps in the plan. Time flows roughly vertically downward. Solid arcs from one step to another indicate a causal link between the source step's effects and the destination step's preconditions.

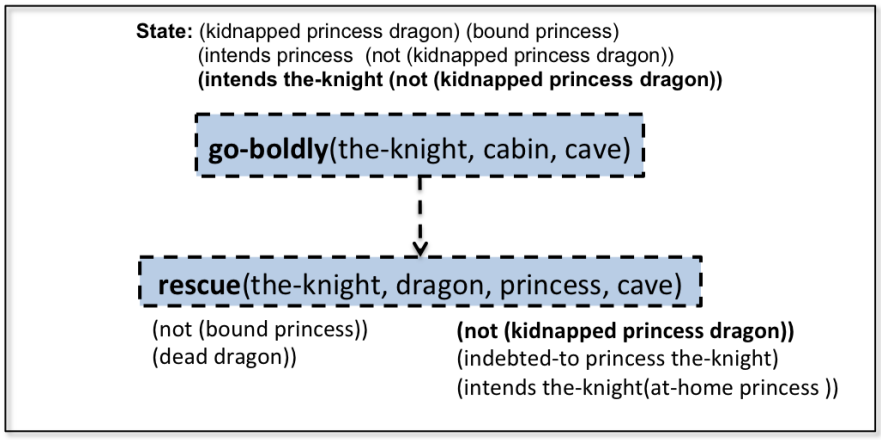

Figure 5.9: Sample Scenario - Intention Frame Generated by The Micro-Planner. In this figure, the rectangular boxes indicate steps in an intention frame. Time flows roughly vertically downward. Arcs from one step to another indicate a causal link between the source step's effects and the destination step's preconditions. Two (2) distinct intention frames for the goal `(not (kidnapped princess dragon))` are shown, out of several that the MP generates an evaluates.

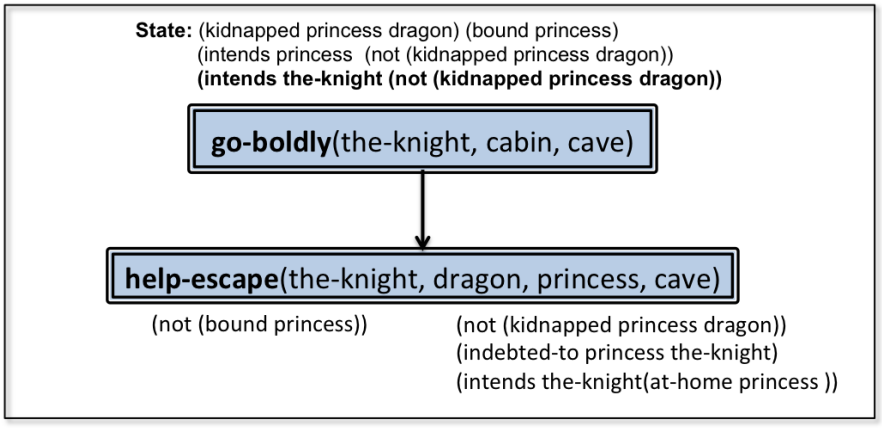

Figure 5.10: Sample Scenario - Intention Frame Generated by The Micro-Planner. In this figure, the rectangular boxes indicate steps in an intention frame. Time flows roughly vertically downward. Arcs from one step to another indicate a causal link between the source step's effects and the destination step's preconditions. Two (2) distinct intention frames for the goal `(not (kidnapped princess dragon))` are shown, out of several that the MP generates an evaluates.

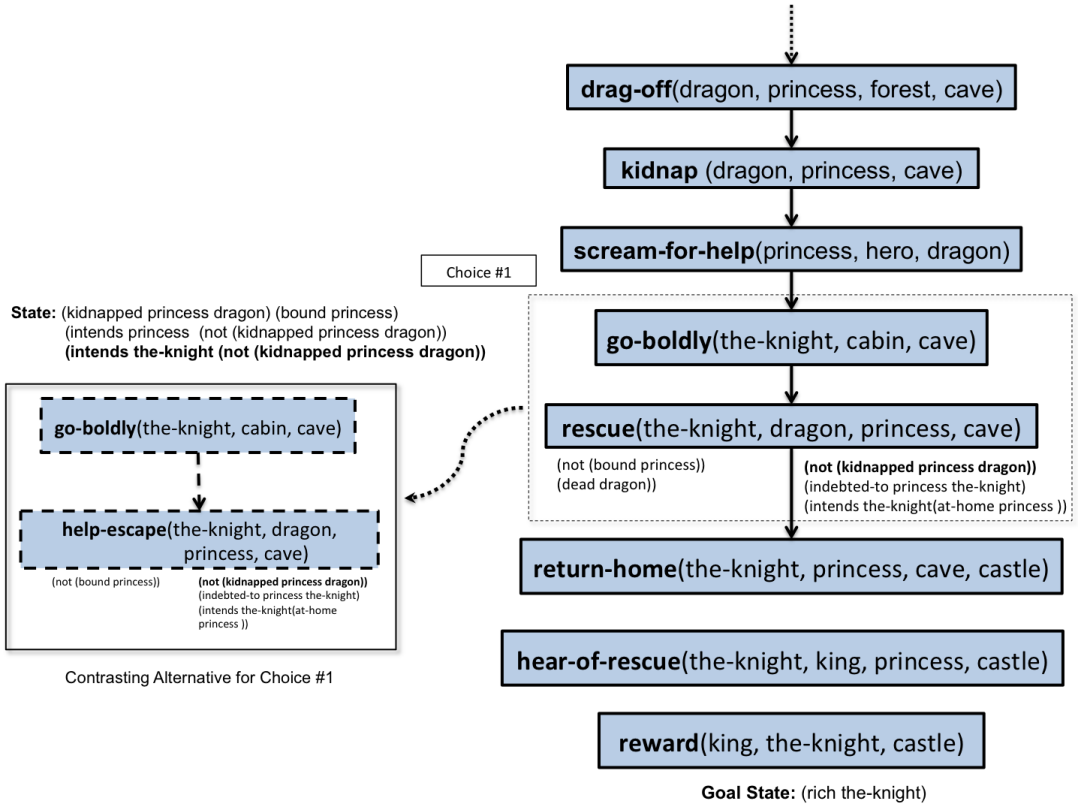

Figure 5.11: Complete Story Plan with Choice and Contrasting Alternative. In this figure, steps drawn with dashed lines indicate a contrasting alternative that is stored as part of the planner's bookkeeping but that is not used to construct the plan. Steps in this option are flagged as being linked of a choice, which makes it possible to use them during discourse generation to help convey the existence of such choice. A box with a double border indicates a step that results from a choice. A dotted line indicates a link between a choice and its contrasting alternative.

Chapter 6

Evaluation

Overview

This section contains the description, analysis, and discussion of three experimental studies. The purpose of these studies was primarily to obtain data used to evaluate the narrative generation mechanism described earlier in this document. The first experiment was mainly exploratory and focused on evaluating the foundation of my thesis. Results from the second experiment tested a more mature and robust version of our model and were used to inform the final version of the algorithms used in the implementation of the *Mask* system. The last experiment evaluated the completed system to test the performance of the model in an actual implementation.

The statistical analysis described in the following sections was completed using *R* version 3.2.3 for MacOS [60].

6.1 Initial Evaluation of the Choice-Based Approach

In this section, I report on the results of a study that was conducted during the Fall semester of 2014. The purpose of this study was to obtain preliminary data to evaluate the following hypothesis: **an audience that experiences a story constructed by a narrative generation system where characters perform a specific action sequence out of a set of contrasting alternatives will make a judgment of the character's personality that is consistent with the personality trait that the choice selected by the system is intended to portray**. Participants were asked to read two short stories designed following the mechanism in the CB-POCL algorithm [8], which is an earlier version of the algorithm described in this paper. All data was collected anonymously, using a web browser and the *Qualtrics* software [59]. Here I provide an overview of the experimental design, describe and analyze the results, and discuss the findings.

6.1.1 Experiment Design

Each experiment iteration consisted of two stories read by the same participant. Participants were randomly assigned to one of six possible groups as shown in tables 6.2 and 6.3. The order of the columns in each table indicates the order in which stories were presented to the participant. The purpose of using this distribution was to prevent learning effects caused by the order in which stories were read.

Participants in the experimental condition were presented with two stories. The first story included actions where the main character behaves in a manner that is consistent with an agreeable personality, as computed by the CB-POCL algorithm. The second story included actions where the main character behaves in a manner that is not consistent with an agreeable personality. The control group was presented with two stories where the behavior of the character is designed to be neutral. Table 6.1 lists all the versions that were used. The complete text of the stories is included in Appendix A.

Significant portions of the story content were the same in all versions of each story. Specific portions were different based on the personality factor that was being portrayed. The stories used were based on *The Hobbit: Chapter 5 - Riddles in The Dark* [78] and *The Adventures of Tom Sawyer: Chapter 20* [79]. The names of characters, places, and other story content were drastically modified to prevent the introduction of bias due to prior knowledge of the story content.

Participants

A total of 91 participants for the study were students recruited from NC State University. Only participants who completed the experiment in its entirety are included in the results. Additionally, I discarded any data from participants who took longer than 100 minutes to complete the experiment; there were very few of these outliers.

Table 6.1: Story Versions

Story ID	**Story Name**	**Personality Factor**
S1-1	Escape from The Forest - Version 1	High Agreeableness
S1-2	Escape from The Forest - Version 2	Low Agreeableness
S1-3	Escape from The Forest - Version 3	Neutral
S2-1	The Broken Clock - Version 1	High Agreeableness
S2-2	The Broken Clock - Version 2	Low Agreeableness
S2-3	The Broken Clock - Version 3	Neutral

Table 6.2: Participants Who Read Story #1 First

Random Assignment of Participants to:	First Story			Second Story		
	High Agreeableness (S1-1)	Low Agreeableness (S1-2)	Neutral (S1-3)	High Agreeableness (S2-1)	Low Agreeableness (S2-2)	Neutral (S2-3)
Experimental Group 1-A	X				X	
Experimental Group 2-A		X		X		
Control Group A			X			X

Table 6.3: Participants Who Read Story #2 First

Random Assignment of Participants to:	Second Story			First Story		
	High Agreeableness (S2-1)	Low Agreeableness (S2-2)	Neutral (S2-3)	High Agreeableness (S1-1)	Low Agreeableness (S1-2)	Neutral (S1-3)
Experimental Group 1-B	X				X	
Experimental Group 2-B		X		X		
Control Group B			X			X

6.1.2 Results and Statistical Analysis

Participants completed an initial demographic information survey, followed by an additional survey after reading each story. The story survey focused on collecting information regarding the participants' perception of the main character's personality in the story they had just experienced. The survey used close-ended questions where a participant must choose an answer from a Likert scale to allow the collection of discrete data on the personality judgment. The survey questions were from the Big Five Inventory (BFI) instrument [33, 34]. Post-processing of the data was done following the instructions provided by the instrument's authors. The post-processed results of the survey provided a score of the story protagonist's personality factors. Even though the raw experiment data was discrete, the score data was a continuous value between 1 and 5.

Figure 6.1 shows a boxplot of the scores for the Agreeableness trait broken down by story version. Note that results for the first story show a slight tendency toward a higher agreeableness score whereas this is not the case for the second story. Figure 6.2 shows a boxplot of the scores for the Conscientiousness trait broken down by story version. Note that results for the first story show a tendency toward a higher conscientiousness score whereas this is not the case for the second story; however, it is important to note that conscientiousness was not a trait that

either one of the stories was specifically designed to portray. Figure 6.3 shows a boxplot of the scores for the Extraversion trait broken down by story version.

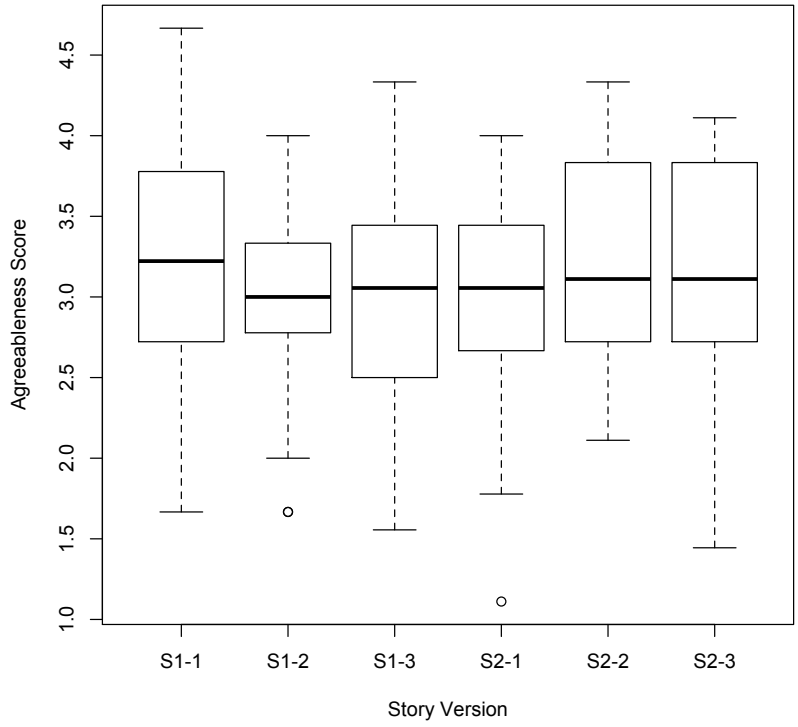

Figure 6.1: Agreeableness Scores Grouped by Story Version

Figure 6.4 shows a box plot for the agreeableness scores of the combined dataset from Story #1 and Story #2. In this figure, the data is grouped by the personality factor that the story is designed to portray. Consequently, we have three groups based on the personality factor that corresponds to each version of the story that was used in the experiment: high-agreeableness for S1-1 and S2-1, low-agreeableness for S1-2 and S2-2, and neutral for S1-3 and S2-3. Note that the quartiles for the versions of stories with the same personality factor do not show a clear tendency toward the agreeableness polarity that the corresponding story version was designed to portray. Nonetheless, there appears to be some difference in the distribution of the personality scores reported for the high-agreeableness version of the stories (S1-1 and S2-1) when compared with those for the low agreeableness versions of the stories (S2-1 and S2-2).

Figure 6.5 shows a box plot for the conscientiousness scores of the combined dataset from

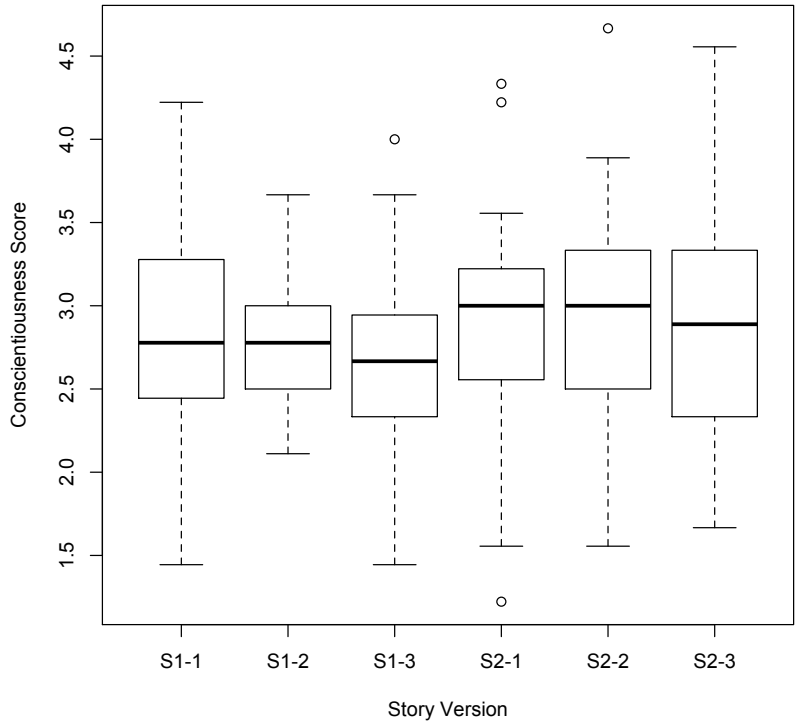

Figure 6.2: Conscientiousness Scores Grouped by Story Version

Story #1 and Story #2. In this figure, the data is grouped by the personality factor that the story is designed to portray. Consequently, we have three groups based on the personality factor that corresponds to each version of the story that was used in the experiment: high-conscientiousness for S1-1 and S2-1, low-conscientiousness for S1-2 and S2-2, and neutral for S1-3 and S2-3. Note that the quartiles for the versions of stories with the same personality factor do not appear to show any difference in the distribution of the data. Additionally, there appears to be no difference among the box blots for the three versions of the stories either. Intuitively, these results indicate that there is no correlation between the version of the story read and the personality scores reported by the audience.

After the exploratory data analysis, I applied an Analysis of Variance (ANOVA) statistical test on the agreeableness score with respect to the story version that participants read. Results from the test are shown below. The test indicates that we cannot reject the null hypothesis that the personality score is independent from the story version read. This is the case for the three FFM factors evaluated.

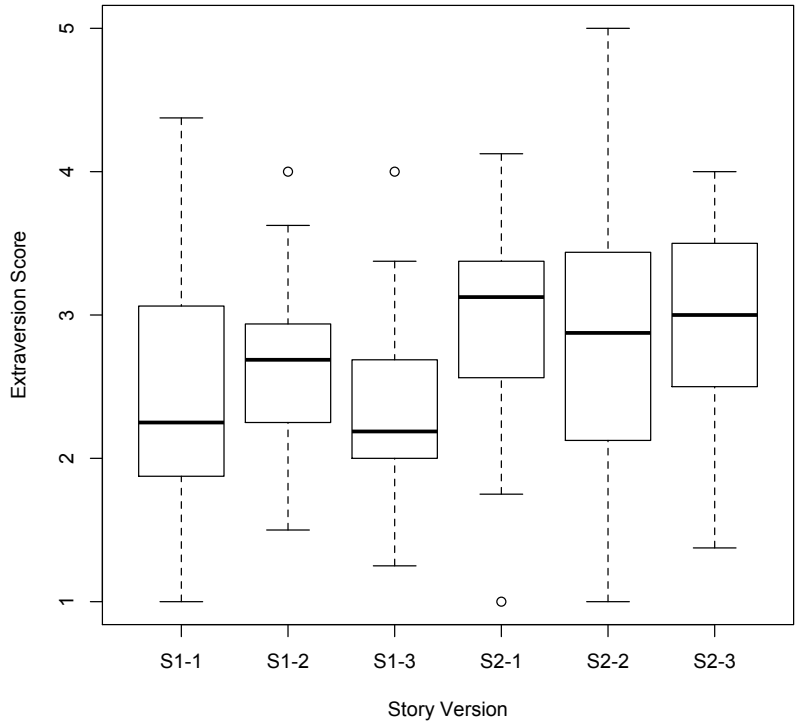

Figure 6.3: Extraversion Scores Grouped by Story Version

Agreeableness:

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Factor_Portrayed	2	0.02	0.0091	0.019	0.981
Residuals	179	84.34	0.4712		

Conscientiousness:

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Factor_Portrayed	2	0.14	0.0686	0.185	0.831
Residuals	179	66.34	0.3706		

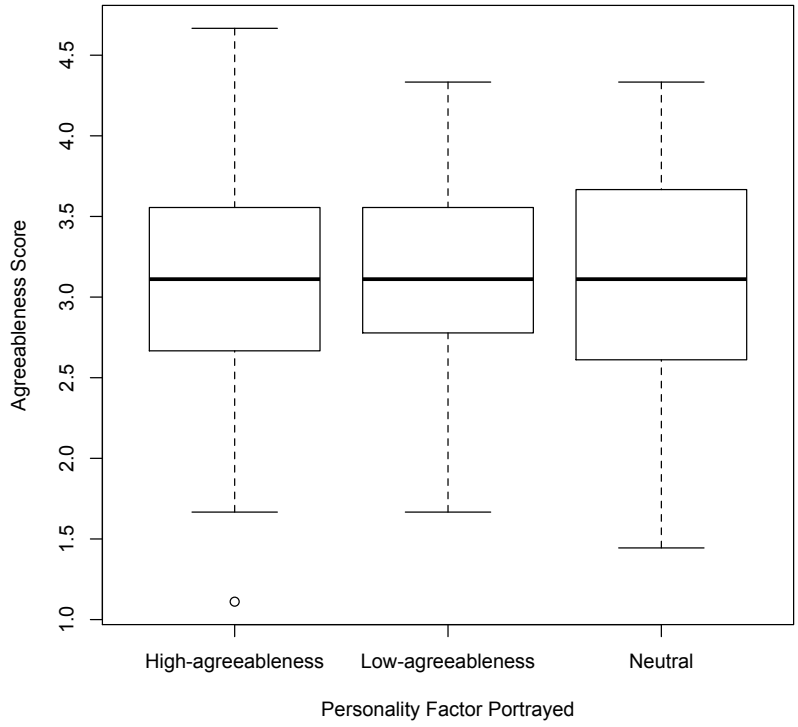

Figure 6.4: Agreeableness Scores for the Combined Dataset (Story #1 and #2)

Extraversion:

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Factor_Portrayed	2	0.38	0.1876	0.312	0.732
Residuals	179	107.52	0.6007		

I also analyzed the data from the first story that participants read, separately from the data from the second story. Even though the experiment was designed to account for learning effects from reading the story, it is possible that being exposed to the questionnaire after reading the first story and before reading the second one may have biased the responses collected during the second part of the iteration. The ANOVA results for this part of the analysis are shown below, note that for the first part of the iteration, the results are statistically significant in favor of rejecting the null hypothesis for the agreeableness and extraversion factors. For the second part of the iteration the results are only significant for the extraversion factor.

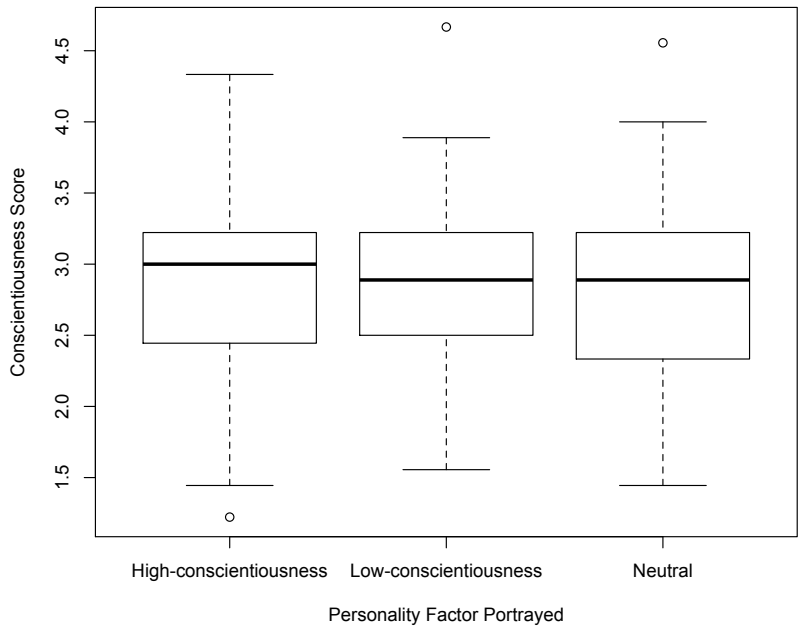

Figure 6.5: Conscientiousness Scores for the Combined Dataset (Story #1 and #2)

Agreeableness - First Story Only:

```
              Df    Sum Sq   Mean Sq   F value      Pr(>F)
Story ID       5     8.346    1.6693     7.376    8.73e-06 ***
Residuals     85    19.235    0.2263
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Agreeableness - Second Story Only:

```
              Df    Sum Sq   Mean Sq   F value     Pr(>F)
Story ID       5     3.153    0.6307     1.767      0.128
Residuals     85    30.333    0.3569
```

Conscientiousness - First Story Only:

```
              Df    Sum Sq   Mean Sq   F value     Pr(>F)
Story ID       5     2.157    0.4314     1.775      0.127
Residuals     85    20.659    0.2430
```

Conscientiousness - Second Story Only:

```
              Df    Sum Sq   Mean Sq   F value     Pr(>F)
Story ID       5      0.38    0.0760     0.198      0.963
Residuals     85     32.65    0.3841
```

Extraversion - First Story Only:

```
              Df    Sum Sq   Mean Sq   F value     Pr(>F)
Story ID       5      7.35    1.4704     3.756    0.00403 **
Residuals     85      33.28    0.3915
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Extraversion - Second Story Only:

```
              Df    Sum Sq   Mean Sq   F value     Pr(>F)
Story ID       5     6.415    1.2830     3.581    0.00549 **
Residuals     85    30.457    0.3583
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

6.1.3 Discussion

The only personality factor with scores that are statistically significant in favor of rejecting the null hypothesis is the **extraversion** factor. The results of the Analysis of Variance (ANOVA) test do not provide enough evidence to support rejecting the null hypothesis in the case of the **agreeableness** or the **conscientiousness** factor.

Analyzing the personality scores from the first story read by participants (S1-1, S1-2, S1-3) separately from those of the second story yielded results that were slightly closer to what I expected. These stories were slightly more successful at portraying a character with an agreeable

personality. However, only the ANOVA test in the case of the first story read indicated a result that would support rejecting the null hypothesis.

In summary, the results of the experiment do not provide enough evidence to support the hypothesis that the stories presented to the participants elicited a personality score indicative of the personality that the story attempted to portray. Nevertheless, there were some indications that different versions of the story affected the perceived *agreeableness* of the character, but these were not statistically significant to be able to make any claims in this respect. Finally, it is important to note that the results indicate that different stories do in fact produce different perceived personality scores, as was the case with *extraversion*.

Addressing the Challenges

The data obtained from this experiment clearly indicated that my approach required revision to be successful. One of the key observations that could be made from the results of the experiment was that the existence of an alternate course of action on its own does not guarantee that such course of action will be discerned by an audience. In other words, a character may have multiple viable options to accomplish a goal, but that does not mean that those reading the story know what these options are or that they even exist. The stories used in the experiment did not appear to have effectively conveyed to the reader the existence of multiple alternate choices for action that were available to the characters, or they did not do so clearly enough. I posit from this observation that not only the effective communication of the existence of choices but also the clear description of their contents is essential to portray the character's behavior that the model is designed to generate. The lack of clear and correctly targeted discourse could have been responsible for the lack of detection of alternatives, which could then have diminished the effect that I was measuring. Consequently, ensuring that the existence of available options and the content of such options are clearly communicated was an important challenge that I needed to address.

My approach to address the effective communication of choices for action is twofold. First, the narrative generation mechanism must keep detailed information about the alternate courses of action that characters could have followed in pursuit of a specific goal. Second, when stories are presented to the audience, a discourse manager must be used to ensure that the contents of alternate courses of action are displayed in addition to the course of action that the character pursues in the end. Even though generation of discourse and discourse management are not the focus of my research, it is necessary to take into account that the effective presentation of a story can be affected by its discourse [15]. However, it is important to consider that the data structures and bookkeeping that my narrative generation mechanism provides is what makes the discourse feasible. It is not possible to produce discourse without an underlying story structure.

I have addressed the element of discourse at a sufficient yet minimum level of detail. My goal has been to ensure that the stories that the *Mask* system generates are effectively presented without biasing the audience through the use of discourse techniques. The discourse elements applied have been limited to a text-based medium and focused on the enumeration of options available during a character's deliberation process. These are a simplified operationalization of commonly used narrative composition techniques such as *internal monologue* and *stream of consciousness* [57, 15].

I validated the soundness of the approach described above as part of a formative study in which a discourse mechanism was incorporated into the narrative generation process. The results and lessons learned from this experiment informed the final design of my model and the implementation of the *Mask* narrative generation system. A detailed report on the design of the formative experiment and on the analysis of the data collected are provided in Section 6.2, below.

6.2 Evaluating the Perception of Personality Traits in Planning-Based Narrative Generation

In this section, I report on the results of a follow up study. This study was conducted after the findings from the preliminary evaluation were addressed and important components of the narrative generation mechanism were modified as a result. The purpose of this study was to collect formative data for the design of a choice-based computational model of character personality. The study focused on the use of character intentions and their effect on the affective response of other characters, to generate narratives that elicit the perception of distinguishable character personality traits in the audience that experiences such narrative.

6.2.1 Study Objective and Thesis

The study was designed to evaluate the basic principles that provide the foundation for the design of the Mask narrative generation system described earlier in this document (See Chapter 4). Data collected from the study aimed at testing the validity of a computational model of character behavior that is informed by psychological research. The model is used in the implementation of a narrative generation mechanism in which characters are portrayed making choices for action and action sequences in accordance with a personality factor that has been assigned to them. In this study, I focused on the Agreeableness factor as defined by Goldberg in the Big Five Factor Model [26].

Thesis Evaluated

The main objective of the study was to evaluate the following thesis: **An audience presented with a set of alternate action sequences generated for a story character by the *Mask* planning-based narrative generation system will select personality trait ratings that have significant correlation with the choices made by such character**. Additionally, the experiment was also designed to test whether an audience can recognize when a character's behavior throughout a story is inconsistent with her assigned personality factor. Data collected from this study was used to fine-tune the design of the narrative generation algorithm and to inform the development of the Mask narrative generation system. Results from this study were used not only to validate core components of the narrative generation algorithm, but also to guide important details of the narrative generation mechanism's design and its implementation into the Mask system.

Use of Discourse

Another objective of this study was to evaluate the effect of using discourse elements in the presentation of a character's choices for action. One of the key findings from the preliminary evaluation was that audiences did not perceive character personality traits that matched those that the stories they experienced intended to portray. Some changes were made to the protocol, but more importantly, I changed how the story content was presented to the readers. The purpose of this was to address the possibility that audiences may not have perceived the existence of multiple contrasting choices even though these were present in the story text. I posit that this was in fact the reason why the null hypothesis that the personality score is independent from the story version read could not be rejected based on the data that was collected. Initially, my intent was to focus on story events and not deal with discourse. I reevaluated this idea in favor of a mechanism that took into account the eventual generation of story discourse, although this is still not the focus of this research.

6.2.2 Experiment Design

Each experiment iteration consisted of three stories read by the same participant. Participants were randomly assigned to one of six possible groups as shown in tables 6.5 and 6.6. The order of the columns in each table indicates the order in which stories were presented to the participant. I used this distribution to prevent learning effects caused by the order in which stories were read.

Participants in the experimental condition were presented with three stories, listed in Table 6.4. The first story includes actions where the main character behaves in a manner that is consistent with an agreeable personality. The second story includes actions where the main

Table 6.4: Story Versions - Formative Study

Story ID	**Story Name**	**Personality Factor**
S1-1	Escape from The Forest - Version 1	Treatment - High Agreeableness
S1-2	Escape from The Forest - Version 2	Treatment - Low Agreeableness
S1-3	Escape from The Forest - Version 3	Control - Neutral
S2-1	The Broken Clock - Version 1	Treatment - High Agreeableness
S2-2	The Broken Clock - Version 2	Treatment - Low Agreeableness
S2-3	The Broken Clock - Version 3	Control - Neutral
S3-1	Lenny - Version 1	Treatment - Inconsistent Choice
S3-2	Lenny - Version 2	Control - Consistent Choice

Table 6.5: Participants Who Read Story #1 First - Formative Study

Random Assignment of Participants	First Story			Second Story			Third Story	
	High Agreeableness (S1-1)	Low Agreeableness (S1-2)	Neutral (S1-3)	High Agreeableness (S2-1)	Low Agreeableness (S2-2)	Neutral (S2-3)	Inconsistent Behavior (S3-1)	Consistent Behavior (S3-2)
Experimental Group 1-A	X				X		X	
Experimental Group 2-A		X		X			X	
Control Group A			X			X		X

character behaves in a manner that is not consistent with an agreeable personality. The third story includes actions where the main character behaves in in a manner that is not consistent with an agreeable personality, except for the last action in the story. The last action is designed to be inconsistent with the character's non-agreeable personality, i.e., it demonstrates traits from an agreeable personality.

Participants in the control group were presented with two stories where the behavior of the character is designed to be neutral. These were followed by a version of the third story where the character's last action is consistent with the character's non-agreeable personality, i.e., it demonstrates traits from an agreeable personality.

The stories used were based on *The Hobbit: Chapter 5 - Riddles in The Dark* [78], *The Adventures of Tom Sawyer: Chapter 20* [79], and , and *The Life of Lazarillo of Tormes; his fortunes and misfortunes as told by himself, Chapter 1* [2]. The names of characters, places, and other story content were drastically modified to prevent the introduction of bias due to prior knowledge of the story content. Significant portions of the story content were the same in all versions of each story. Specific portions toward the end of each story were customized depending on the personality factor that was being portrayed. The complete text of the stories that were used in this study is included in Appendix A.

Table 6.6: Participants Who Read Story #2 First - Formative Study

Random Assignment of Participants	Second Story			First Story			Third Story	
	High Agreeableness (S2-1)	Low Agreeableness (S2-2)	Neutral (S2-3)	High Agreeableness (S1-1)	Low Agreeableness (S1-2)	Neutral (S1-3)	Inconsistent Behavior (S3-1)	Consistent Behavior (S3-2)
Experimental Group 1-B	X				X		X	
Experimental Group 2-B		X		X			X	
Control Group B			X			X		X

Participants

The study included a total of 137 participants, who were students recruited from North Carolina State University. Only participants who completed the experiment in its entirety are included in the results. All of the participants were eighteen (18) years of age, or older. The average participant age was 21 years old.

Platform and Deployment

The platform chosen for the study was *Qualtrics* [59], which was used both for the presentation of the narrative content and for the collection of data. All data was collected anonymously, on-line, using a web browser. Participants used any web browser capable of displaying content formatted by the Qualtrics software. The experiment was not conducted in a controlled environment, hence factors such as computer speed, noise levels, and workstation comfort may have been different for each participant; however, this was not expected to have introduced any significant bias.

6.2.3 Results and Statistical Analysis

Participants completed an initial demographic information survey, followed by an additional survey after reading each story. The story survey focused on collecting information regarding the participants' perception of the main character's personality in the story they had just experienced. The survey used close-ended questions where a participant must choose an answer from a Likert scale to allow the collection of discrete data on the personality judgment. The survey questions were from the Big Five Inventory (BFI) instrument [33, 10, 34] developed at the Berkeley Personality Lab. Post-processing of the data was done following the instructions provided by the instrument's authors. The post-processed results of the survey provided a score of the story protagonist's personality factors. Even though the raw experiment data was discrete, the score data was a continuous value between 1 and 5. A copy of the BFI materials is included in Appendix A.

Exploratory Data Analysis

Figure 6.6 shows a box plot of the scores for the Agreeableness trait for the first story (S1), broken down by story version. Note that results for the first story version (S1-1) show a clear tendency toward a higher agreeableness score, whereas the scores for the second story version (S1-2) show an opposing tendency. Furthermore, the scores for the neutral version of the story (S1-3) are very close to the center of the scale, as was expected.

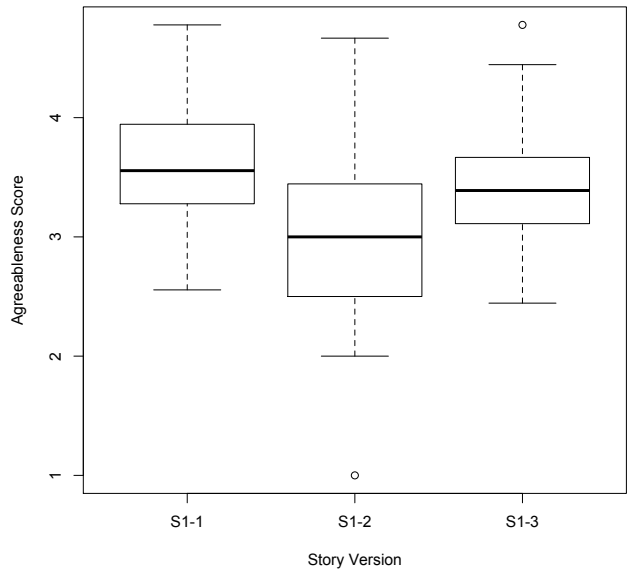

Figure 6.6: Agreeableness Scores Grouped by Story Version - Story #1 in The Formative Study

Figure 6.7 shows a box plot of the scores for the Agreeableness trait for the second story (S2), broken down by story version. Note that results for the first story version (S2-1) show a tendency toward a higher agreeableness score, whereas the scores for the second story version (S2-2) show an opposing tendency. Furthermore, the scores for the neutral version of the story (S2-3) are close to the center of the scale, as was expected.

Figure 6.8 shows a box plot for the agreeableness scores of the combined dataset from Story #1 and Story #2. In this figure, the data is grouped by the personality factor that the story is designed to portray. Consequently, we have three groups based on the personality factor that corresponds to each version of the story that was used in the experiment: high-agreeableness for S1-1 and S2-1, low-agreeableness for S1-2 and S2-2, and neutral for S1-3 and S2-3. Note that

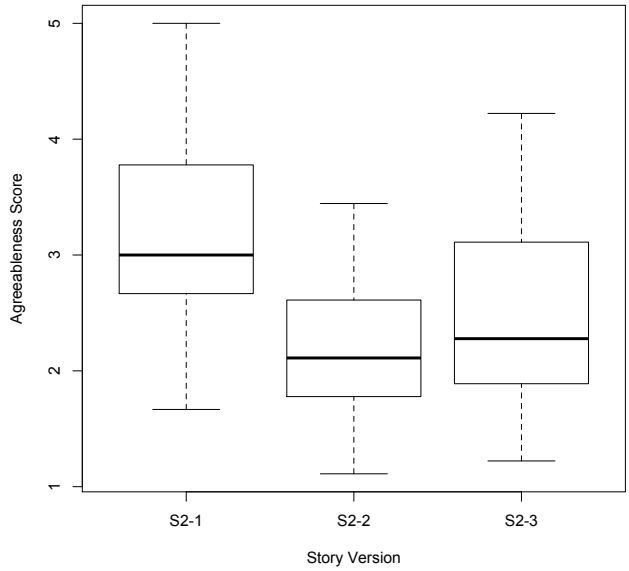

Figure 6.7: Agreeableness Scores Grouped by Story Version - Story #2 in The Formative Study

the quartiles for the versions of stories with the same personality factor show a clear tendency toward the agreeableness polarity that the corresponding story version was designed to portray.

Even though conscientiousness was not a trait that either one of the stories (S1 or S2) was specifically designed to portray, the BFI instrument that was used enabled the measurement of the audience's perception of this factor. Figures 6.9 and 6.10 show box plots of the scores for the conscientiousness factor, grouped by story and broken down by story version. The box plot for the first story (S1) shows similar tendencies as those seen for the agreeableness trait (see Figure 6.6). The box plot for the second story (S2) shows similar tendencies as those seen for the agreeableness factor (see Figure 6.7); however, these are not as strong. This is particularly noticeable when examining the relationship of the distribution for S2-1 versus that for S2-2. It is of relevance to this discussion to note that the main character of the second story (on whose actions the personality perception is evaluated) is modeled on Tom Sawyer, a story character who is benign but who would not intuitively be described as being very conscientious.

Statistical Analysis

I analyzed the results of the experiment applying an Analysis of Variance (ANOVA) statistical test on the agreeableness score with respect to the story version that participants read. Results from the test are shown below. Note that the test indicates statistical significance such that the

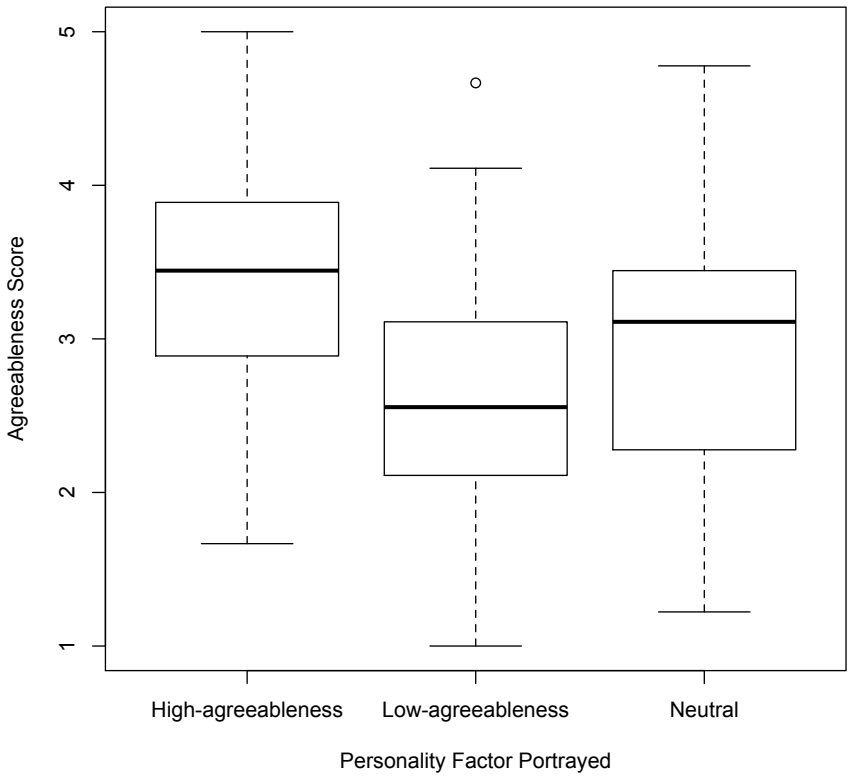

Figure 6.8: Agreeableness Scores for the Combined Dataset (Story #1 and #2) in The Formative Study

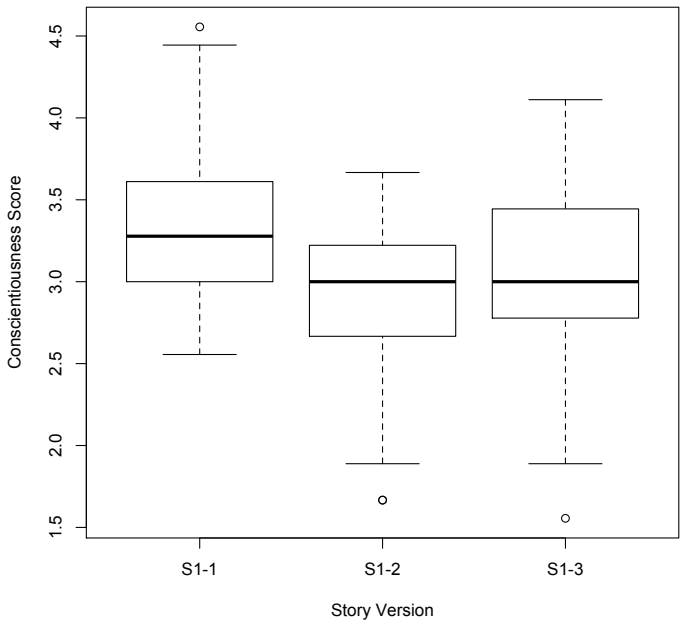

Figure 6.9: Conscientiousness Scores Grouped by Story Version - Story #1

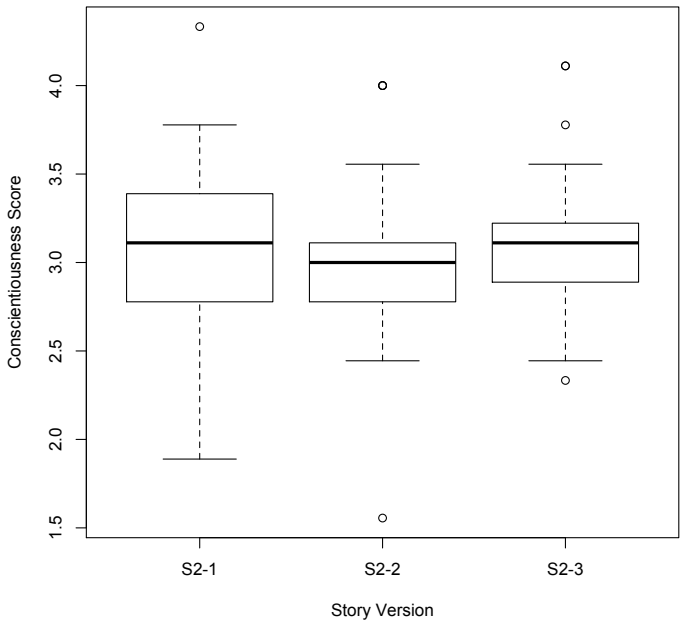

Figure 6.10: Conscientiousness Scores Grouped by Story Version - Story #2

null hypothesis can be rejected in the case of the agreeableness personality factor.

Agreeableness - First Story (S1):

```
             Df Sum Sq Mean Sq   F value   Pr(>F)
Story_ID      2   9.12   4.562   14.86     1.48e-06 ***
Residuals   134  41.13   0.307
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1
```

Agreeableness - Second Story (S2):

```
             Df Sum Sq Mean Sq   F value   Pr(>F)
Story_ID      2  20.31  10.153   21.03     1.14e-08 ***
Residuals   134  64.71   0.483
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1
```

Agreeableness - Combined Dataset (S1 and S2):

```
                  Df   Sum Sq   Mean Sq   F value     Pr(>F)
Factor_Portrayed   2    24.41    12.203     22.29   1.09e-09 ***
Residuals        271   148.34     0.547
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1
```

In the case of the conscientiousness personality factor, the data only enables us to reject the null hypothesis in the case of the first story (S1). However, it is important to note that the stories were not specifically designed to portray traits consistent with conscientious behavior. Nevertheless, because the BFI instrument allows the measurement of this factor, we show the results here for comparison purposes. Additionally, note that the results show correlation between the version of the story that was read and the personality score measured, which was true in the case of the first story (S1) and also in the case of the combined dataset. These results further support our hypothesis that audiences who are presented with a set of alternate action sequences for a story character will select personality trait ratings that have significant

correlation with the choices made by such character.

Conscientiousness - First Story (S1):

```
             Df Sum Sq Mean Sq   F value   Pr(>F)
Story_ID      2  3.171  1.5854   7.1       0.00117 **
Residuals   134 29.922  0.2233
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1
```

Conscientiousness - Second Story (S2):

```
             Df Sum Sq Mean Sq   F value   Pr(>F)
Story_ID      2  0.326  0.1630   0.866     0.423
Residuals   134 25.228  0.1883
```

Conscientiousness - Combined Dataset (S1 and S2):

```
                    Df   Sum Sq   Mean Sq    F value    Pr(>F)
Factor_Portrayed     2     2.20    1.1007      5.281   0.00562 **
Residuals          271    56.48    0.2084
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1
```

Measuring the Consistency of Character Behavior

The third story that was presented to the study participants was designed to evaluate whether they could perceive the existence of inconsistent character behavior. In this story, the main character performs several actions that are typical of a low-agreeableness personality factor. Toward the end of the control version of the story (S3-2), the character's final action is consistent with his personality factor, i.e., he behaves according to the personality traits typical of low-agreeableness. In the treatment version of the story (S3-1), the character's final action is not consistent with his personality factor. The action he performs is an example of altruism, which is a trait typical of a high-agreeableness personality factor and hence in contrast with the personality portrayed by the character up to that point in the story.

Table 6.7 shows the distribution of participants' responses, grouped by story version. The percentage of responses from participants within each group who reported inconsistent behavior clearly indicates that such behavior was perceivable by the audience. This further supports our thesis, by strengthening the argument that audiences are able to detect contrast between different character actions when such contrast exists. The stacked bar graph in Figure 6.11 shows the same distribution, enabling a side by side comparison of the inconsistent behavior that was reported for each story.

Table 6.7: Behavior Consistency Perception by Story Version - Formative Study

	Inconsistent Behavior Perceived		
Story ID	**Yes**	**No**	**Percentage of Participants in Group**
S3-1	79	12	87% perceived inconsistent behavior
S3-2	8	38	17% perceived inconsistent behavior

Personality Measurement

In addition to the consistency data, participants also completed a personality evaluation of the main character in the third story (S3). This evaluation was conducted using the BFI instrument described earlier in this document. Figure 6.12 shows the distribution of the personality scores, grouped by story version.

Because both versions of the story were designed to portray the main character as having a low-agreeableness personality factor, we expected scores to be in the 1.0 to 3.0 range. The average personality score for the Agreeableness factor of this character was **2.28** for the treatment version of the story, whereas the average was **1.86** for the control version. Both scores are indicative of a low-agreeableness personality factor. This is precisely what the story was designed to portray. Also, note that the score is significantly higher (23%) for the version of the story where the character performed one action that was consistent with a high-agreeableness factor.

6.2.4 Discussion

Analysis of the data collected from this study indicates that the personality scores for the **agreeableness** factor and their relationship with the story read by the participant are statistically significant in favor of rejecting the null hypothesis. The results of the ANOVA test provide enough evidence to support this conclusion. Additionally, an analysis of the agreeableness scores for each story, independently from each other, yielded results that disprove the existence of an

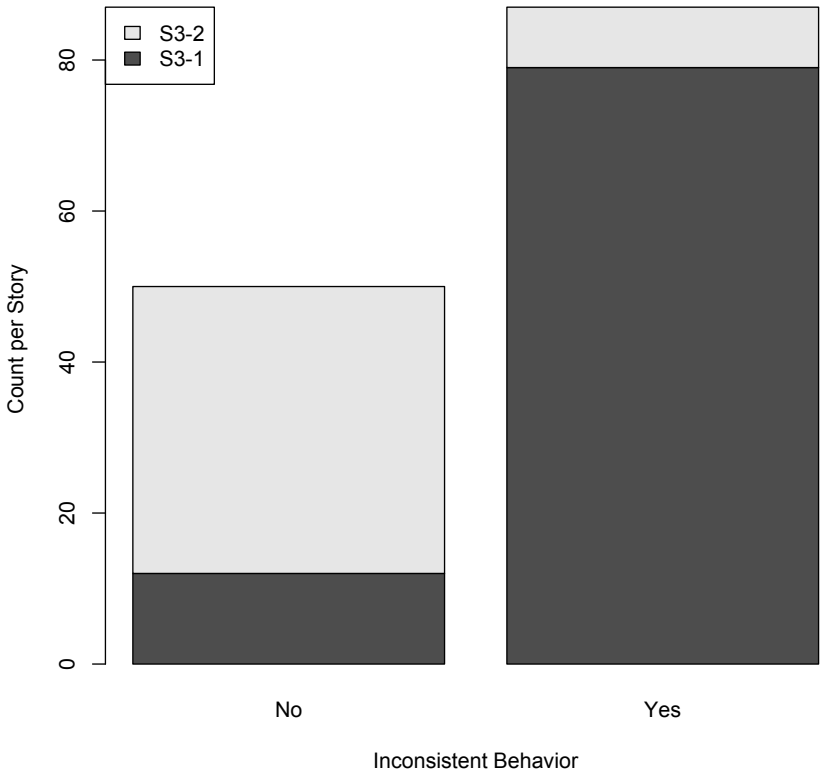

Figure 6.11: Behavior Consistency Perception by Story Version - Formative Study

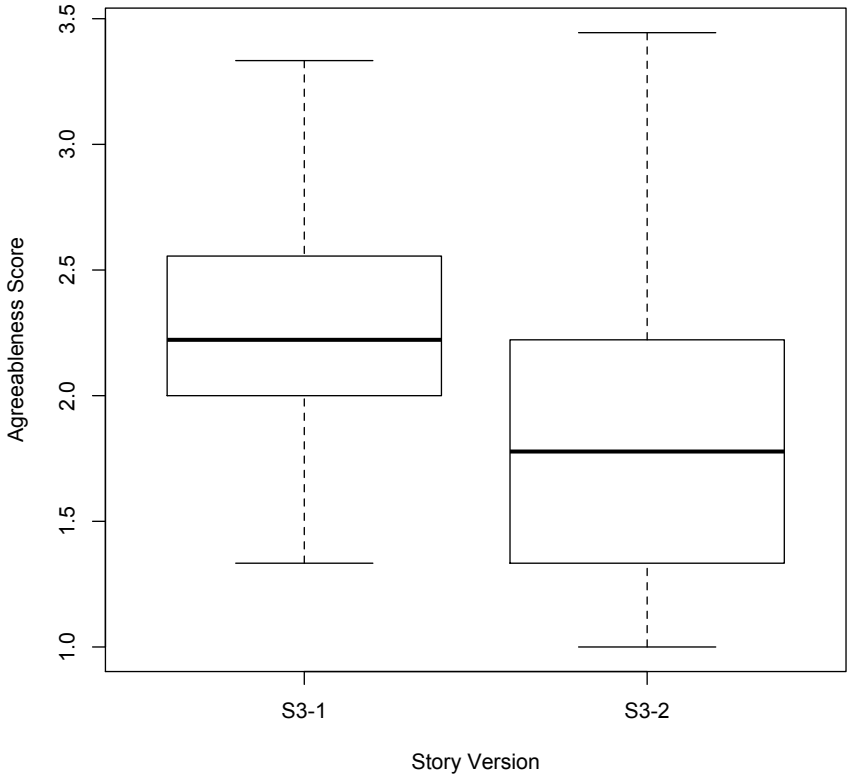

Figure 6.12: Agreeableness Scores Grouped by Story Version - Story #3

imbalance between the results for each story. Each story had the expected effect on the audience when considered on its own and when considered within the context of both stories read.

Further evidence that different versions of the story affected the perceived *agreeableness* of the character's personality was found in the personality scores for the *conscientiousness* factor. Although the stories were not designed to portray behavior consistent with a highly conscientious personality, the ANOVA test indicated correlation between the version of the story read and the personality score for this factor. It is important to note that this effect was only observed in the case of the first story and when considering the combined scores (S1 and S2).

Finally, data from this study also provides evidence that audiences are able to perceive contrast in a character's actions when such contrast is present. This was observed in the distribution of responses from participants who indicated the existence of an action that was indicative of inconsistent character behavior.

Summary

In summary, the results of the experiment provide enough evidence to support our hypothesis that *an audience presented with a set of alternate action sequences for a story character will select personality trait ratings that have significant correlation with the choices made by such character*. This hypothesis provides the foundation for the design of the narrative generation mechanism presented in this document.

The data obtained from this experiment clearly indicates that the narrative generation approach used in the Mask system has the potential to be successful. This is particularly true in the portrayal of the agreeableness personality factor, which lends itself well to the representation of good (high-agreeableness) vs. evil (low-agreeableness) characters in storytelling [45].

6.2.5 Evaluation of the Mask System

In this section, I report on the results of a formal evaluation of the *Mask* narrative generation system. In this evaluation, stories were automatically generated by the planning-based algorithm and translated into natural language using the *SimpleNLG* natural language realizer. These stories were then presented to a human audience, following the same protocol utilized for the formative study described in the previous section (see Section 6.2).

Data collected from the study aimed at testing the validity of the computational model used in the implementation of *Mask* to generate stories in which specific actions and action sequences are selected to portray character personality traits. The model, which is described earlier in this document, is designed to promote character actions that portray them as making choices for action and action sequences that are consistent with a pre-assigned personality factor. In

this study, I focused on the Agreeableness factor as defined by Goldberg in the Big Five Factor Model [26]. Even though it could be argued that Mask provides a framework for the portrayal of a diverse set of personality traits, the results that will be discussed below focus on the successful portrayal of behavior that is associated with agreeableness. The implementation and evaluation of behavior typical of other other factors will be the subject of future work.

The main objective of the study was to evaluate the following thesis: **An audience presented with a set of alternate action sequences generated for a story character by the *Mask* planning-based narrative generation system will select personality trait ratings that have significant correlation with the choices made by such character**. Additionally, the experiment was also designed to test whether an audience can recognize when a character's behavior over the course of a story is inconsistent with her assigned personality factor. In contrast with the two experiments described earlier in this chapter, where the stories used were hand-crafted, this evaluation was conducted using stories generated by the Mask narrative generation system.

Experimental Design

In order to determine whether readers are able to make inferences about the personality traits of characters by observing them make choices corresponding to those we describe in Section 4.3, I conducted a study where participants read a series of computer-generated short stories designed to include events where the main character is faced with having to choose a specific course of action from a set of applicable alternatives. These stories are presented in natural language (English); however, they are representative of a plan-based story structure such as the ones described in Section 5.12. The chosen action and its alternatives were devised to contrast with each other, ensuring the portrayal of behavior that was either typical of the agreeableness personality factor or its opposite. The mechanism used to generate the natural language representation of the stories is one of the components implemented as part of the Mask system. This mechanism uses a simple discourse manager that is built on top of the *SimpleNLG* natural language Java API [24].

Subjects were assigned in a round-robin manner into one of six groups. Each participant read three stories, but the ordering of the stories was counterbalanced across the six groups to control for potential learning effects. Three of the groups, called the experimental condition groups, read three stories characterized as follows: a) a story that includes actions where the main character makes choices to act in a manner that is consistent with an agreeable personality, b) a story that includes actions where the main character makes choices to act in a manner that is not consistent with an agreeable personality, and c) a story that includes actions where the main character makes choices to act in in a manner that is not consistent with an agreeable personality, except

for the last action in the story. The last action is designed to be inconsistent with the character's non-agreeable personality, i.e., it demonstrates traits from an agreeable personality. The stories used are listed in Table 6.8. Note that the first story (S1-n) was computer-generated, even though it has the same title and a similar theme as two of the stories used in the experiments described earlier. The complete text of the stories is included in Appendix A.

Table 6.8: Story Versions - Mask System Evaluation

Story ID	**Story Name**	**Personality Factor**
S1-1	Escape from The Forest - Version 1	Treatment - High Agreeableness
S1-2	Escape from The Forest - Version 2	Treatment - Low Agreeableness
S1-3	Escape from The Forest - Version 3	Control - Neutral
S2-1	The Kidnapping of The Princess - Version 1	Treatment - High Agreeableness
S2-2	The Kidnapping of The Princess - Version 2	Treatment - Low Agreeableness
S2-3	The Kidnapping of The Princess - Version 3	Control - Neutral
S3-1	Jane - Version 1	Treatment - Inconsistent Choice
S3-2	Jane - Version 2	Control - Consistent Choice

Participants in the other three groups, called the control condition groups, were presented with two stories where the choices for action of the character are designed to be neutral and a version of the story where the character's last action is consistent with the character's non-agreeable personality, i.e., it demonstrates traits from an non-agreeable personality. Participants' assignments to one of the six possible groups are shown in Tables 6.9 and 6.10. The order of the columns in each table indicates the order in which stories were presented to the participant.

Table 6.9: Participants Who Read Story #1 First - Mask System Evaluation

Random Assignment of Participants	First Story			Second Story			Third Story	
	High Agreeableness (S1-1)	Low Agreeableness (S1-2)	Neutral (S1-3)	High Agreeableness (S2-1)	Low Agreeableness (S2-2)	Neutral (S2-3)	Inconsistent Behavior (S3-1)	Consistent Behavior (S3-2)
Experimental Group 1-A	X				X		X	
Experimental Group 2-A		X		X			X	
Control Group A			X			X		X

The stories used were based on passages from *The Hobbit: Chapter 5 - Riddles in The*

Table 6.10: Participants Who Read Story #2 First - Mask System Evaluation

Random Assignment of Participants	Second Story			First Story			Third Story	
	High Agreeableness (S2-1)	Low Agreeableness (S2-2)	Neutral (S2-3)	High Agreeableness (S1-1)	Low Agreeableness (S1-2)	Neutral (S1-3)	Inconsistent Behavior (S3-1)	Consistent Behavior (S3-2)
Experimental Group 1-B	X				X		X	
Experimental Group 2-B		X		X			X	
Control Group B			X			X		X

Dark [78], *The Life of Lazarillo of Tormes; his fortunes and misfortunes as told by himself, Chapter 1* [2], and also on themes typically found in popular fairy tales. The names of characters, places, and other story content were modified to obscure the actual narrative sources in order to prevent the introduction of bias due to prior knowledge of the story content. Significant portions of the story content were the same in all versions of each story. Specific portions toward the end of each story were customized depending on the personality factor that was being portrayed. The stories all involved characters with personality traits either typical (e.g. altruism, unselfishness) or atypical (e.g. belligerent, selfish) of the agreeableness personality factor. Each of the stories required the main character to choose between one of several courses of action. There were three versions of each story, depending on the choice made by the character. In the treatment versions, the choice portrays behavior that is either typical of high agreeableness or typical of low agreeableness. The control versions eliminated the need for the character to make a choice through the intervention of a neutral third party or event.

The study included a total of 96 participants. Some of the participants were students recruited from North Carolina State University. Participants were also recruited through social media. Only participants who completed the experiment in its entirety are included in the results. A total of 35 participants started the experiment but did not finish it, none of their data is included in this report. Subjects accessed the system via a web browser and were presented with textual narratives followed by a series of questions with Likert-scale responses.

Participants completed an initial demographic information survey, then read each story, completing an additional survey before moving on to read the next story. The story survey focused on collecting information regarding the participants' perception of the main character's personality in the story they had just read. Subjects provided Likert scale responses to questions about the stories' main character that were drawn from the Big Five Inventory (BFI) instrument [33, 10, 34] developed at the Berkeley Personality Lab. Post-processing of the data was done following the instructions provided by the instrument's authors. The post-processed results of the survey provided a score of the story protagonist's personality factors. Even though the raw experiment data was discrete, the score data was a continuous value between 1 and 5.

Exploratory Data Analysis

Figure 6.13 shows a box plot of the scores for the Agreeableness factor for the first story (S1), broken down by story version. Note that results for the first story version (S1-1) show a tendency toward a higher agreeableness score, whereas the scores for the second story version (S1-2) show an clear tendency toward a low agreeableness score. Furthermore, the scores for the neutral version of the story (S1-3) are very close to the center of the scale, as was expected.

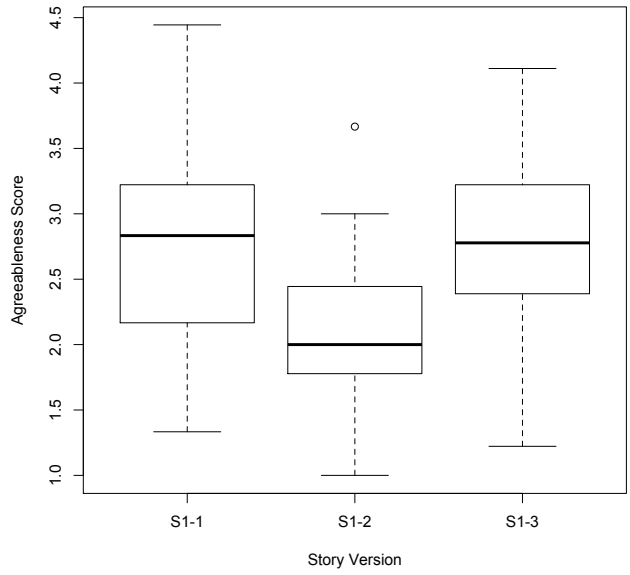

Figure 6.13: Agreeableness Scores Grouped by Story Version - Story #1 - Mask System Evaluation

Figure 6.14 shows a box plot of the scores for the Agreeableness factor for the second story (S2), broken down by story version. Note that results for the first story version (S2-1) show a clear tendency toward a higher agreeableness score, whereas the scores for the second story version (S2-2) show an opposing tendency, although the tendency is not as clear. Furthermore, the scores for the neutral version of the story (S2-3) are close to the center of the scale, as was expected.

Figure 6.15 shows a box plot for the combined dataset from Story #1 and Story #2. In this figure, the data is grouped by the personality factor that the story is designed to portray. Consequently, we have three groups based on the personality factor that corresponds to each

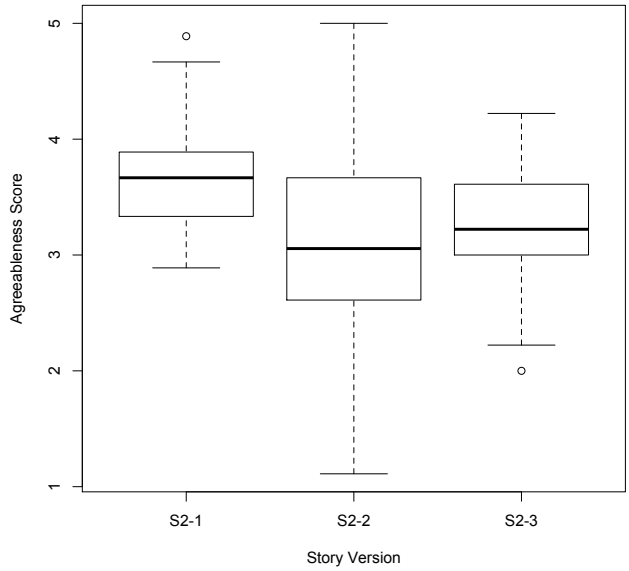

Figure 6.14: Agreeableness Scores Grouped by Story Version - Story #2 - Mask System Evaluation

version of the story that was used in the experiment: high-agreeableness for S1-1 and S2-1, low-agreeableness for S1-2 and S2-2, and neutral for S1-3 and S2-3. Note that the quartiles for the versions of stories with the same personality factor show a similar distribution to the one we saw in the formative study (see Figure 6.8), i.e., the box plot shows a clear tendency toward the agreeableness polarity that the corresponding story version was designed to portray.

Results and Statistical Analysis

I utilized an Analysis of Variance (ANOVA) statistical test to analyze the results of the experiment. The test was applied on the data obtained from the agreeableness score with respect to the story version that participants read. Results from the test are shown in Table 6.11. The test indicates statistical significance such that the null hypothesis can be rejected in the case of the agreeableness personality factor. This provides evidence that there is correlation between the version of the story that participants read and the perceived personality factor of the main character in such story.

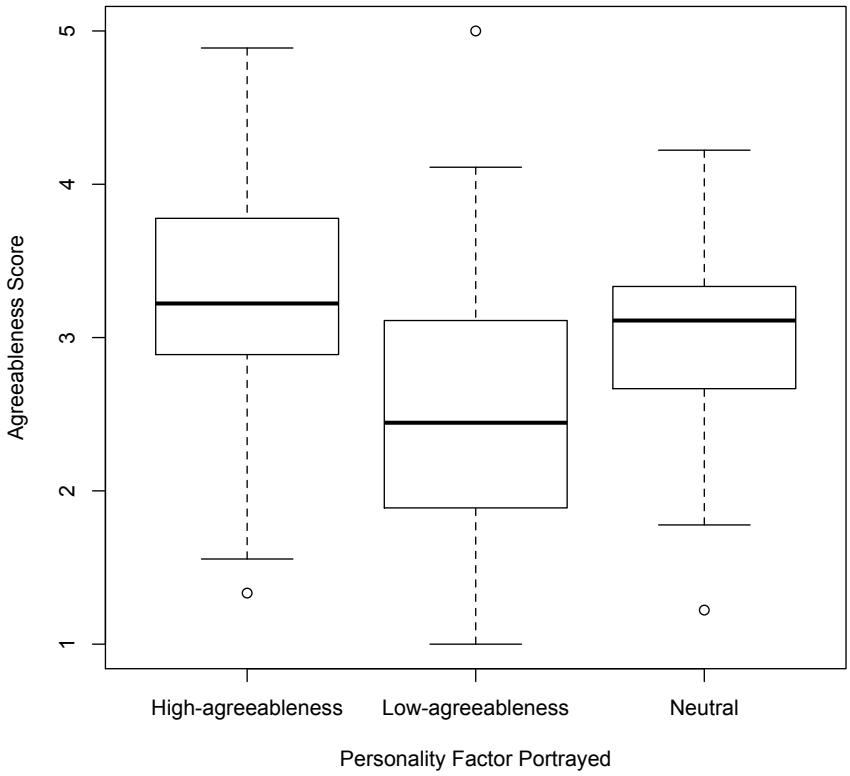

Figure 6.15: Agreeableness Scores for the Combined Dataset (Story #1 and #2) - Mask System Evaluation

Measuring the Consistency of Character Behavior

The third story that was presented to the study participants was designed to evaluate whether they could perceive the existence of inconsistent character behavior. In this story, the main character performs several actions that are typical of a low-agreeableness personality factor (e.g. stealing). Toward the end of the control version of the story (S3-2), the character's final action is consistent with his personality factor, i.e., she behaves according to the personality traits typical of low-agreeableness. In the treatment version of the story (S3-1), the character's final action is not consistent with her personality factor. The action she performs is an example of altruism, which is a trait typical of a high-agreeableness personality factor and hence in contrast with the personality portrayed by the character up to that point in the story.

For Story S3-1, 41.54% (27 out of 65) reported perceiving inconsistency in the main char-

Table 6.11: Analysis of Variance (ANOVA) Test Results for The Agreeableness Factor - First and Second Story - Mask System Evaluation

Agreeableness Score - S1					
First Story					
	DF	Sum Sq	Mean Sq	F value	PR(>F)
Story-ID	2	10.99	5.494	12.71	1.32e-05
Residuals	93	40.21	0.432		
Agreeableness Score - S2					
Second Story					
	DF	Sum Sq	Mean Sq	F value	PR(>F)
Story-ID	2	6.76	3.379	8.946	0.00028
Residuals	93	35.13	0.378		
Agreeableness Score - Combined Dataset (S1 and S2)					
Combined Dataset					
	DF	Sum Sq	Mean Sq	F value	PR(>F)
Factor Portrayed	2	15.03	7.516	12.71	6.62e-06
Residuals	189	111.75	0.591		

acter's behavior, while 58.46% of subjects (38 out of 65) reported not perceiving inconsistency. For Story S3-2, 70.97% (22 out of 31) reported perceiving inconsistency in the main character's behavior, while 29.03% (9 out of 31) reported not perceiving inconsistency. Although these results are not quite as strong as the ones obtained in the formative study, the percentage of responses from participants within each group who reported inconsistent behavior indicates that such behavior was somewhat perceivable by the audience; however, this is an informal assessment and there is no conclusive evidence to make any claims.

The stacked bar plot shown in Figure 6.16 shows that a larger percentage of the participants who read the control version of the third story (S3-1) thought that the main character did not behave in a consistent manner, whereas the opposite is shown for participants who read the treatment version (S3-2). To further evaluate this aspect, participants were specifically asked if they thought that the character's actions regarding a specific character action seemed odd or unusual, with similar results (shown in Figure 6.17).

Even though the results from this portion of the experiment are not statistically significant, they lend some support to our thesis, by strengthening the argument that audiences are able to detect contrast between different character actions when such contrast exists. Nonetheless, it is confounding that the contrast perception is closer to the opposite of what the story was designed to portray. It is worth noting that informal feedback provided by some of the study participants indicated a possible ambiguity in the survey question that was used to collect this

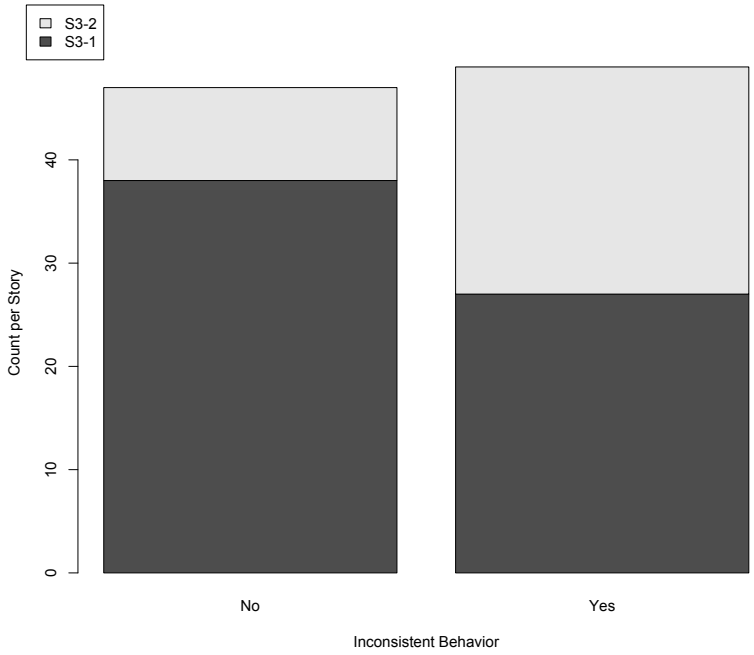

Figure 6.16: Behavior Consistency Perception - Grouped by Story Version

data. Hence, it is possible that the story accomplished its objective but that the wording of the question presented to participants was not clear enough to obtain accurate results.

I also analyzed the consistency data using the *Pearson's Chi-square test of independence with Yates' continuity correction*. The results yielded a χ^2 value of 6.5124, with 1 degree of freedom and a p-value of 0.01071. These results allow us to reject the null hypothesis that the perceived consistency of the story is independent from the story version read. Furthermore, these results provide support for our hypothesis that given a sequence of actions, performed by the same character, an audience will be able to perceive that a character's actions are inconsistent with the personality factor that is exhibited in the character's previous actions. However, it is very important to note that the audience did not perceive the consistency of the stories in the manner that I expected they would, i.e., inconsistency in the story character's choice for action was perceived, but this occurred on the story in which the character's actions should have been perceived as consistent. Conversely, consistency was perceived in the story in which the character's actions should have been perceived as inconsistent. Also note, that the results obtained were not as dramatic as those observed in the formative study. A possible source for the ambiguity of these results is in the possible lack of clarity in the survey questions used. It is also plausible that the content of the stories used may have proved confusing to the audience. I believe that this is a question that deserves further exploration.

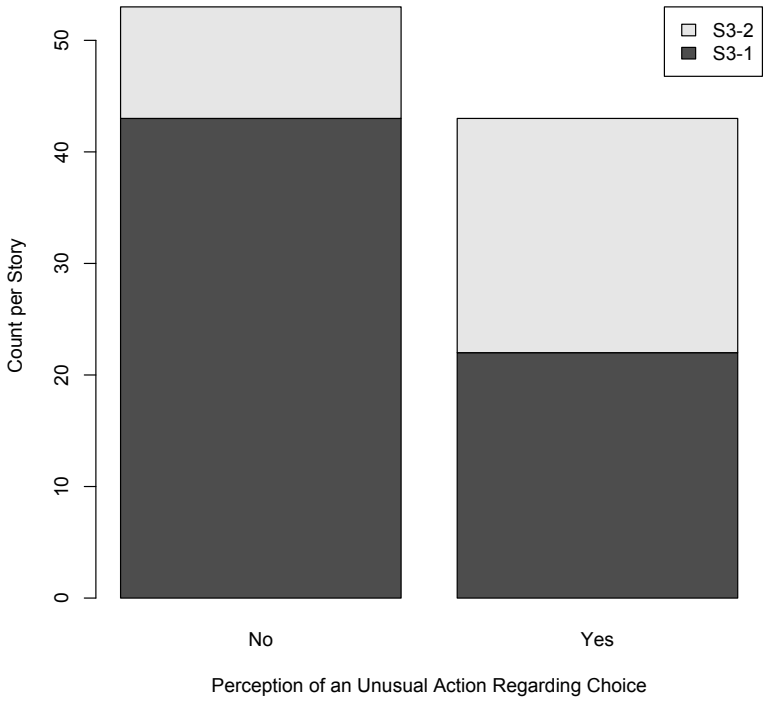

Figure 6.17: Perception of Unusual Character Actions - Grouped by Story Version

Personality Measurement. In addition to the consistency data, participants also completed a personality evaluation of the main character in the third story (S3). This evaluation was conducted using the BFI instrument described earlier in this document. Figure 6.18 shows the distribution of the personality scores, grouped by story version. Because both versions of the story were designed to portray the main character as having a low-agreeableness personality factor, we expected scores to be in the 1.0 to 3.0 range. The average personality score for the Agreeableness factor of this character was **3.26** for the treatment version of the story (S3-1) and **1.61** for the control version (S3-2). The score for S3-2 is clearly indicative of a low-agreeableness personality factor. This is precisely what the story was designed to portray. Also, note that the score is significantly higher (103%) for the version of the story where the character performed exactly one action that was consistent with a high-agreeableness factor. This particular result is something I expected, yet it is surprising considering the results from the consistency perception data because it indicates that actions of the main story character elicited the perception of different personality traits depending on the version of the story that

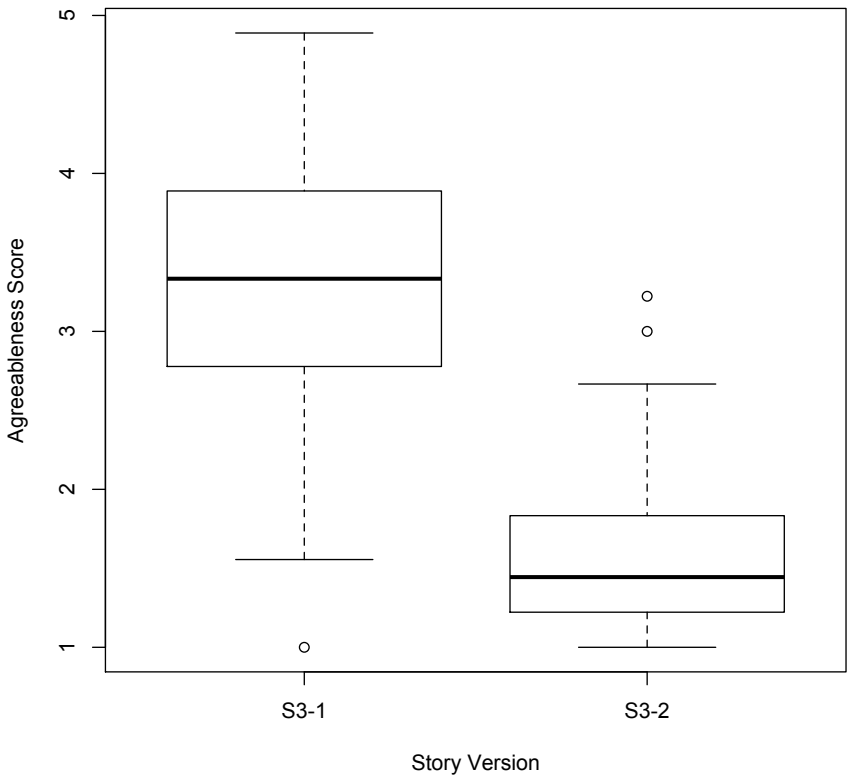

Figure 6.18: Agreeableness Scores Grouped by Story Version - Story #3 - Mask System Evaluation

was read. Nonetheless, the audience did not appear to identify that there was an inconsistency in the character's actions, even though it is this very inconsistency that causes the signifficant difference in the personality scores.

I also utilized an Analysis of Variance (ANOVA) statistical test to analyze the personality data collected for Story #3. The test was applied on the data obtained from the agreeableness score with respect to the story version that participants read. Results from the test are shown in Table 6.12. The test indicates statistical significance such that the null hypothesis can be rejected in the case of the agreeableness personality factor.

Discussion

Analysis of the data collected from the evaluation of the Mask system indicates that the personality scores for the **agreeableness** factor and their relationship with the story read by the

Table 6.12: Analysis of Variance (ANOVA) Test Results for the Agreeableness Factor - Third Story - Mask System Evaluation

Agreeableness Score - S3					
	DF	Sum Sq	Mean Sq	F value	PR(>F)
Story-ID	1	57.67	57.67	108.2	<2e-16
Residuals	94	50.08	0.53		

participant are statistically significant in favor of rejecting the null hypothesis. The results of the ANOVA test provide compelling evidence to support this conclusion. Additionally, an analysis of the agreeableness scores for each story, independently from each other, yielded results that disprove the existence of an imbalance between the results for each story. Each story had the expected effect on the audience when considered on its own and when considered within the context of both stories read. Furthermore, the data collected from this experiment yielded results that are comparable to those obtained from the formative study. This is important because it provides validation that the algorithm can be successfully implemented as part of a planning-based narrative generation system and retain its effectiveness.

6.2.6 Conclusion

In summary, the results obtained from the experiments described in this chapter provide empirical evidence of the validity of my approach. Validation of the choice-based mechanism used by the CB-POCL algorithm has been completed both using hand-crafted stories that follow the same principles and process applied by the algorithm and also using a fully-automated system in which an AI planner generates the story structure and a discourse manager creates the human-readable text. The results from both evaluations are not only comparable but also statistically significant in a manner that supports the hypothesis previously stated that *an audience presented with a set of alternate action sequences for a story character will select personality trait ratings that have significant correlation with the choices made by such character*. This hypothesis provided the foundation for the design of the *Mask* narrative generation mechanism presented in this document.

The data obtained from the experiment clearly indicates that the narrative generation approach used in the design of the CB-POCL algorithm and in the implementation of the Mask system is valid for the portrayal of the agreeableness personality factor. I argue that this is a significant result for the advancement of planning-based narrative generation because it provides a solid foundation for the portrayal of a theme that is used in many narratives, namely the juxtaposition of good (high-agreeableness) vs. evil (low-agreeableness) characters [45]. The *Mask* system can accomplish this in a manner that has the potential to scale much better than

typical non-declarative approaches. Furthermore, *Mask* provides a platform with the potential to facilitate the portrayal of other personality factors, such as conscientiousness and extraversion. I propose that this would be a worthwhile continuation of the research presented in this dissertation.

Chapter 7

Conclusion

7.1 Summary

The research described in this document focuses on the development and evaluation of an intelligent mechanism that enables the automatic generation of narrative that elicits the perception of distinct character personality traits without requiring the labor-intensive process of hand-annotating individual planning operators. The solution presented here is based on a declarative approach, one in which character properties, the story context, and a micro-theory of human behavior are used to model the choices that determine the set of actions that they perform in the course of the story.

The narrative generation mechanism used by *Mask* has its foundation on a character-centric model of action selection. Within this model, we work under the assumption that story characters act intentionally and consider multiple courses of action as they pursue their goals. Consequently, the model described in this document uses an operationalization of character intentionality based on the one defined by Riedl and Young for the IPOCL algorithm [68] and later expanded by Ware and Young for the CPOCL algorithm [82]. In these approaches, sub-plans called *intention frames* explicitly mark the adoption of a new goal by a character, the action in the story that gives rise to the new goal, the steps that the character takes in pursuit of that goal and the point in the story at which the sub-plan to achieve the goal ends execution.

In contrast to a traditional narrative planner where a uniform planning process handles the construction of a story, in choice-based narrative generation, planning is interleaved between a macro-planner and a micro-planner. The macro-planner is responsible for constructing the authorial view of the global story and its causal coherence. The micro-planner is a restricted version of a planning system, designed to simulate the decision-making process of characters as they work toward accomplishing a goal. To represent the character's process of considering multiple plausible courses of action to achieve her goal, the micro-planner generates the set

of possible intention frames that allow the achievement of such goal and then evaluates them utilizing a simplified model of affect appraisal theory.

The approach described extends a conventional planning-based narrative generation algorithm to ensure that choice is treated as a first-class object. The planner's data structures and supporting processes have been modified and enhanced to this effect. Additionally, the nondeterministic selection of actions has been replaced by a mechanism that incorporates choice as a key component of the story generation process. Finally, the portrayal of specific personality traits has been operationalized in terms of the effects that result from the choices made by characters as they perform their role in the narrative and the contrast provided by alternate actions. The effectiveness of this approach has been validated for the portrayal of personality traits that are linked to the agreeableness personality factor.

7.2 Broader Impacts

Results from this work most directly apply to systems used to create interactive narratives (e.g. digital games, training simulations) due to the improved scalability of the approach presented here, as opposed to a purely manual approach. Additionally, it is possible that the use of a system such as mask may result in increased creative freedom by enabling human authors to focus on other aspects of narrative creation. However, a model for character action in a manner that uses choice to affect personality perception also has the potential to be applied to enhance existing models of narrative comprehension and generation. Focusing on the effect that choices have on personality perception in the context of narrative could help us advance models of story comprehension and potentially develop methods to automatically generate stories that purposely affect such comprehension.

7.3 Limitations and Future Work

Future versions of the algorithm may be expanded to use a more robust model to evaluate character intentions. One such model may incorporate the use of character knowledge that is limited by their observations or that uses a belief system where characteristics such as incomplete or inaccurate knowledge play a role. In such a model, every character could potentially have their own version of the state of the story world, which may not agree with other characters' versions and thus result in narratives that are potentially more expressive.

7.3.1 Limitations

Imperfect Character Knowledge

In the current version of *Mask*, evaluation of intention frames assumes omniscient characters, i.e., all story characters have full knowledge of each other's intentions. To make this possible, the macro-planner maintains a database of every character's current intentions. However, it may be of value to support scenarios where a character's knowledge of the state of the story world is either incomplete or erroneous. Such scenarios may lead to narratives that are possibly more interesting and complex. Furthermore, they could be more suitable for the use of composition techniques that introduce elements of surprise or suspense in a narrative [5].

Adjusting to Changing Story Conditions

Mask does not handle the case where later story events create a state that no longer matches that which the character considered when she made a particular choice. Just as it often happens in narratives, characters can change their mind or find new ways to achieve their goals. However, the ability to prevent or at least manage this situation could enable the construction of stories where characters have very clearly defined personalities and also help ensure that the effects of a choice for action are not diluted by other actions that occur at a later time in the story.

One possible step in this direction would be to preserve the soundness of character action sequences. The causal consistency of each new action added by the micro-planner must be considered in the context of the choices previously made by story characters. Ideally, once a contrasting set is identified, the current plan should be modified to prevent the viability of story versions that are not clearly consistent or inconsistent. This last step is intended to ensure that clear contrasting options are available in the resulting story, thus clearly conveying to the audience that the character had a choice in action. The approach currently in place achieves the intended purpose; however, I posit that an approach that modifies the structure of the story plan would facilitate the construction of stories that are more expressive. Additionally, it would help guarantee that character's actions are consistent or that they are better justified by their previous actions.

Evaluation of Intention Frames

Determining the optimal number of intention frames to generate, or deciding which ones to generate is an area where the algorithm could be improved in future versions. Currently, the micro-planner will generate a set number and use these to evaluate the affective response elicited by a character's actions upon other characters. Ideally, the MP should generate as many intention frames as necessary to achieve maximum contrast, while preserving the tractability of

the computational problem. Informal system testing during the development of *Mask* indicated that the number of intention frames generated by the MP can dramatically affect the running time needed to generate a story. Currently, it is possible to generate a complete story in less than two (2) seconds, while evaluating several intention frames for multiple choice points. However, increasing the number of intention frames has the tendency to dramatically increase such running time. Likely, this will require additional experimentation and work on the optimization of the Java code that is used in the implementation of *Mask*. Furthermore, I posit that it may also be necessary to develop a new heuristic in order to keep the problem tractable.

7.3.2 Future Work

Planning-based narrative generation, Interactive Narratives, virtual worlds and related technologies offer multiple opportunities for novel research. These technologies not only have the potential to be an effective mechanism for the delivery of educational or entertainment content, but also to provide a platform that facilitates efforts that aim to invent and study new methods of Human-Computer Interaction. The former could provide the foundation for innovative and possibly more effective methods to deliver educational content. The latter could enhance human abilities to solve problems, collaborate, and to communicate with each other.

Enhanced Affect Response Evaluation

I envision that later versions of the algorithm will include evaluation of additional criteria, such as taking into account the degree to which one character's actions assist other characters in the achievement of their goals and also considering how detrimental the negative impact of a harmful action or action sequence is. For the purposes of this research, I generalized harm to be the inability or difficulty in achieving a goal, i.e., fulfilling an intention. However, there could be varying degrees of harm. The current version of *Mask* focuses on whether such harm exists or not. Varying degrees of harm could be evaluated using a model that takes into account the effort necessary to undo the damage (e.g. total steps, action cost, or some other plan-based metric) or it could also take into account whether recovery is at all possible. A case in point is that of irreversible effects (e.g. the death of a character). In the current version of *Mask*, I generalized benefit to be the achievement of a character's goal or one or more of the conditions necessary to achieve it. However, one could imagine that some actions or action sequences can be more beneficial than others. Incorporating these types of considerations into the micro-theory of character behavior could potentially produce narratives that are made more expressive by the portrayal of more nuanced effects that are linked to character's choices.

Additional Personality Factors

Even though it could be argued that Mask provides a framework for the portrayal of a diverse set of personality traits, the results that were presented earlier (see Section 6.2.5) focus on the successful portrayal of behavior that is associated with agreeableness. The implementation and evaluation of behavior typical of other other FFM factors [26] such as conscientiousness and extraversion constitute a natural progression for this work. I believe that portraying multiple personality factors can be as important as addressing the limitations and potential enhancements described earlier.

Using Mixed-Initiative Techniques to Author Narratives

An area of research that I am particularly interested in is the development of mixed-initiative [30] techniques to create intelligent authoring tools that efficiently combine the subject-matter knowledge of a human expert and the reasoning capability of an AI system to create narratives [75, 76]. This type of environment could be used to develop systems that assist in the creation of instructional curricula, help prepare virtual world scenarios for military or law enforcement training simulations, and guide crime scene witnesses in the description of actual events. One of the challenges that I encountered constantly during my research was that of designing and implementing planning domains for narrative generation. This type of work is typically done manually, and it tends to be quite onerous, time-consuming and error prone. I would like to work on the development of user interfaces that not only simplify the process but that also enable the collaboration between a human in the loop who provides subject-matter knowledge and creativity, and a planning-based narrative generation system that can very quickly produce multiple possible versions of a story scenario, while ensuring that the content is coherent.

Intelligent Tutoring Systems

Another area of research where I would like to explore the applications of my work is in the use of virtual worlds and procedurally generated content to develop intelligent tutoring systems. Previous work in the area of narrative-centered learning environments has demonstrated the significant potential of these types of systems [69]. A concrete research project that I intend to pursue is the use of procedurally generated virtual crime scenes, in conjunction with an intelligent system, to train crime scene photographers on the correct methods to preserve and catalog evidence found in a crime scene. As part of my work on the IC-CRIME project, I had the opportunity to supervise the design and implementation of a prototype system that explored some of these ideas [6]. I believe that the *Mask* system could also be part of a solution that enables crime scene investigators to develop and analyze narrative scenarios that describe the

events of a crime scene. In particular, I would like to design and evaluate an Intelligent User Interface that facilitates the generation of multiple "what if?" scenarios that can be used to test different investigative theories about a specific crime.

Parallel Processing

One of the computational processes that are at the core of the *Mask* system is that of generating and evaluating multiple courses of action that a character may follow to achieve a single intention. In the current implementation, the system only explores a limited number of such options due to the additional processing and memory requirements that are incurred by this part of the story generation algorithm. Consequently, it is not tractable to exhaustively explore all of the possibilities that are viable at a given choice point even though this is theoretically possible. Furthermore, the additional processing needed to perform the evaluation significantly increases the amount of time that is needed to create one story. Execution times where in the range of 1.5 to 2.0 seconds to process one of the story domains described earlier in this document and produce a story, which intuitively does not seem to be very slow; however, ideally I would like to see execution times in the sub-second range, which would increase the feasibility of using *Mask* in interactive narrative applications (e.g. digital games and training simulations).

A possible solution that I would like to explore is that of using parallel programming and processing methods to offload the work done by the micro-planner to multiple processing cores and possibly to multiple distributed systems as well. Instead of having two processes, the macro-planner and the micro-planner, competing for computing and memory resources, we could have a more efficient process where the micro-planner has its own memory space and a dedicated processing core or machine. Additionally, each viable alternative could be generated and evaluated by a separate process, in an environment where several such processes are executed in parallel with each other, instead of serially as it is currently done.

The approach that I propose would need to go beyond the systems design and implementation aspect. It also would require significant focus beyond that of designing a multi-threaded processing system. I believe that the more interesting part of the work would be in the design of new planning algorithms that can divide one problem into multiple self-contained sub-problems that can be solved on their own, in a manner that allows the main process to combine their separate results into a single solution for the original problem. Important components of this approach would require the design of scheduling and synchronization mechanisms to allow the use of multiple instances of the micro-planner in a manner that maximizes the efficient use of modern multi-core architectures, while still ensuring the completeness and soundness of the planner. I posit that by following this approach, we could design a solution that is practical, without having to compromise on the expressiveness of the stories that are produced.

7.4 Closing Remarks

The principal motivation for my work has been the creation of a character-centric model of narrative generation that ensures the inclusion of characters that are defined by the presence of a perceivable personality. The long-term goal of this research is the development of architectures and techniques that support the implementation of automated and human in the loop narrative authoring environments that are considerably more scalable than the manual-based approaches typically used to author content for computer-generated narratives and virtual worlds.

Storytelling is an essential component of human culture. It is difficult to think of human interaction without thinking of stories. Using stories to transfer knowledge and to make sense of the world that we live in is at the core of who we are as cultural beings. Narratives are everywhere, from something as mundane and utilitarian as an instruction manual, to something as profound and in depth as a history book that describes the demise of a foregone empire. If we are ever to achieve the ideal of creating machines that can reason in a manner that resembles human reasoning, narrative must be part of this achievement. This is something that I wholeheartedly believe in, the idea that we must have systems that can—on their own—create stories that are coherent, interesting, creative, and compelling.

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APPENDICES

Appendix A

Study Materials

This appendix contains the materials used in the experiments that were conducted as part of this research. These are exact copies of what was approved by the Institutional Review Board for the Protection of Human Subjects in Research (IRB) and presented to study participants.

A.1 Preliminary Evaluation

I used the Qualtrics platform to present the stories to participants and to collect their responses. Screen captures of the web pages that were used in the research study are included below. Note that these materials differ slightly from the scenarios discussed in Section 5.12. The names of characters, places, and other story content were modified to obscure the actual narrative sources in order to prevent the introduction of bias due to prior knowledge of the story content.

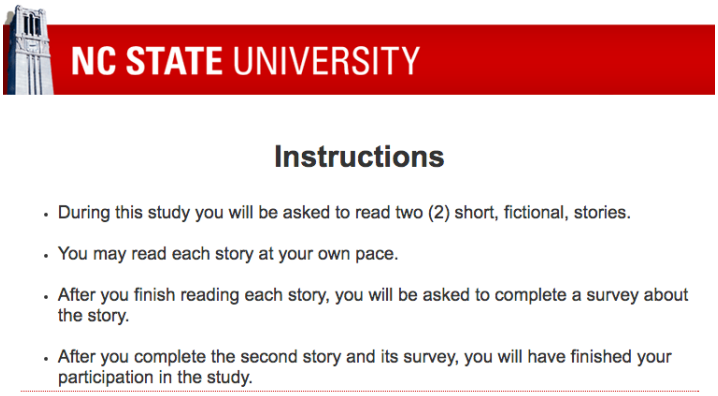


Figure A.1: Preliminary Evaluation - Participant Instructions

How old are you? (in years)

Please identify your gender: (please select one)

- Male
- Female
- Other
- Prefer not to disclose

What is the highest level of education you have completed? (please select one)

- Some High School
- High School Degree
- Trade/Technical/Vocational Degree
- Undergraduate Freshman
- Undergraduate Sophomore
- Undergraduate Junior
- Undergraduate Senior
- Undergraduate Degree
- Graduate Terminal Degree (example: MBA, JD)
- Graduate Non-Terminal Degree
- Doctoral Degree (example: PhD, ScD)

Please rate your proficiency with the American English language: (please select one)

- No Proficiency
- Elementary Proficiency
- Limited Working Proficiency
- Professional Working Proficiency
- Full Professional Proficiency
- Native Proficiency

Figure A.2: Preliminary Evaluation - Demographic Survey (Pre-Experiment)

Escape from The Forest

Long time ago, in a land far away, lived a young man named John. On a day like any other, John was invited by a group of friends to explore a nearby forest. The forest offered the chance to do something interesting on an otherwise ordinary day.

On they went, John and his friends, into the forest. The further they walked the taller the trees seemed to be and the darker their path became. Feeling a bit tired, John sat on a log to rest for a moment; however, to his dismay he suddenly realized that he was alone. His friends had gone on without him, and he was now lost.

Aware of his predicament, John looked all around until he saw what appeared to be smoke. Following the smoke, he arrived at an old cabin where he ran into a grouchy, old, and scruffy man. Not knowing what else to do, John told the man that he was lost and asked if he would show him the way out of the forest. The old man, although not being very friendly, agreed to help but only after supper. He argued that he seldom had company, and it would be nice to enjoy dinner with someone else. John reluctantly agreed, not feeling that he had other options, and besides it was getting dark.

Having finished supper, John reminded the old man of his promise to help; however, the old man kept stalling. Meanwhile he sharpened a hunting knife while insisting that John should just spend the night. Eventually, it became apparent to John that the old man was not going to help him and that perhaps his life could be in danger. Tired of the old man's shenanigans, he got up and started to walk away. At this moment, his suspicions were confirmed when the old man lunged and tried to grab him. Luckily, the old man tripped, and John was able to start running.

John ran away from the cabin as fast as he could. Not very far behind him, he kept hearing the old man's footsteps and his yells of "I'm going to kill you!" and "I will get you!" He ran until he arrived at some very large rocks, some as big as a house, the perfect place to hide. He climbed on one of these rocks, where he could keep an eye on the old man without being seen. There, he waited while the old man kept getting closer and closer yet appeared unable to see him.

While he waited and wondered what to do, John suddenly realized that from the top of the rock he could see the path that he and his friends had taken earlier in the day. By chance, he had found the way out! It was right in front of him! Unfortunately, the old man was now on the path in front of John, next to some bushes, blocking his only way back to town. Meanwhile he kept repeating his threats and brandishing the hunting knife.

In desperation, John looked around, hoping for a way out. That is when he noticed that next to the edge was a rock that with a push would fall right on the old man's head and crack his skull. This would surely kill him and get John out of his predicament.

Slowly and very quietly, John got as close to the edge as he could without being seen. There he could hear the old man still talking although now what he heard was more like the ramblings of a crazy person. He also noticed that the old man's face looked not only tired but also sad.

In a split second, John decided that jumping over the old man would allow him to escape. He jumped and landed on the bushes on the other side of the path, narrowly missing hitting a tree branch. He also was lucky that although the old man saw him, he was too startled to catch him. John then ran as fast as he could toward the way out of the forest, not stopping until he could finally see the road into town.

He eventually found his friends and told them all about his adventure in the forest with the grouchy old man.

The End

Figure A.3: Preliminary Evaluation - Short Story #1 - Version 1

Slowly and very quietly, John got as close to the edge as he could without being seen. There he could hear the old man still talking although now what he heard was more like the ramblings of a crazy person. He also noticed that the old man's face looked not only tired but also sad.

In a split second, John decided to push the rock, which fell with a loud thud and crushed the old man's skull. This allowed John to escape. He then ran as fast as he could toward the way out of the forest, not stopping until he could finally see the road into town.

He eventually found his friends and told them all about his adventure in the forest with the grouchy old man.

The End

Figure A.4: Preliminary Evaluation - Short Story #1 - Version 2. In this figure, only the alternate ending is shown. The rest of the story is the same as in version 1.

Slowly and very quietly, John got as close to the edge as he could without being seen. There he could hear the old man still talking although now what he heard was more like the ramblings of a crazy person. He also noticed that the old man's face looked not only tired but also sad.

Suddenly, a beautiful deer appeared, a few yards from where the old man stood. Forgetting about John and more interested in a feast, he decided to go in its pursuit. This enabled John to get away, he ran as fast as he could toward the way out of the forest, not stopping until he could finally see the road into town.

He eventually found his friends and told them all about his adventure in the forest with the grouchy old man.

The End

Figure A.5: Preliminary Evaluation - Short Story #1 - Version 3. In this figure, only the alternate ending is shown. The rest of the story is the same as in version 1.

The second story will be displayed next.

Instructions

- You may read the story at your own pace.
- After you finish reading the story, you will be asked to complete a survey about the story.
- After you complete the story and its survey, you will have finished your participation in the study.

Figure A.6: Preliminary Evaluation - Participant Instructions - Story # 2

The Broken Clock

Bob lived in a small town, where he worked at the local furniture factory. Even though he went to work almost every day, working was not Bob's favorite activity. He often times showed up late and on occasion faked a cold, so he could take the day off and go fishing instead.

Lately, though, work had become less of a chore, and Bob even appeared to be cheerful about it. The reason for this change was the arrival of a new employee, whose name was Jane. She was a pretty brunette who worked in the same area of the production line as Bob, under the supervision of Mr. Jones a middle age man who inspired as much respect as he did fear. Although Bob and Jane were not a couple, they had shared a few laughs, often talked during their break, and sometimes ate lunch together at the company's cafeteria.

On this day, though, Bob was not happy with Jane. He happened to walk by the local pub the prior evening and saw her at the bar having a drink with Jim, instead of joining him for a movie as he had asked earlier. Jim was a former football quarterback, who also worked at the factory and who it was obvious also had an interest in Jane. Bob had never been fond of Jim and seeing him with Jane filled him with anger and jealousy.

There were rumors that Mr. Jones owned a very fancy and rare table clock, a constant reminder that his true passion was selling fine antiques and not the making of cheap furniture that he daily supervised in order to make a living. Nobody had seen this clock, except for furtive glances on the rare occasion that the office door was open. Jones kept to himself, not only by always working behind a closed door but also by locking it whenever he was away. His secretive behavior made it impossible to ascertain the existence of the clock.

On this same day it just so happened that Jones was summoned to a very sudden, yet important meeting, and in the haste to leave his office he forgot to lock it. Noticing this, Jane snuck in and found the clock. She picked it up to admire it, noticing that it was indeed a beautiful timepiece with an intricate design and an immaculate finish. Suddenly she noticed Bob next to her, with a curious look on his face. Startled by this, she tried to put the clock back on the table with such bad luck that it fell, cracking the glass on the face. In panic, she put the clock back and both her and Bob went back to their stations and their work.

Later in the day, Jones returned to his office, and it was not long before he noticed the damaged clock. Very upset at the thought that someone had gone into his private space and broken his precious possession he decided to investigate. One by one he called all the employees into his office and asked them if they were responsible for the transgression. While this was going on, Bob kept looking at Jane, being curious about her reaction. Still being upset about seeing her with Jim last night, he thought that perhaps getting in trouble served Jane well for hanging out with Jim instead of going to the movies with him. Nonetheless, he could not help but notice that Jane looked terrified, as the incident would most likely end with a reprimand and possibly her getting fired. He also wondered how bad this could be for her. If it were he, he would not care, as he did not think much of this job and would rather be somewhere else. Jane on the other hand seemed to enjoy being there and he knew that she was an excellent employee. Perhaps, he wondered, there was something that could be done.

Meanwhile, Jones continued his inquiry, eventually summoning Jane, who slowly got up and began walking toward his office. She was about to enter, when suddenly Bob ran in front of her and upon entering Jones' office blurted: "I did it, I broke your fancy clock!"

Bob did not get fired, but he did get a nasty reprimand and was ordered to work overtime until he paid for what it cost to repair the clock.

The End

Figure A.7: Preliminary Evaluation - Short Story #2 - Version 1

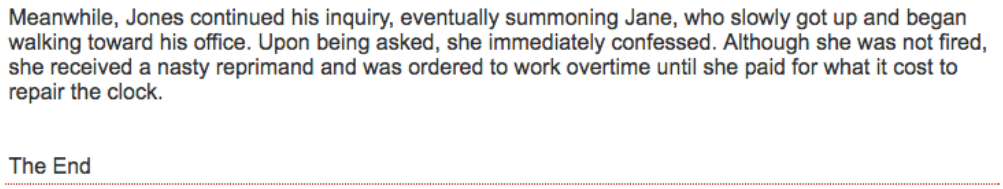


Figure A.8: Preliminary Evaluation - Short Story #2 - Version 2. In this figure, only the alternate ending is shown. The rest of the story is the same as in version 1.

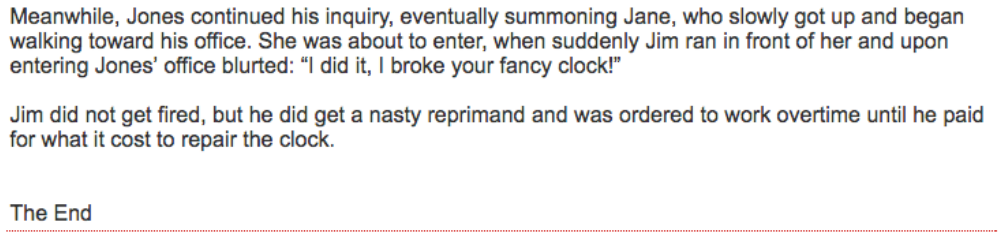


Figure A.9: Preliminary Evaluation - Short Story #2 - Version 3. In this figure, only the alternate ending is shown. The rest of the story is the same as in version 1.

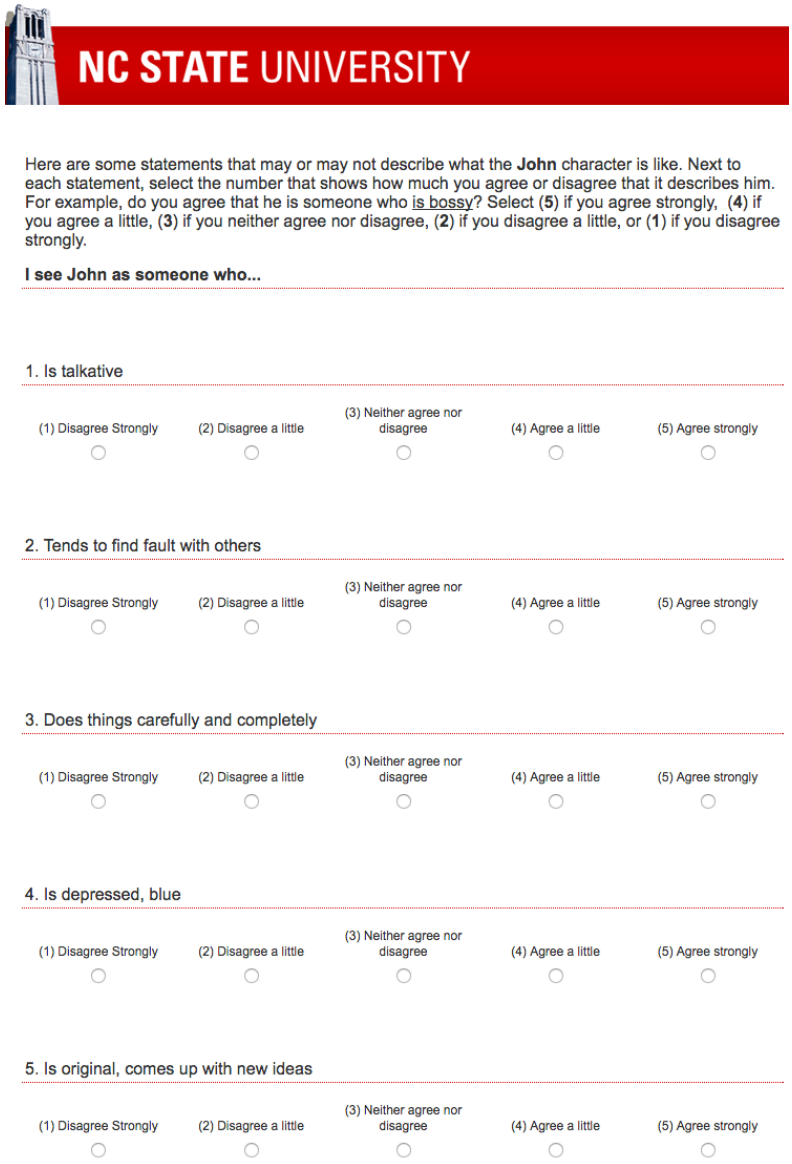


Figure A.10: Preliminary Evaluation - Short Story #1 - Personality Survey - Page 1

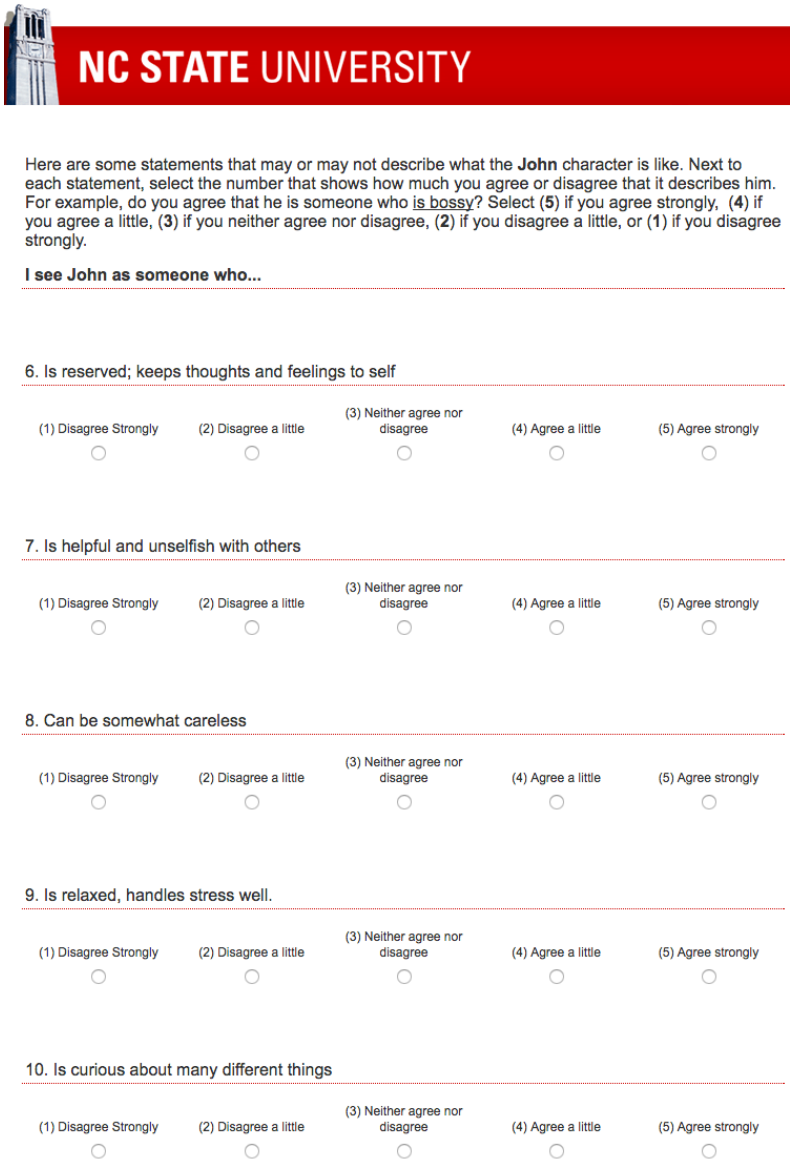


Figure A.11: Preliminary Evaluation - Short Story #1 - Personality Survey - Page 2

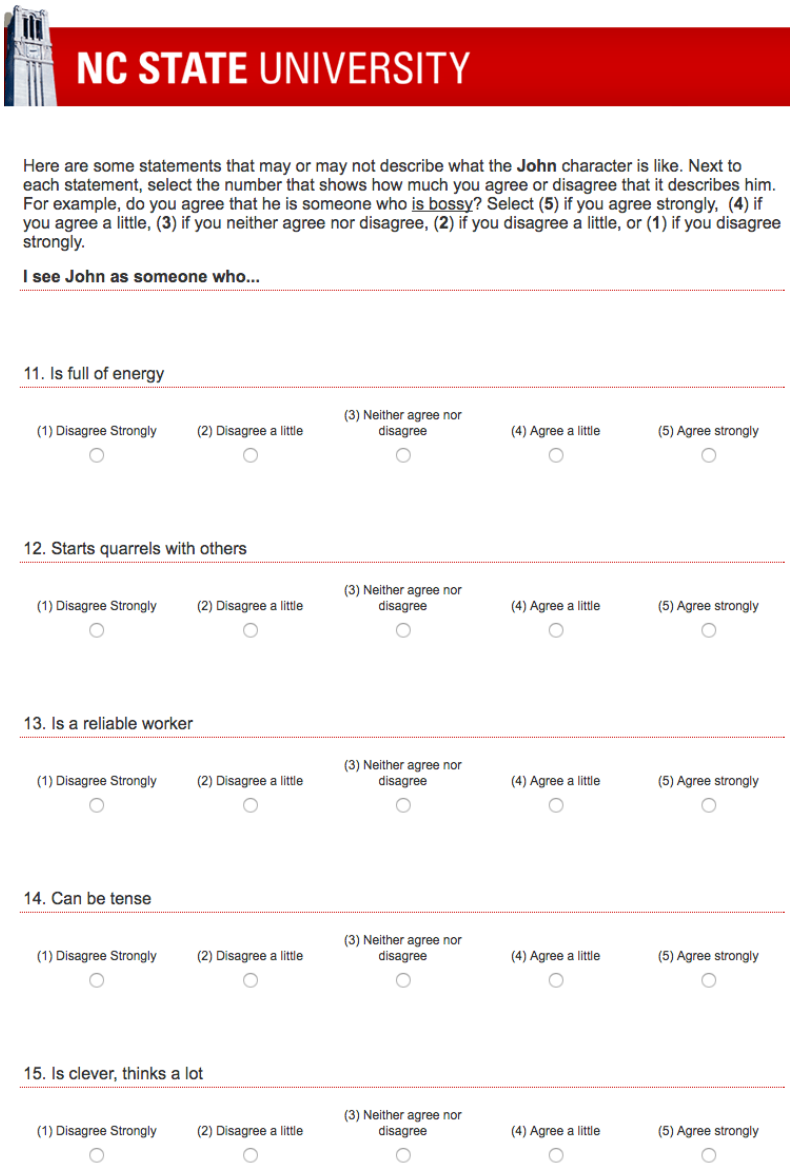


Figure A.12: Preliminary Evaluation - Short Story #1 - Personality Survey - Page 3

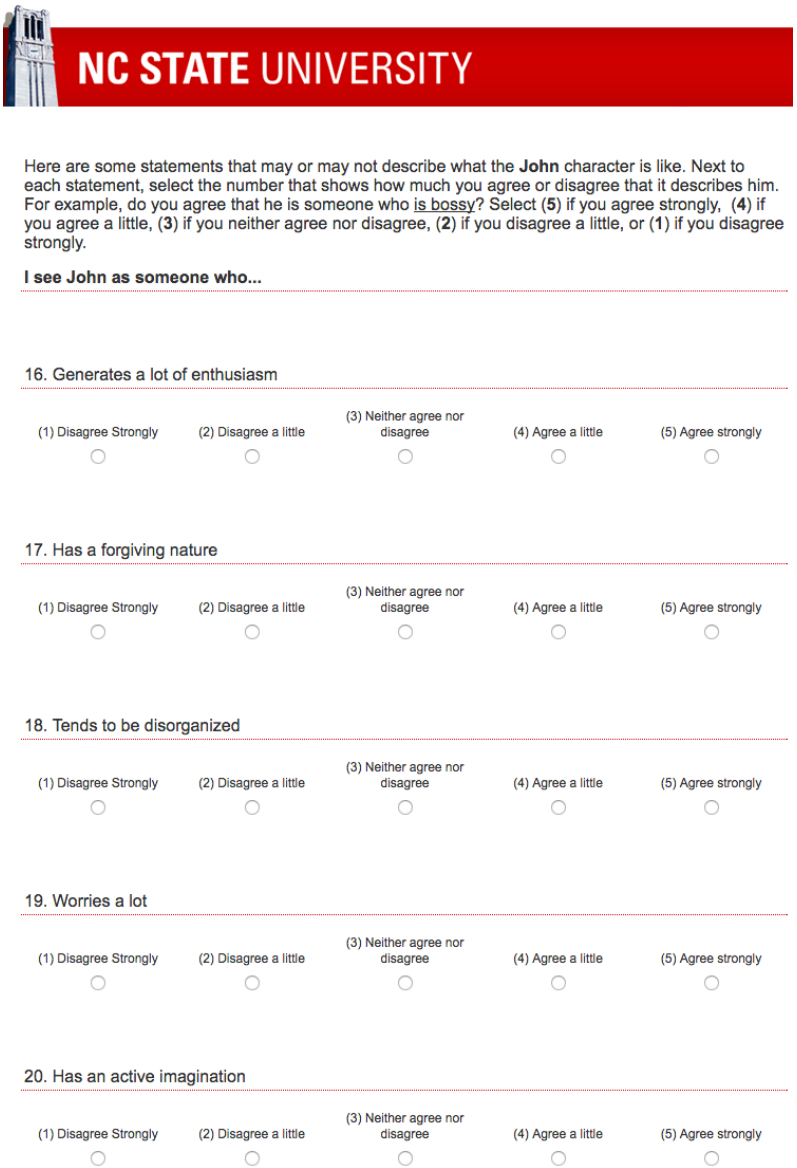


Figure A.13: Preliminary Evaluation - Short Story #1 - Personality Survey - Page 4

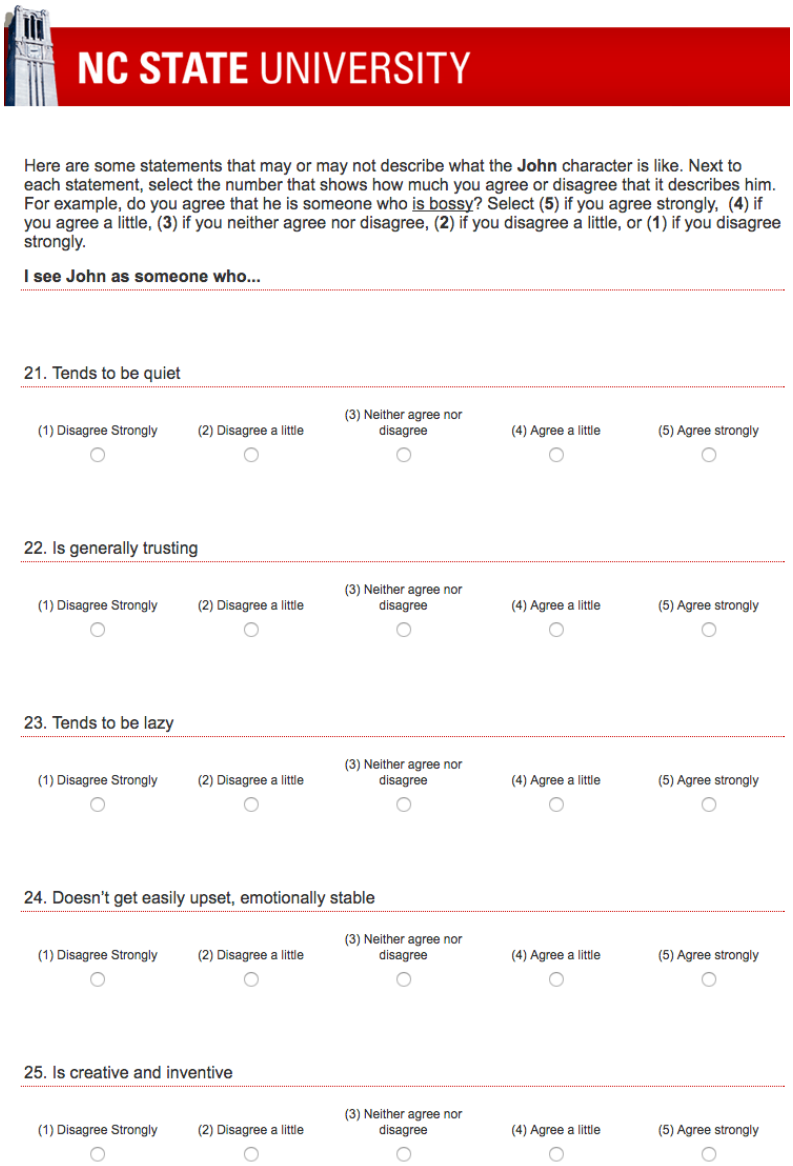


Figure A.14: Preliminary Evaluation - Short Story #1 - Personality Survey - Page 5

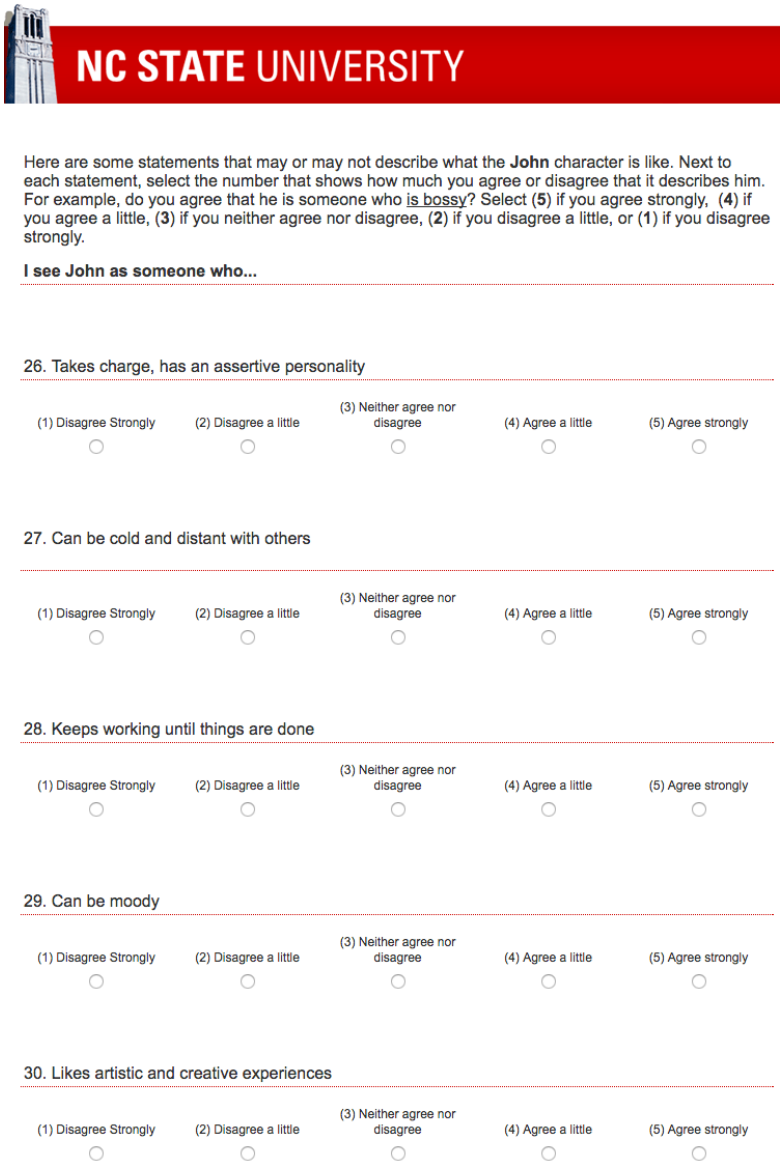


Figure A.15: Preliminary Evaluation - Short Story #1 - Personality Survey - Page 6

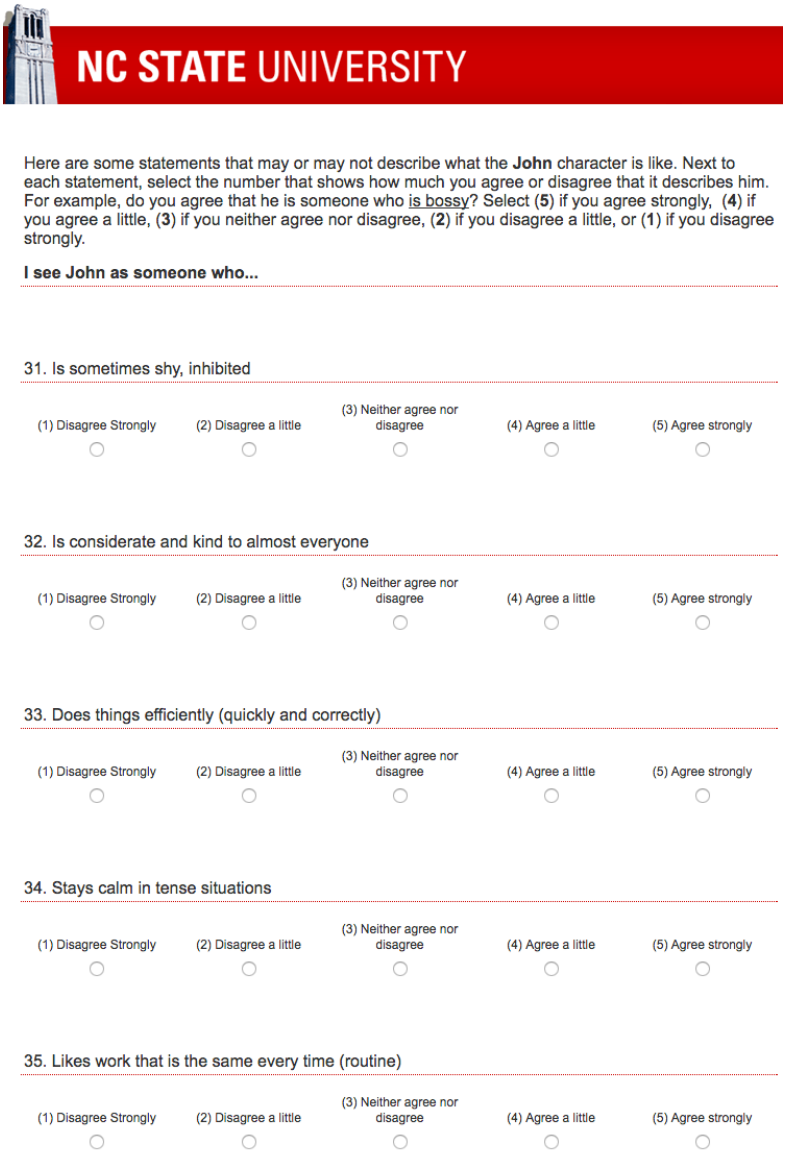


Figure A.16: Preliminary Evaluation - Short Story #1 - Personality Survey - Page 7

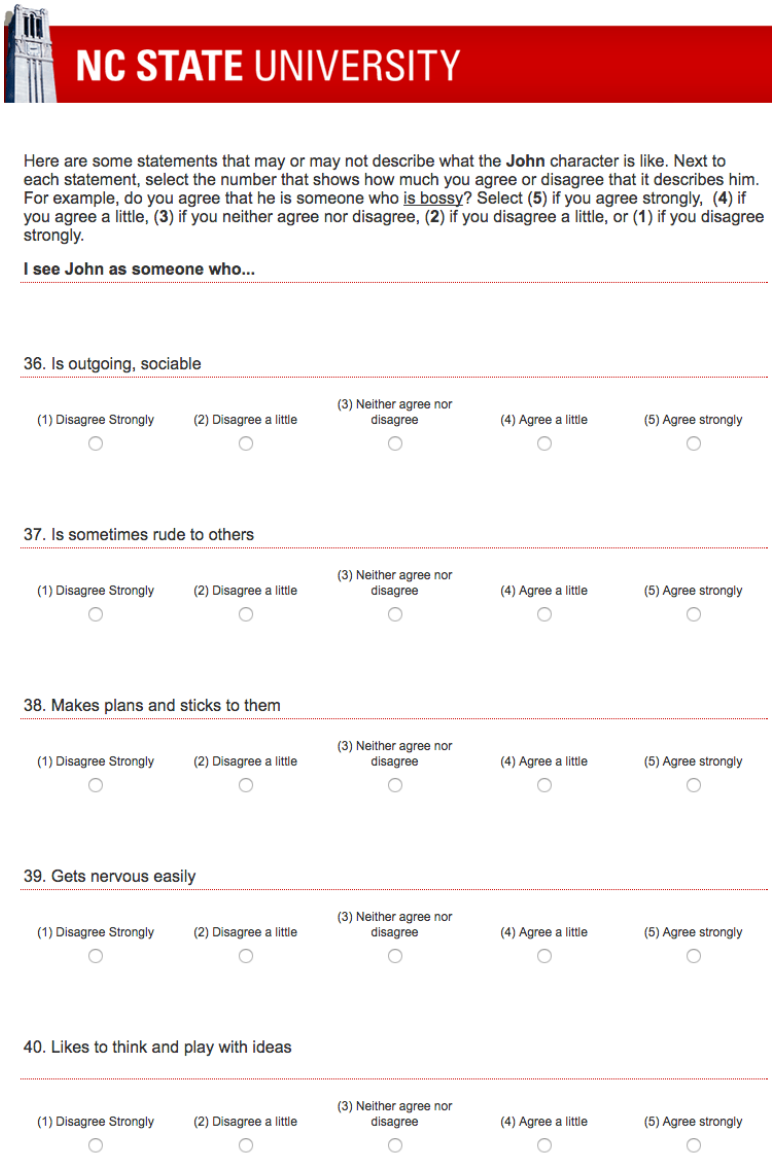
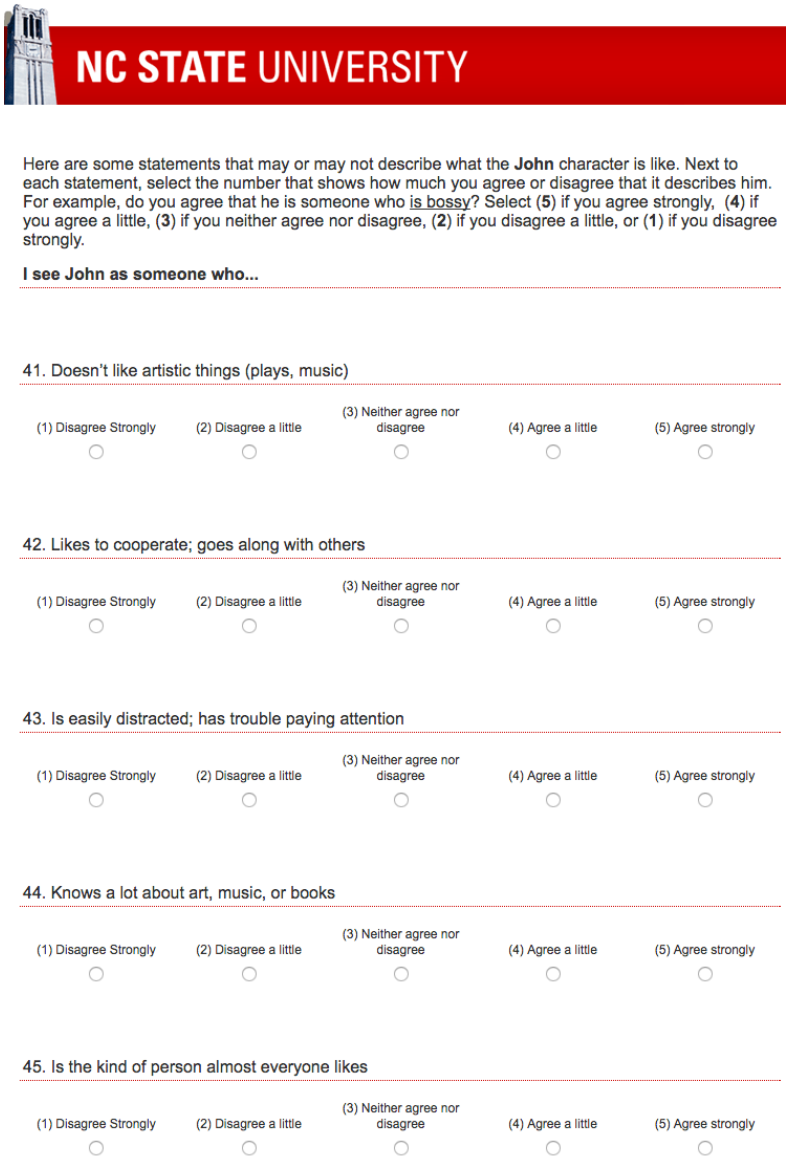


Figure A.17: Preliminary Evaluation - Short Story #1 - Personality Survey - Page 8


NC STATE UNIVERSITY

Here are some statements that may or may not describe what the **John** character is like. Next to each statement, select the number that shows how much you agree or disagree that it describes him. For example, do you agree that he is someone who is bossy? Select (**5**) if you agree strongly, (**4**) if you agree a little, (**3**) if you neither agree nor disagree, (**2**) if you disagree a little, or (**1**) if you disagree strongly.

I see John as someone who...

41. Doesn't like artistic things (plays, music)

(1) Disagree Strongly	(2) Disagree a little	(3) Neither agree nor disagree	(4) Agree a little	(5) Agree strongly
○	○	○	○	○

42. Likes to cooperate; goes along with others

(1) Disagree Strongly	(2) Disagree a little	(3) Neither agree nor disagree	(4) Agree a little	(5) Agree strongly
○	○	○	○	○

43. Is easily distracted; has trouble paying attention

(1) Disagree Strongly	(2) Disagree a little	(3) Neither agree nor disagree	(4) Agree a little	(5) Agree strongly
○	○	○	○	○

44. Knows a lot about art, music, or books

(1) Disagree Strongly	(2) Disagree a little	(3) Neither agree nor disagree	(4) Agree a little	(5) Agree strongly
○	○	○	○	○

45. Is the kind of person almost everyone likes

(1) Disagree Strongly	(2) Disagree a little	(3) Neither agree nor disagree	(4) Agree a little	(5) Agree strongly
○	○	○	○	○

Figure A.18: Preliminary Evaluation - Short Story #1 - Personality Survey - Page 9

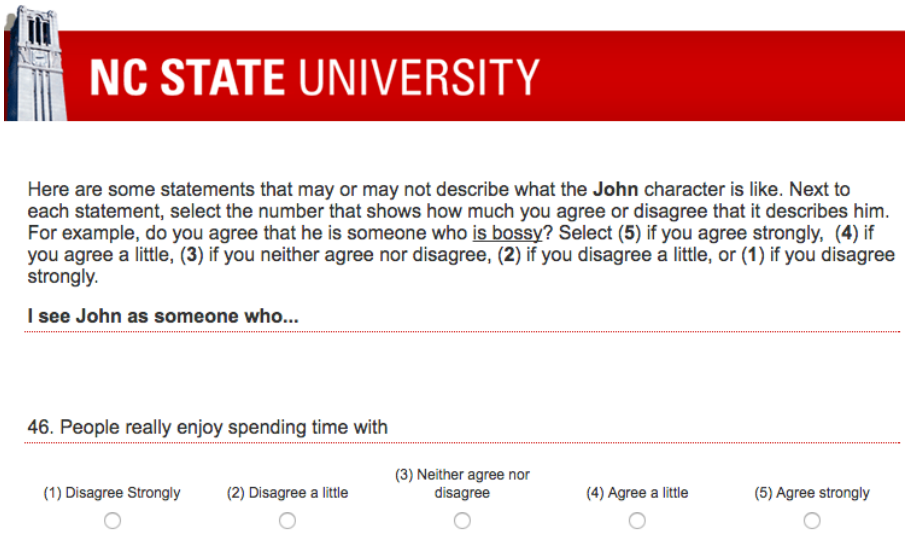


Figure A.19: Preliminary Evaluation - Short Story #1 - Personality Survey - Page 10

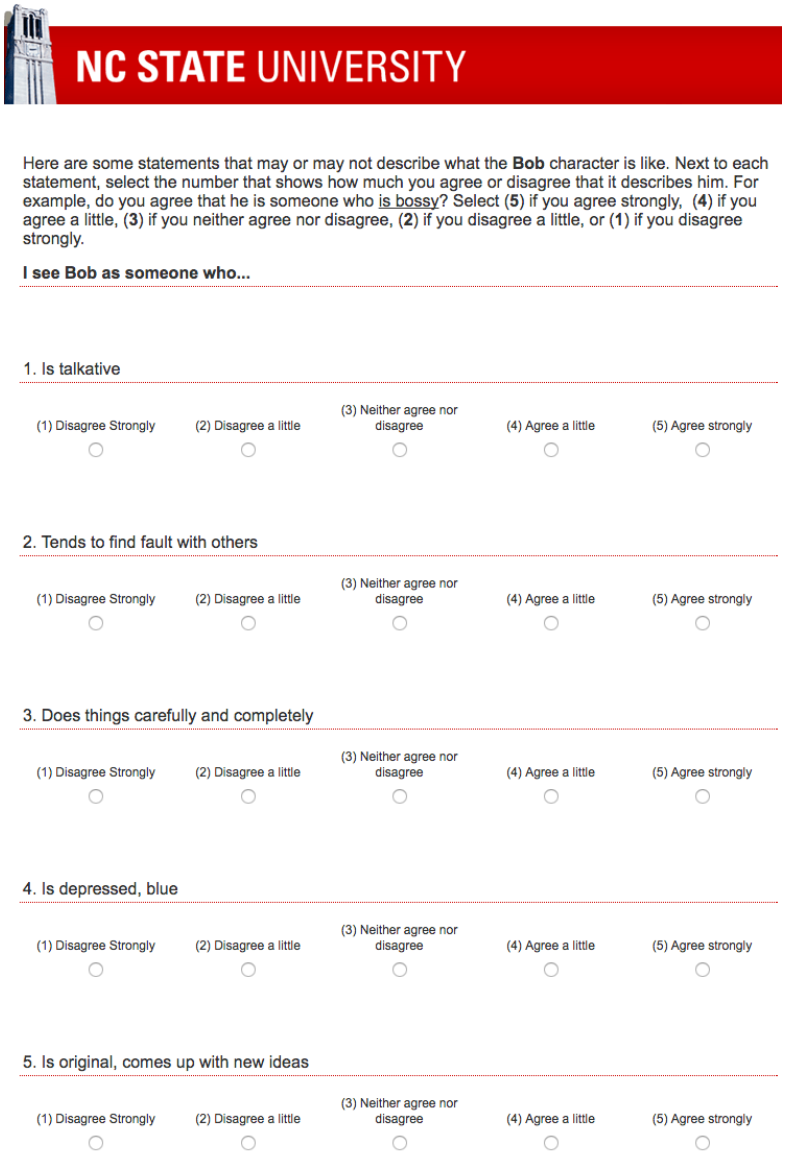


Figure A.20: Preliminary Evaluation - Short Story #2 - Personality Survey - Page 1

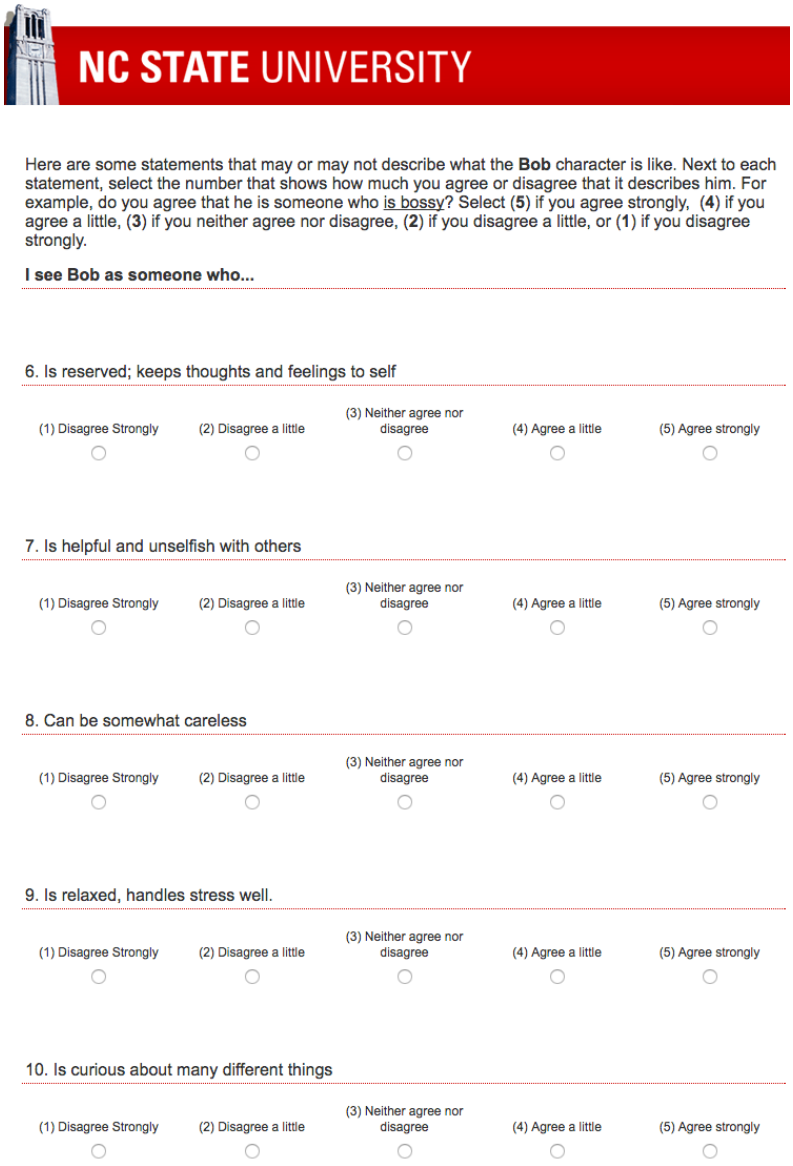


Figure A.21: Preliminary Evaluation - Short Story #2 - Personality Survey - Page 2

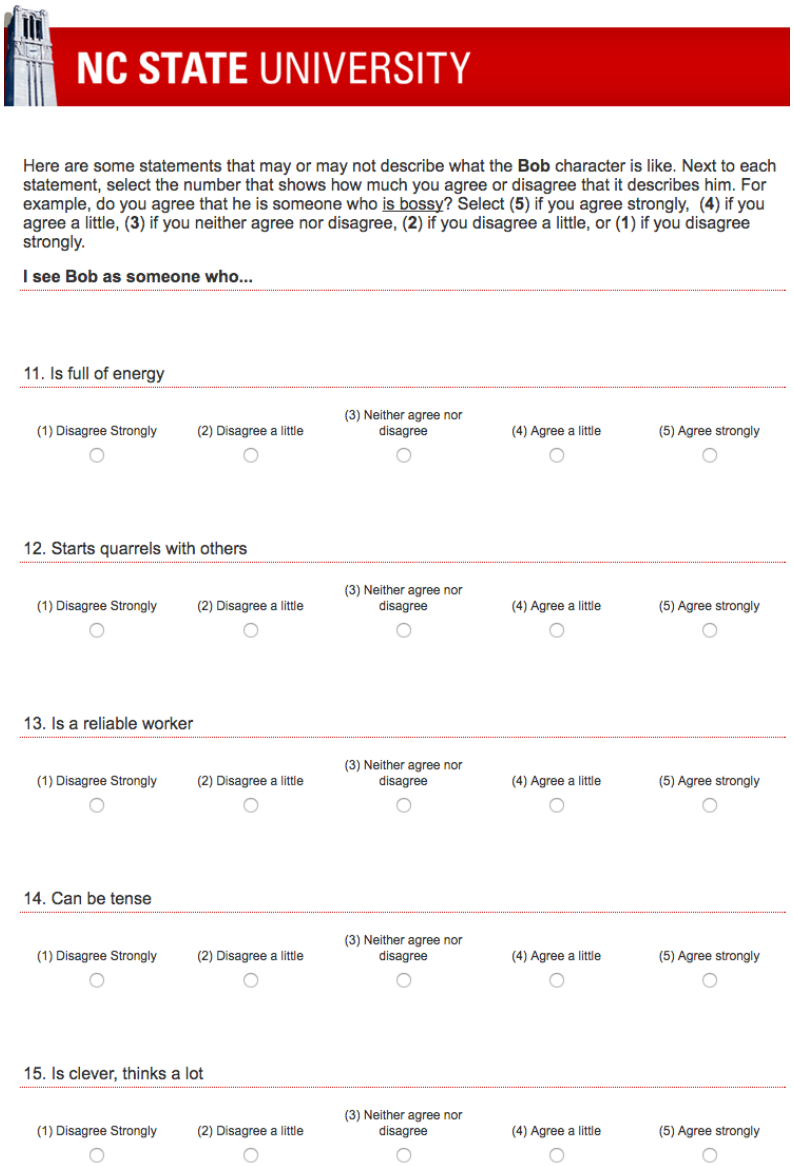


Figure A.22: Preliminary Evaluation - Short Story #2 - Personality Survey - Page 3

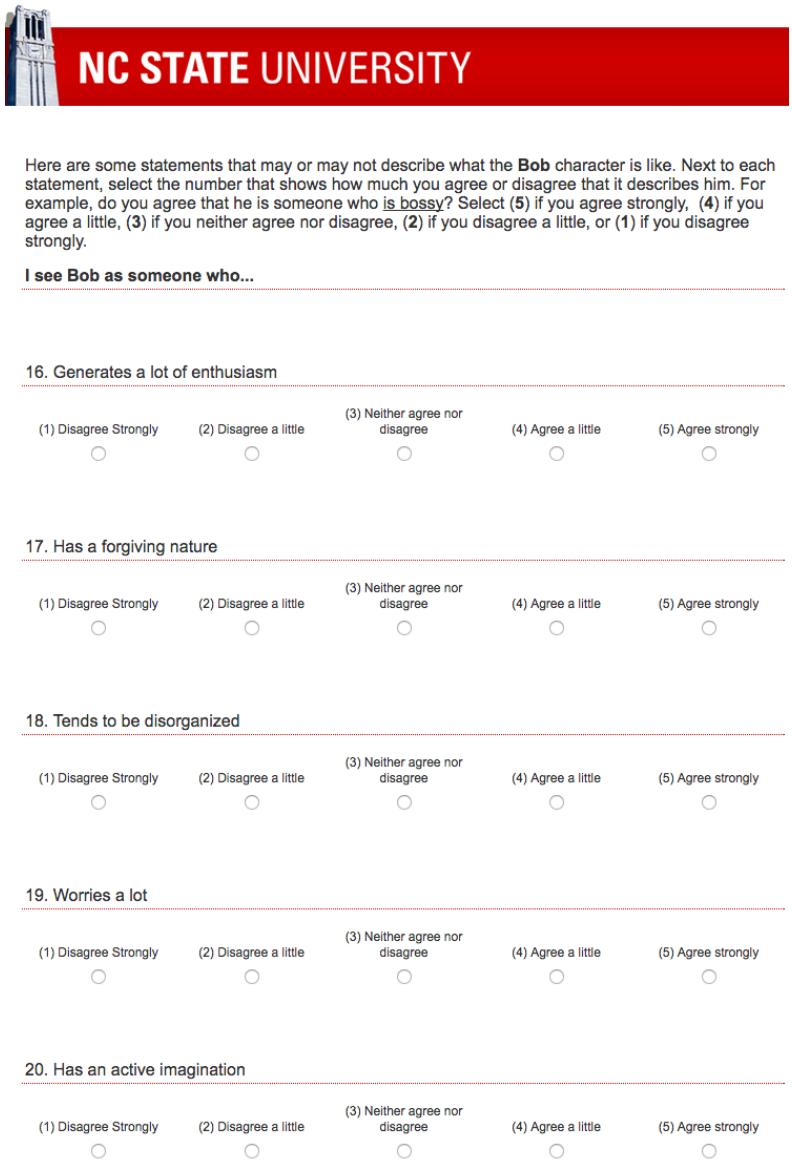


Figure A.23: Preliminary Evaluation - Short Story #2 - Personality Survey - Page 4

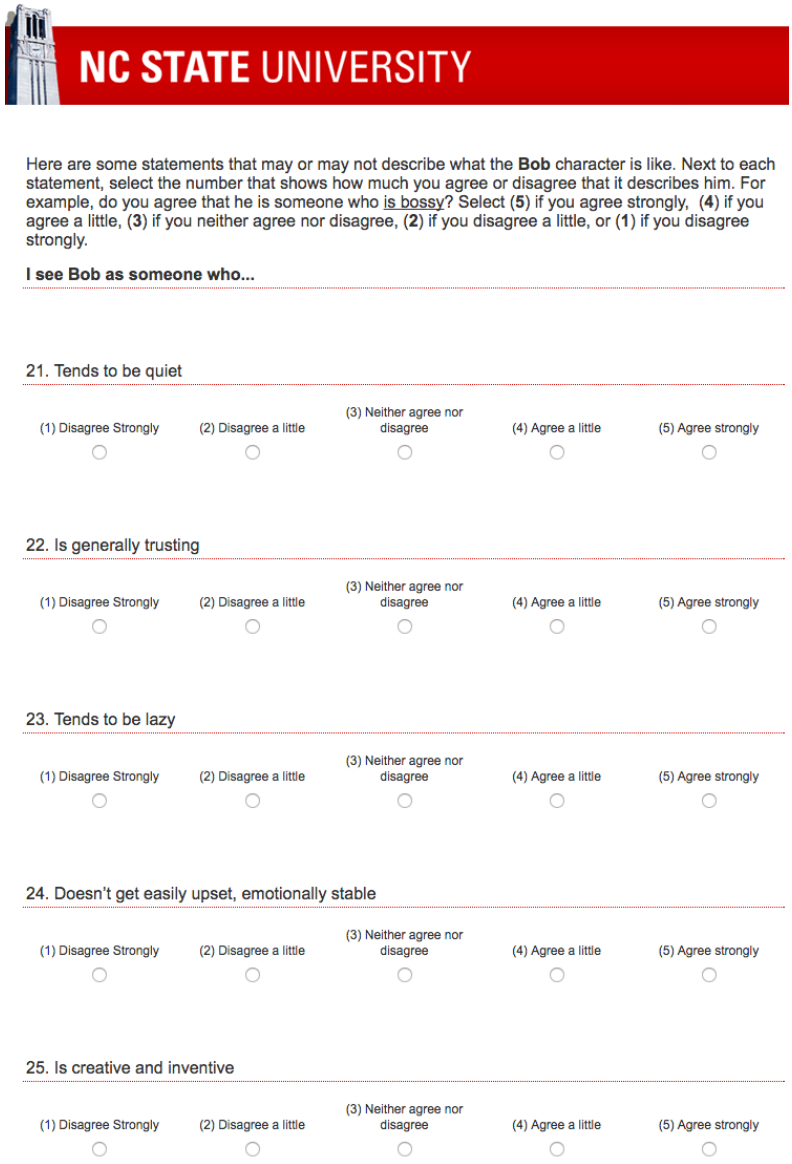


Figure A.24: Preliminary Evaluation - Short Story #2 - Personality Survey - Page 5

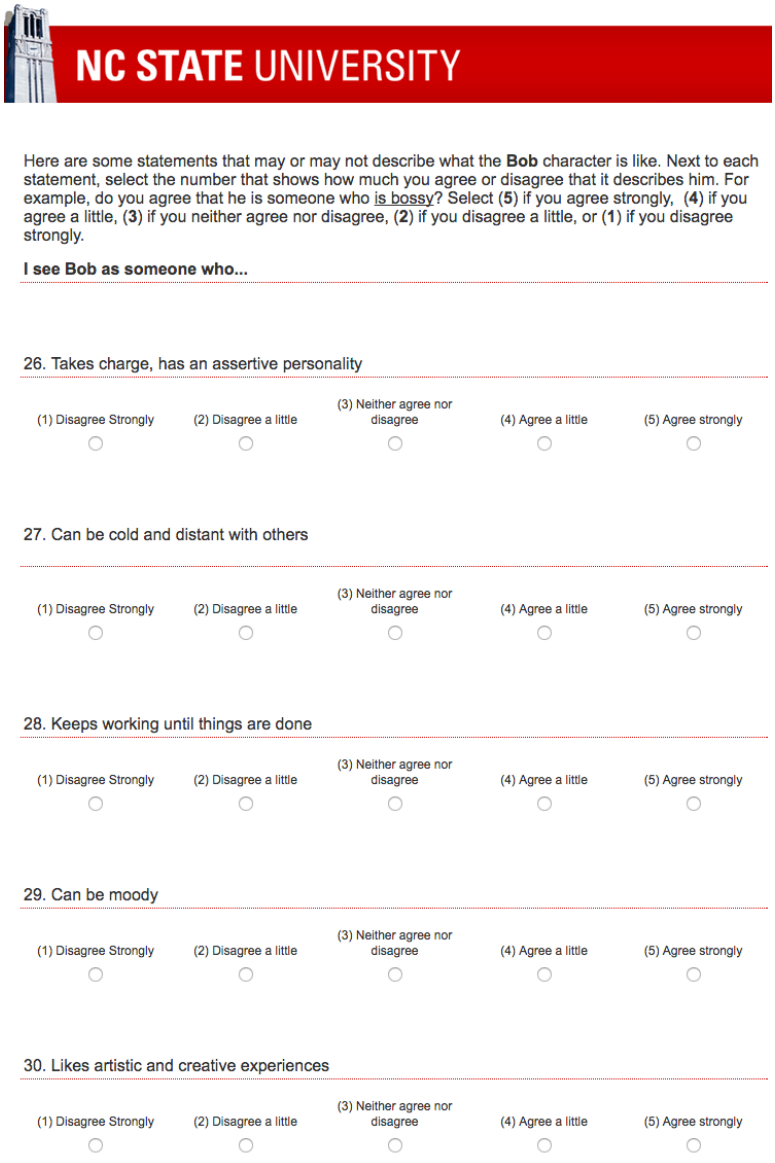


Figure A.25: Preliminary Evaluation - Short Story #2 - Personality Survey - Page 6

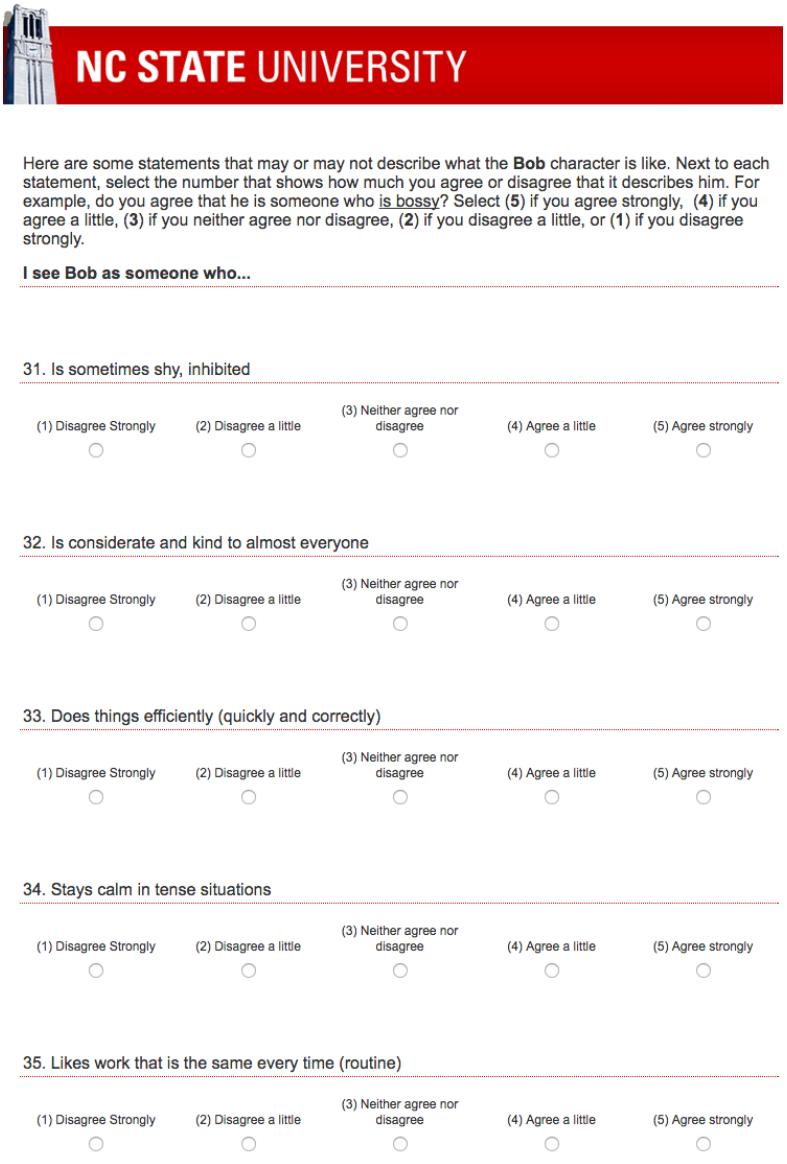


Figure A.26: Preliminary Evaluation - Short Story #2 - Personality Survey - Page 7

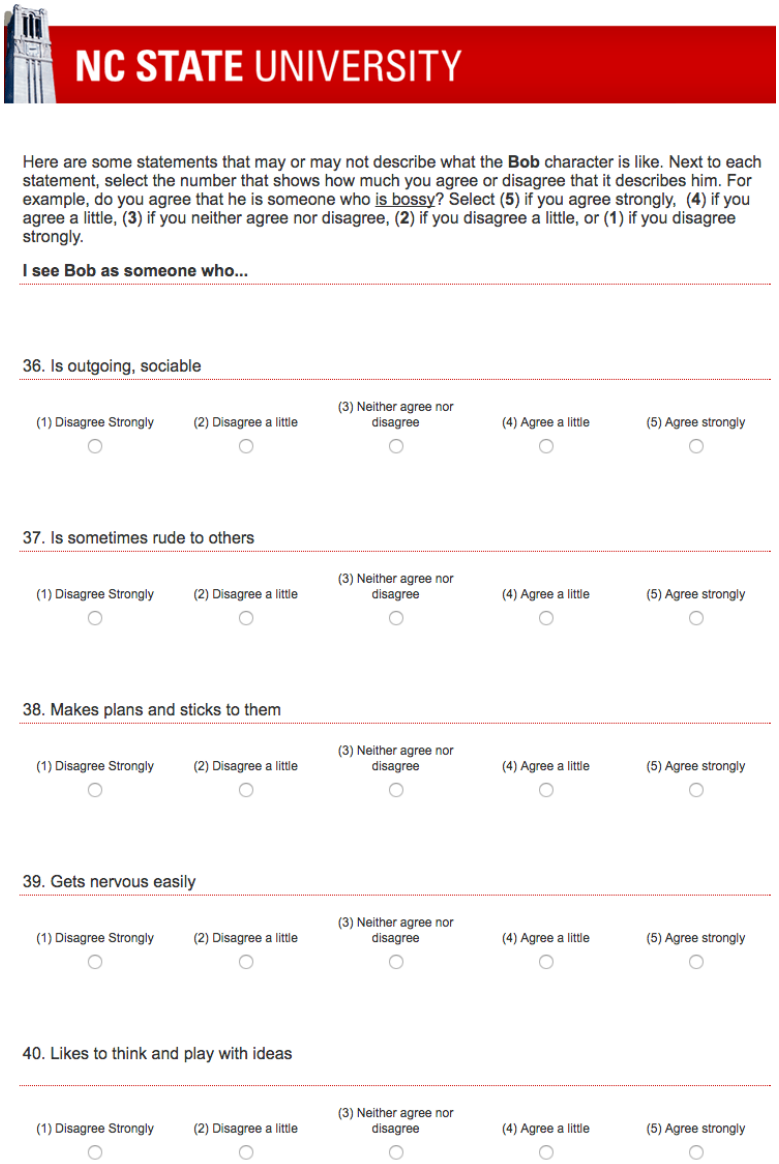


Figure A.27: Preliminary Evaluation - Short Story #2 - Personality Survey - Page 8

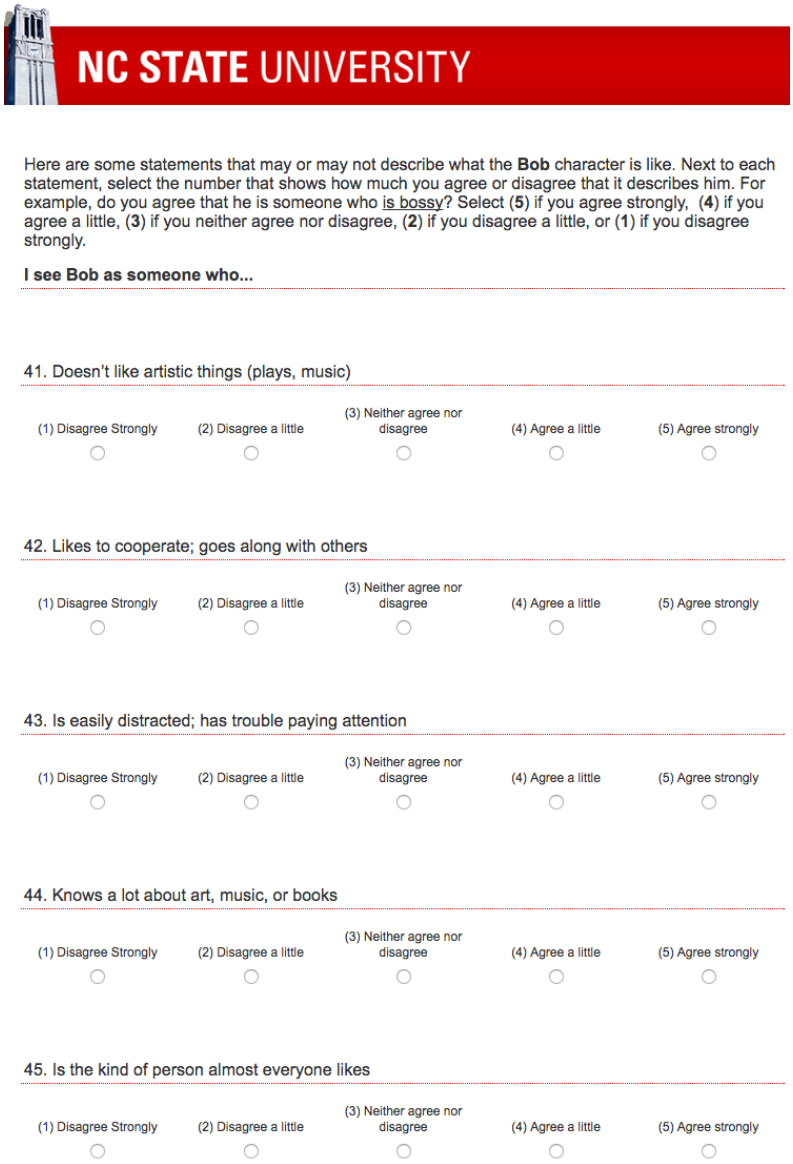


Figure A.28: Preliminary Evaluation - Short Story #2 - Personality Survey - Page 9

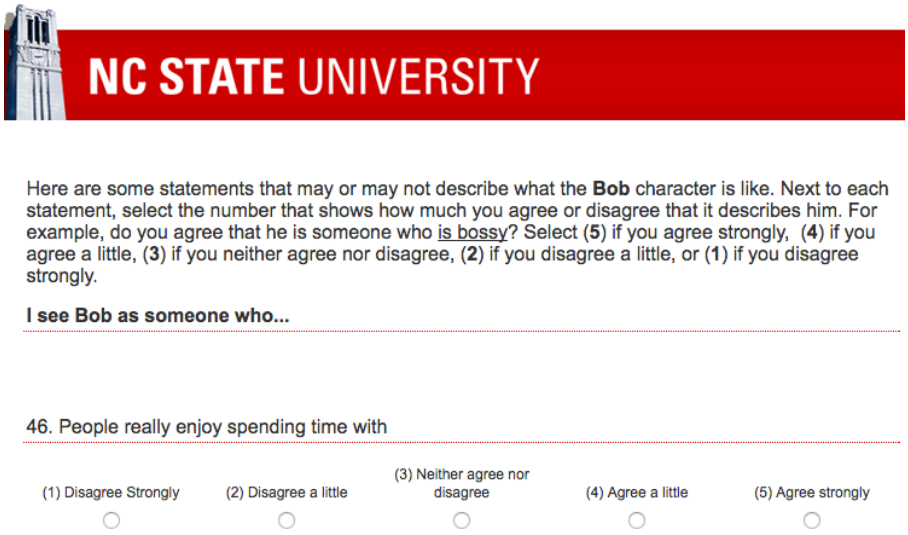


Figure A.29: Preliminary Evaluation - Short Story #2 - Personality Survey - Page 10

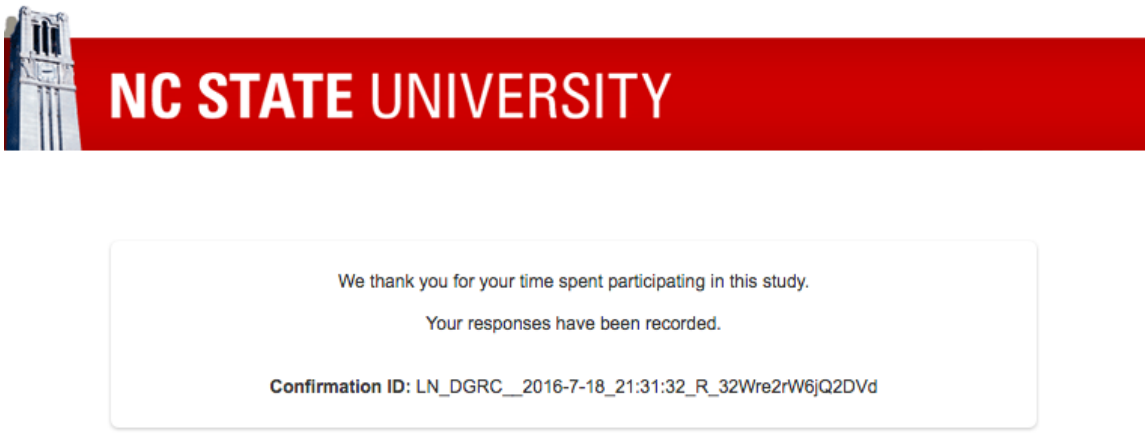


Figure A.30: Preliminary Evaluation - Participation Confirmation Page. This figure shows the unique confirmation code that is provided to participants at the end of the study.

A.2 Follow Up Formative Study

The materials used for the formative study were very similar to those used in the preliminary evaluation. The main differences were in the content of the stories used and in the addition of a third story. The personality surveys were the same, with the addition of a third personality survey where the main character is named *Lenny*. The questions used can be seen in Figures A.10 to A.19 and Figures A.20 to A.29. I also added a survey about the story contents, which was used only with the third story. This survey is shown in Figures A.42 to A.45.

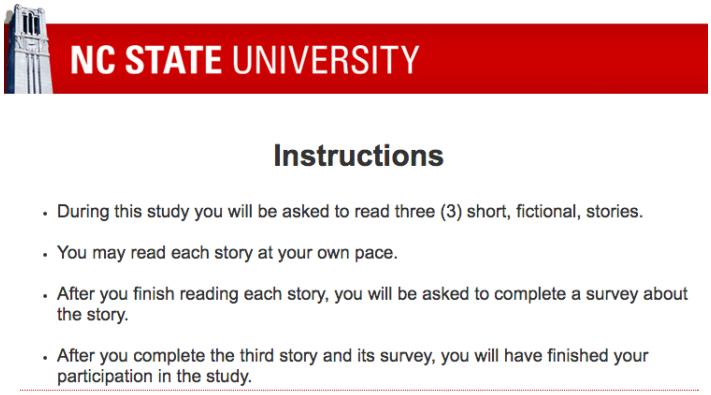


Figure A.31: Formative Study - Participant Instructions - Story #1

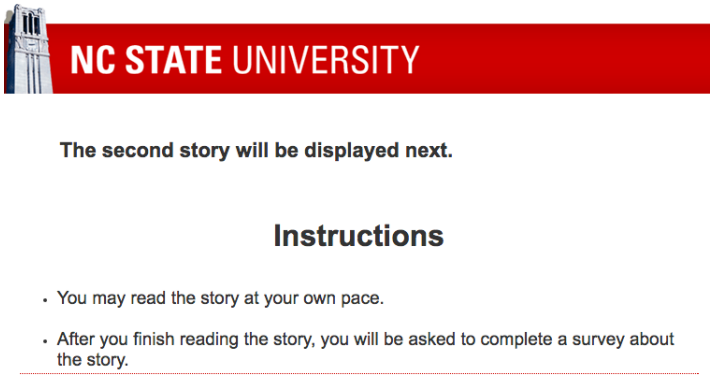


Figure A.32: Formative Study - Participant Instructions - Story #2

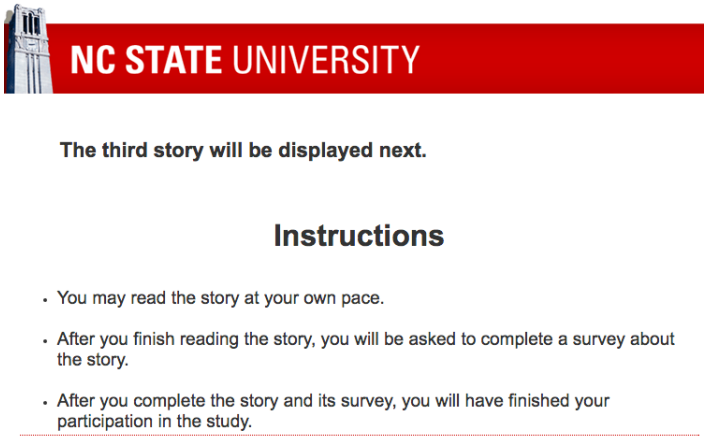


Figure A.33: Formative Study - Participant Instructions - Story #3

Escape from The Forest

John was invited by a group of friends to go hiking in a nearby forest. After walking for a while, he sat on a log to rest, not noticing that his friends kept going without him. Feeling lost, he looked around until he saw a plume of smoke. Following it, he arrived at a cabin where there was a grouchy, scruffy, old man. John told the man that he was lost and asked if he could show him the way out of the forest. The old man agreed to help but only after supper, explaining that he seldom had company, and that it would be nice to share dinner with someone.

Having finished supper, John reminded the old man of his promise to help; however, the old man kept stalling. He sharpened a hunting knife while insisting that John should stay overnight. Eventually, it became apparent that the old man was not going to help and that perhaps John's life could be in danger. Tired of the shenanigans, John got up to leave. Seeing this, the old man lunged and tried to grab him; however, he stumbled and John was able to run away.

John ran from the cabin as fast as he could. Not very far behind him, he could hear the old man's footsteps and his yells of "I'm going to find you and kill you!" He ran until he arrived at an area full of boulders, some as big as a house, a great place to hide. He climbed onto one of them, from where he could see all around without being seen. While trying to figure out what to do, John realized that the path that he and his friends had taken earlier in the day was right in front of him. By chance, he had found the way out! Unfortunately, the old man was now right next to the boulder where he was hiding, blocking the way back home, and still making threats.

John looked around, thinking of what to do, and noticed that next to the edge of the boulder was a rock about the size of a basketball. He also saw some thick bushes, next to where the old man was standing.

At this point, John had a choice. He knew that he could grab the rock and throw it at the old man without being seen. Doing so would surely kill or severely injure the old man and allow John to escape. He also knew that he could jump over the old man, land on the bushes, and make a run for it. Doing so could result in John hitting a large rock that was next to the bushes, getting hurt, and being caught while trying to get away.

John decided to jump over the old man. He jumped and landed on a bush, narrowly missing the big rock. Although the old man saw him and tried to grab him, John was able to get away. He ran as fast as he could and following the path found his way out of the forest.

Figure A.34: Formative Study - Short Story #1 - Version 1

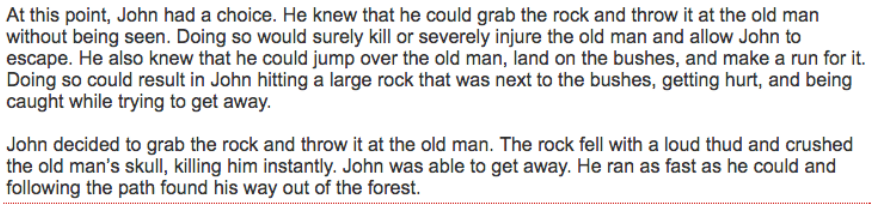


Figure A.35: Formative Study - Short Story #1 - Version 2. In this figure, only the alternate ending is shown. The rest of the story is the same as in version 1.

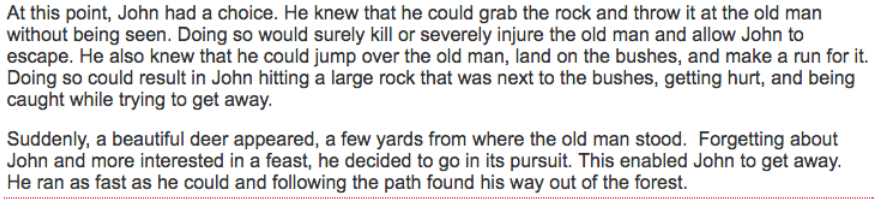


Figure A.36: Formative Study - Short Story #1 - Version 3. In this figure, only the alternate ending is shown. The rest of the story is the same as in version 1.

The Broken Clock

Robert lived in a small town, where he worked at a furniture factory. Lately, work had been very enjoyable due to the arrival of a new employee named Jane. She was a pretty brunette who worked in the same area as Robert. Even though they had just met, Jane and Robert had shared a few laughs, often talked during their break, and sometimes ate lunch together in the company cafeteria.

Today, though, Robert was very upset with Jane. Yesterday he had invited her to the movies, to which she had declined. However, later that evening he happened to walk by the local diner and saw her having coffee with Charles, who also worked at the furniture factory. Robert did not like Charles, and seeing him with Jane filled him with jealousy and a desire to get back at Jane.

There were rumors that Mr. Jones, Robert and Jane's supervisor, owned a very expensive and rare table clock, a constant reminder that his true passion was selling fine antiques and not the making of cheap furniture that he supervised daily in order to make a living. None of the employees had ever seen this clock, as Mr. Jones kept to himself and usually locked his office whenever he was away. Everyone in the factory was very curious to see what it looked like.

While Robert was thinking of the previous day's events, Mr. Jones was suddenly summoned to a very important meeting. In the haste to leave his office, he forgot to lock it. Noticing this, Jane entered the office, found the clock, and picked it up to admire it. It was indeed beautiful and of a unique design. Suddenly Jane noticed that someone was standing at the door; it was Robert, who was giving her an inquisitive look. Startled, she dropped the clock, breaking it. In a panic, she put the clock back, and went back to her work area, crying and blaming Robert for scaring her and making her break the clock.

After Mr. Jones returned to his office, it was not long before he noticed the broken clock and became furious. One by one he questioned the employees. Meanwhile, Robert looked at Jane, curious about her reaction, and a way glad to see her get in trouble. However, when it came Jane's turn to be questioned by Mr. Jones, Robert noticed that her face was pale, that she was shaking with fear, and that she was about to cry.

At this point, Robert had a choice. He knew that if he remained silent, Jane would confess to breaking the clock. Doing so would surely result in her having to pay for the repairs and possibly get her fired. Robert also knew that he could take the blame for breaking the clock. Doing so would surely result in him having to pay for the repairs and possibly get him fired.

When Jane's turn came, Robert confessed to breaking the clock. He was ordered to pay for the repairs and was fired immediately.

Figure A.37: Formative Study - Short Story #2 - Version 1

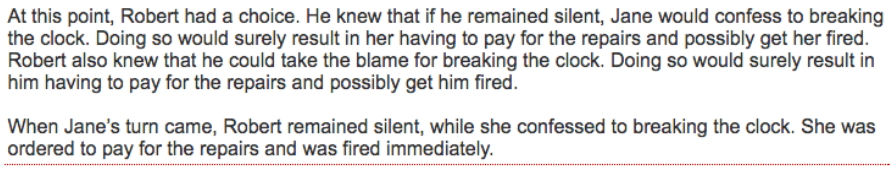


Figure A.38: Formative Study - Short Story #2 - Version 2. In this figure, only the alternate ending is shown. The rest of the story is the same as in version 1.

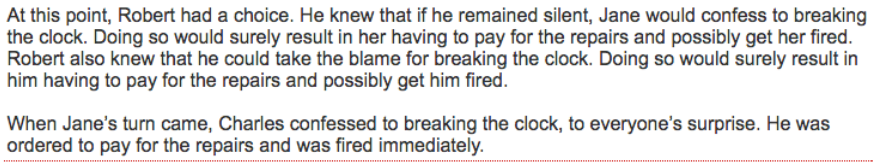


Figure A.39: Formative Study - Short Story #2 - Version 3. In this figure, only the alternate ending is shown. The rest of the story is the same as in version 1.

Lenny

A long time ago there was a young man named Lenny who from an early age had lived away from home. Not having any education or a trade, he worked all kinds of odd jobs. Sometimes he barely survived.

His current work was that of serving as the guide for a blind beggar. Together they went from town to town, panhandling in order to make a living. Lenny was not very fond of his boss, so he took every opportunity to disrespect and annoy him. One of his favorite schemes was to steal items from the sack where the beggar carried his belongings. He would undo the seam, take something out, and then sew it back. When people handed them coins, he was in charge of accepting them and putting them in a box, but he always stole the big coins by hiding them up his sleeve.

Lenny even figured out multiple ways to steal the beggar's wine. When invited to drink, he would take two sips while pretending to take just one. He also made a very long straw that enabled him to drink from a distance. His audacity was such that he even put a hole at the bottom of the wine jug, which he covered with wax, enabling him to steal a drink whenever the beggar was distracted while relaxing by a warm bonfire.

Another one of his shenanigans was to guide the beggar through the worst possible path, making sure that he would walk over sharp pebbles or get his feet dirty in mud puddles.

One day at the market, one of the farmers wanted to help, so he offered them lunch, which they gladly accepted since they were starving. As part of Lenny's job, he would need to help the beggar find his food. The farmer brought over two plates full of food. One had carrots, turnips, and beets. The other had sausages, potatoes, and beef stew.

At this point Lenny had a choice. He knew that he could hand the plate with the turnips to the beggar and keep the one full of meat for himself. Doing so would surely make Lenny happy and leave the beggar feeling hungry. Lenny also knew that he could hand the plate full of meat to the beggar and keep the one with the turnips for himself. Doing so would surely make the beggar happy and leave Lenny feeling hungry.

Lenny chose to give the plate full of meat to the beggar. The beggar was very happy with his meal, while Lenny was left feeling hungry.

Figure A.40: Formative Study - Short Story #3 - Version 1

35. At this point Lenny had a choice. He knew that he could hand the plate with the
36. turnips to the beggar and keep the one full of meat for himself. Doing so would
37. surely make Lenny happy and leave the beggar feeling hungry. Lenny also knew
38. that he could hand the plate full of meat to the beggar and keep the one with the
39. turnips for himself. Doing so would surely make the beggar happy and leave
40. Lenny feeling hungry.
41.
42. Lenny chose to give the plate with the turnips to the beggar. Lenny was very
43. happy with his meal, while the beggar was left feeling hungry.

Figure A.41: Formative Study - Short Story #3 - Version 2. In this figure, only the alternate ending is shown. The rest of the story is the same as in version 1.

1. Did Lenny have a choice at any moment in the story?

Yes ○ No ○

2. Did Lenny's chosen course of action surprise you at any point in the story?

Yes ○ No ○

Figure A.42: Formative Study - Short Story #3 - Additional Survey - Page 1

3. If you answered yes to question #2, please indicate the line or line numbers in the story where this occurred.

Lenny

A long time ago there was a young man named Lenny who from an early age had lived away from home. Not having any education or a trade, he worked all kinds of odd jobs. Sometimes he barely survived.

His current work was that of serving as the guide for a blind beggar. Together they went from town to town, panhandling in order to make a living. Lenny was not very fond of his boss, so he took every opportunity to disrespect and annoy him. One of his favorite schemes was to steal items from the sack where the beggar carried his belongings. He would undo the seam, take something out, and then sew it back. When people handed them coins, he was in charge of accepting them and putting them in a box, but he always stole the big coins by hiding them up his sleeve.

Lenny even figured out multiple ways to steal the beggar's wine. When invited to drink, he would take two sips while pretending to take just one. He also made a very long straw that enabled him to drink from a distance. His audacity was such that he even put a hole at the bottom of the wine jug, which he covered with wax, enabling him to steal a drink whenever the beggar was distracted while relaxing by a warm bonfire.

Another one of his shenanigans was to guide the beggar through the worst possible path, making sure that he would walk over sharp pebbles or get his feet dirty in mud puddles.

One day at the market, one of the farmers wanted to help, so he offered them lunch, which they gladly accepted since they were starving. As part of Lenny's job, he would need to help the beggar find his food. The farmer brought over two plates full of food. One had carrots, turnips, and beets. The other had sausages, potatoes, and beef stew.

At this point Lenny had a choice. He knew that he could hand the plate with the turnips to the beggar and keep the one full of meat for himself. Doing so would surely make Lenny happy and leave the beggar feeling hungry. Lenny also knew that he could hand the plate full of meat to the beggar and keep the one with the turnips for himself. Doing so would surely make the beggar happy and leave Lenny feeling hungry.

Lenny chose to give the plate with the turnips to the beggar. Lenny was very happy with his meal, while the beggar was left feeling hungry.

Figure A.43: Formative Study - Short Story #3 - Additional Survey - Page 2

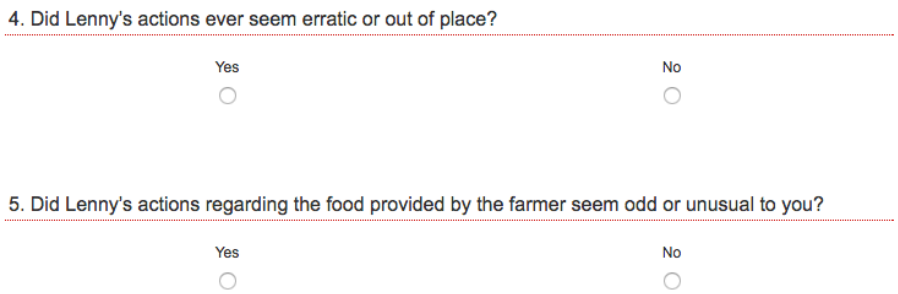


Figure A.44: Formative Study - Short Story #3 - Additional Survey - Page 2 (cont'd)

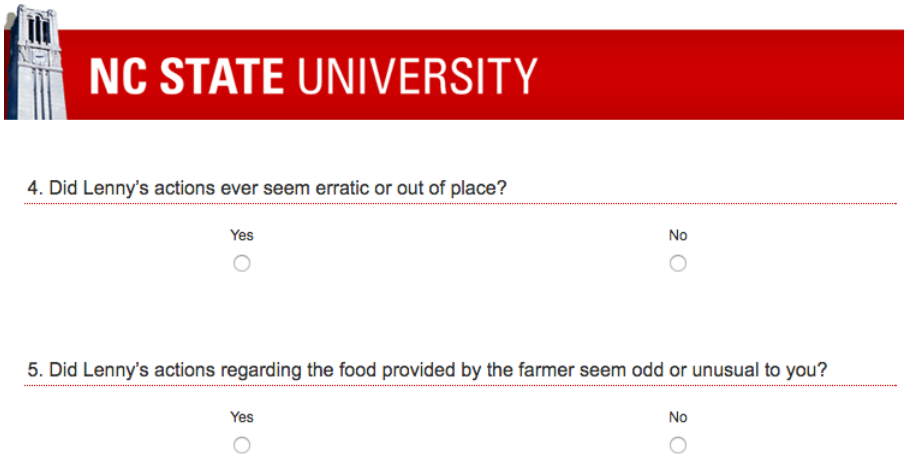


Figure A.45: Formative Study - Short Story #3 - Additional Survey - Page 3

A.3 Mask System Evaluation

The materials used for the evaluation of the *Mask* system were almost identical to those used in the formative study. The main differences were in the content of the stories used, which were generated by *Mask* instead of being handcrafted, as is the case for the previous studies. The personality and content surveys were the same. The survey questions used can be seen in Figures A.10 to A.19, in Figures A.20 to A.29, and in Figures A.42 to A.45.

The Kidnapping of The Princess

Once upon a time...
A Princess went from the royal palace to the forest.
She enjoyed herself.
She lost track of time.
She stayed too long, attracting the attention of a Dragon.
The Dragon went from the cave to the forest.
He dragged off the Princess from the forest to the cave.
He kidnaped the Princess to the cave.
The Princess screamed for help, to attract the attention of a Knight.

At this point, the Knight knew that he had a choice. First, he could go from the cabin to the cave and help organize the escape of the Princess from the Dragon. As a result of this choice, the Dragon would not die.
Alternatively, he could go from the cabin to the cave, fight to rescue the Princess from the Dragon and return back home with the Princess. As a result of this choice, the Dragon would die.
The Knight decided on the first option: go from the cabin to the cave and help organize the escape of the Princess from the Dragon.

He helped organize the escape of the Princess from the Dragon.
He returned back home with the Princess.
The King heard about the rescue of the Princess.
He rewarded the Knight.

-- The End --

Figure A.46: Mask System Evaluation - Short Story #1 - Version 1

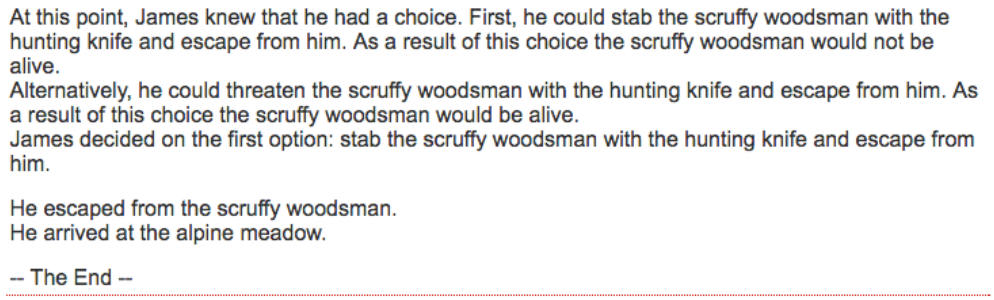


Figure A.47: Mask System Evaluation - Short Story #1 - Version 2. In this figure, only the alternate ending is shown. The rest of the story is the same as in version 1.

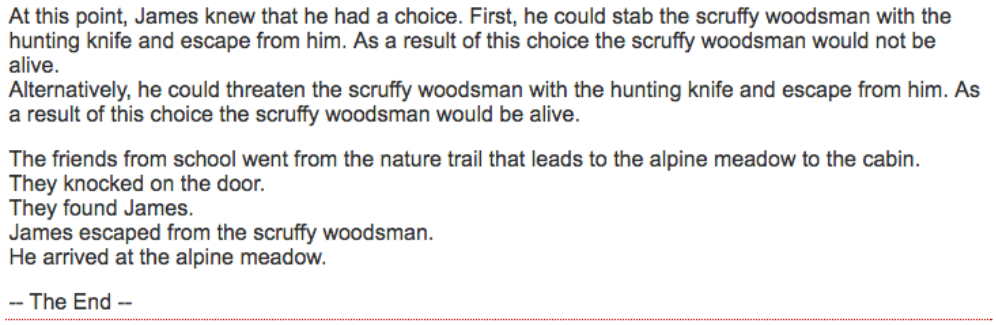


Figure A.48: Mask System Evaluation - Short Story #1 - Version 3. In this figure, only the alternate ending is shown. The rest of the story is the same as in version 1.

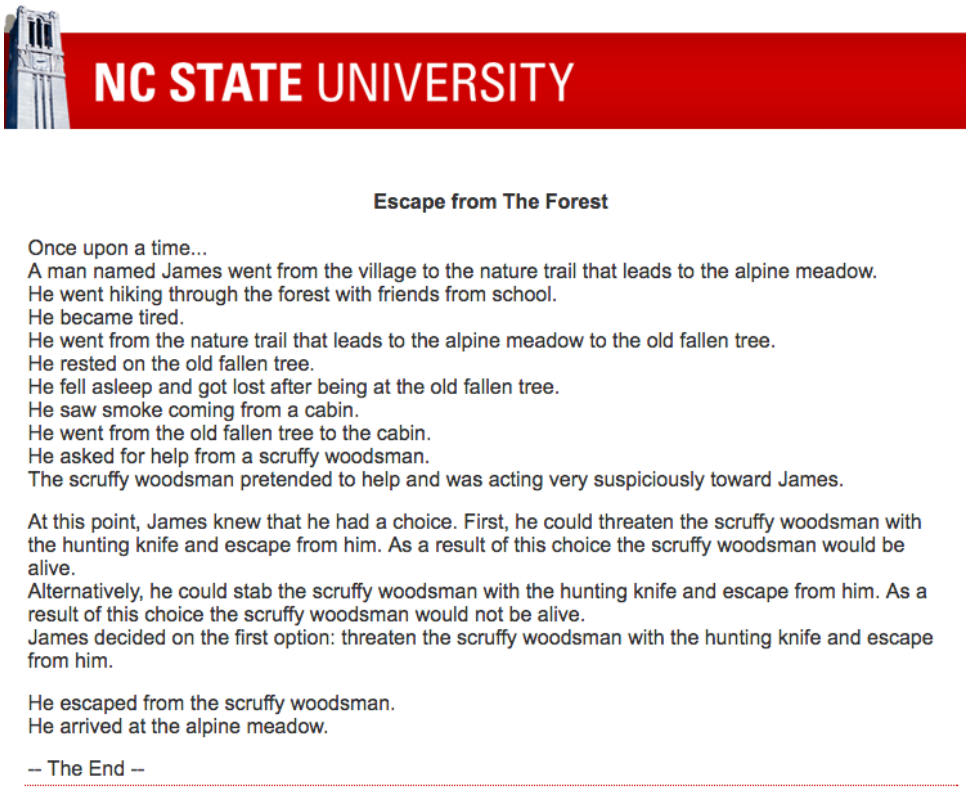


Figure A.49: Mask System Evaluation - Short Story #2 - Version 1

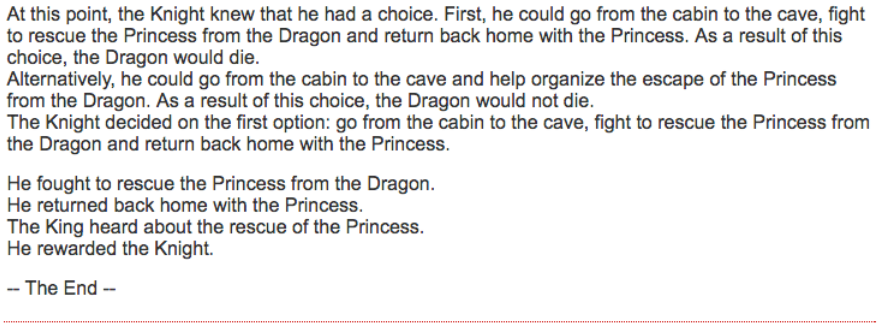


Figure A.50: Mask System Evaluation - Short Story #2 - Version 2. In this figure, only the alternate ending is shown. The rest of the story is the same as in version 1.

At this point, the Knight knew that he had a choice. First, he could go from the cabin to the cave, fight to rescue the Princess from the Dragon and return back home with the Princess. As a result of this choice, the Dragon would die.
Alternatively, he could go from the cabin to the cave and help organize the escape of the Princess from the Dragon. As a result of this choice, the Dragon would not die.

The Dragon got hungry.
He decided to hunt for food.
The Dragon went from the cave to the forest.
The Princess managed to escape.
She went from the cave to the royal palace.

-- The End --

Figure A.51: Mask System Evaluation - Short Story #2 - Version 3. In this figure, only the alternate ending is shown. The rest of the story is the same as in version 1.

Jane

1. Once upon a time...
2. A woman named Jane got cold.
3. She stole a winter jacket from the department store at the mall.
4. She wore the winter jacket.
5. She got hungry.
6. She stole bread from the neighborhood bakery.
7. She ate the bread.
8. She got thirsty.
9. She stole a soda pop from the convenience store at the end of the street.
10. She drank the soda pop.
11. A homeless person asked Jane for bread.
12.
13. At this point, Jane knew that she had a choice. First, she could share with
14. the homeless person a generous portion of bread. As a result of this choice,
15. the homeless person would have bread and he would not be hungry.
16. Alternatively, she could beat up the homeless person. As a result of
17. this choice, the homeless person would not have bread and he would
18. be hungry. Jane decided on the first option: share with the homeless
19. person a generous portion of bread.
20.
21. Jane shared with the homeless person a generous portion of bread.
22.
23. -- The End --

Figure A.52: Mask System Evaluation - Short Story #3 - Version 1

13. At this point, Jane knew that she had a choice. First, she could beat up
14. the homeless person. As a result of this choice, the homeless person
15. would not have bread and he would be hungry.
16. Alternatively, she could share with the homeless person a generous
17. portion of bread. As a result of this choice, the homeless person would
18. have bread and he would not be hungry.
19. Jane decided on the first option: beat up the homeless person.
20.
21. Jane beat up the homeless person.
22.
23. -- The End --

Figure A.53: Mask System Evaluation - Short Story #3 - Version 2. In this figure, only the alternate ending is shown. The rest of the story is the same as in version 1.

Appendix B

Implementation of Narrative Generation Scenarios

This appendix contains the planning domain and planning problem definitions that were used to generate stories. The resulting plans and the English text produced by Mask are also included. The planning domains, planning problems, and plans are written in PDDL. Note that the names of characters and places were modified in the stories that were presented to study participants. This was done to obscure the actual narrative sources in order to prevent the introduction of bias due to prior knowledge of the story content. For example, *Bilbo* was renamed *James* and *Gollum* became the *Scruffy Woodsman*.

B.1 Riddles in The Dark

B.1.1 Planning Domain

```
;;;
;;; A highly simplified version of the events that take place
;;; when Bilbo Baggins is trapped under The Misty Mountains
;;; and being chased by Gollum.
;;;
;;; Created by Julio C. Bahamon
;;;

;;;
(define (domain bilbo-cave)
  (:requirements :adl :domain-axioms :intentionality)
```

```
  (:types character place - object
          weapon - item
          monster - character
          evildoer - character
          protagonist - character)
  (:constants  trail meadow fallen-tree town cabin
               boulder - place)
  (:predicates (alive ?actor - character)
               (at ?actor - character ?place - place)
               (has ?actor - character ?item - item)
               (stabbed ?actor - character)
               (next-to ?place-x - place ?place-y - place)
               (disabled ?actor)
               (captured ?actor)
               (alone ?actor)
               (tired ?actor)
               (lost ?actor)
               (has-visited ?actor - character ?location - place)
               (cross-trail ?actor)
               (by-self ?actor - character ?location - place)
               (have-seen-smoke ?actor)
               (get-help ?actor)
               (requested-help ?actor)
               (help-exists ?place)
               (in-danger ?actor)
               (being-followed ?actor ?follower - character)
               (injured ?actor)
               (well-rested ?actor)
)



  ;;; A character moves from one place to another.
  ;;; The places must be next to each other and
  ;;; the destination cannot be blocked.
  (:action move
    :parameters   (?actor - character ?from - place ?to - place)
```

```
    :precondition (and (not (= ?from ?to))
                       (alive ?actor)
                       (at ?actor ?from)
                       (or (next-to ?from ?to)
                           (next-to ?to ?from))
                  )
    :effect        (and (not (at ?actor ?from))
                       (at ?actor ?to))
        )


(:action capture
    :parameters   (?captor - evildoer ?victim - character)
    :precondition (and (alive ?captor)
                       (alive ?victim)
                       (lost ?victim)
                       (not (captured ?victim))
                       (not (= ?captor ?victim)))
    :effect       (captured ?victim)
    :actor (?captor)
    )



(:action go-hiking
    :parameters  (?actor - protagonist ?companion - character)
    :precondition  (and (alive ?actor) (alive ?companion)
                        (at ?actor trail) (at ?companion trail)
                        (not (= ?actor ?companion))
                        )
    :effect        (and (cross-trail ?actor)
                        (cross-trail ?companion)
                        )
    :agents (?actor)
    )
```

```
(:action get-tired
    :parameters  (?actor - protagonist)
    :precondition  (and (cross-trail ?actor)
                        (alive ?actor)
                        )
    :effect        (and (tired ?actor)
                        (intends ?actor (not (tired ?actor)))
                        )
    )



(:action rest
    :parameters  (?actor - protagonist ?location - place)
    :precondition  (and (tired ?actor)
                        (alive ?actor)
                        (at ?actor ?location)
                        (= ?location fallen-tree)
                   )
    :effect        (and (not (tired ?actor)) (alone ?actor)
                    (well-rested ?actor))
    :agents (?actor)
    )


(:action get-lost
    :parameters    (?actor - protagonist ?location - place)
    :precondition  (and (alive ?actor)
                        (alone ?actor)
                        (at ?actor ?location)
                        (by-self ?actor ?location)
                        )
    :effect         (and (lost ?actor)
                         (intends ?actor (not (lost ?actor)))
                         )
    :actor (?actor)
    )
```

```
(:action visit-special-location
 :parameters (?actor - protagonist ?location - place)
 :precondition  (and (cross-trail ?actor)
                     (alive ?actor)
                     (not (tired ?actor))
                     (not (alone ?actor))
                     (well-rested ?actor)
                   )
    :effect (and (has-visited ?actor ?location)
                 (at ?actor ?location))
    :agents (?actor)
    )


(:action see-smoke
    :parameters    (?actor - protagonist ?smoke-location
                    ?actor-location - place)
    :precondition  (and (alive ?actor)
                        (lost ?actor)
                        (next-to ?actor-location ?smoke-location)
                        (help-exists ?smoke-location)
                        )
    :effect        (and (have-seen-smoke ?actor)
                        (intends ?actor (requested-help ?actor)))
    )


(:action ask-for-help
    :parameters    (?actor - protagonist ?helper - character
                    ?location - place)
    :precondition  (and (alive ?actor)
                        (lost ?actor)
                        (at ?actor ?location)
                        (at ?helper ?location)
                        (not (= ?actor ?helper))
```

```
                    (have-seen-smoke ?actor)
                    (help-exists ?location)
                    )
    :effect       (and (requested-help ?actor)
                    (intends ?helper (captured ?actor)))
    )


(:action pretend-to-help
    :parameters    (?pretender - evildoer ?actor - protagonist
                    ?location - place)
    :precondition  (and (alive ?actor)
                    (lost ?actor)
                    (at ?actor ?location)
                    (at ?pretender ?location)
                    (not (= ?actor ?pretender))
                    (requested-help ?actor)
                    )
    :effect       (and (in-danger ?actor) ;(not (safe ?actor))
                    (intends ?actor (not (in-danger ?actor)))
                    )
    )


(:action escape
 :parameters    (?actor - protagonist ?follower - evildoer)
    :precondition  (and (alive ?actor)
                    (not (= ?actor ?follower))
                    ;(being-followed ?actor ?follower)
                    (disabled ?follower)
                    )
    :effect       (and (not (alone ?actor))
                    (not (in-danger ?actor))
                  )
    :agents (?actor)
    )
```

```
;;; A character can stab another character to death,
;;; but not himself.
;;; Also, they should be at the same location.
(:action stab-to-death
    :parameters    (?actor - protagonist ?victim - character
                    ?weapon - weapon ?place - place)
    :precondition  (and  (not (= ?actor ?victim))
                         (alive ?actor)
                         (alive ?victim)
                         (has ?actor ?weapon)
                         (and (at ?actor ?place)
                                (at ?victim ?place))
                         (in-danger ?actor)

                         ;;; Prevents character from
                         ;;; re-stabbing others
                         (not (stabbed ?victim)))
    :effect (and (disabled ?victim) (stabbed ?victim)
                 (not (alive ?victim)))
    :agents (?actor)
  )


;;; A character can stab another character to disable him/her,
;;; but not himself.
;;; Also, they should be at the same location.
(:action stab-to-disable
    :parameters    (?actor - protagonist ?victim - character
                    ?weapon - weapon ?place - place)
    :precondition  (and  (not (= ?actor ?victim))
                         (alive ?actor)
                         (alive ?victim)
                         (has ?actor ?weapon)
                         (and (at ?actor ?place)
                                (at ?victim ?place))
```

```
                         (in-danger ?actor)
                         ;(being-followed ?actor ?victim)

                         ;;; Prevents character from
                         ;;; re-stabbing others
                         (not (stabbed ?victim)))
    :effect        (and (disabled ?victim)
                        (stabbed ?victim)
                        (injured ?victim)
                        ;(not (being-followed ?actor ?victim))
                        )
    :agents (?actor)
    )


;;;
;;; AXIOMS - USED IN SOME PRECONDITIONS
;;;

;;; When only one character is at a given location, the character
;;; is by herself
(:axiom
     :vars     (?actor - protagonist ?location - place)
     :context  (and (at ?actor ?location)
                    (not (exists (?other-char - character)
                                 (and (at ?other-char ?location)
                                      (not (= ?other-char ?actor))
                                      )
                                 )
                         )
                    )
     :implies  (by-self ?actor ?location)
     )
)
```

B.1.2 Planning Problem

```
;;;
;;; A highly simplified version of the events that take place when
;;; Bilbo Baggins is trapped in a cave under The Misty Mountains
;;; and being chased by Gollum.
;;;
;;; Created by Julio C. Bahamon
;;;

(define (problem escape-cave)
  (:domain bilbo-cave)
  (:objects bilbo - protagonist
            merry-party - character
            gollum - evildoer
            knife - weapon
            )

  (:init

;;;
;;; Bilbo's state and intentions
         (alive bilbo)
         (at bilbo town)
         (has bilbo knife)
         (not (alone bilbo))
         (intends bilbo (has-visited bilbo meadow))

;;; Bilbo's friends - state
         (alive merry-party)
         (at merry-party trail)

;;; Gollum's state and preferences
         (alive gollum)
         (at gollum cabin)
```

```
;;; General aspects of the initial state
(help-exists cabin)


;;; A basic map of the world, i.e. what locations are connected.
;;; The order does not matter.
         (next-to town trail)
         (next-to fallen-tree trail)
         (next-to fallen-tree cabin)
         (next-to cabin boulder)


;;; END-OF-INITIAL-STATE
    )

;;; Story goal
    (:goal
     (and
      (requested-help bilbo)
      (has-visited bilbo meadow)
      ;(has-visited merry-party meadow)
     )
    )

)
```

B.1.3 Plan Generated for High Agreeableness

```
(
(define (plan escape-cave-solution)
  (:problem escape-cave)
  (:steps ;;; Step ID: 0
          (start)
          ;;; Step ID: 1
          (move bilbo town trail)
          ;;; Step ID: 2
          (go-hiking bilbo merry-party)
```

```
        ;;; Step ID: 3
        (get-tired bilbo)
        ;;; Step ID: 4
        (move bilbo trail fallen-tree)
        ;;; Step ID: 5
        (rest bilbo fallen-tree)
        ;;; Step ID: 6
        (get-lost bilbo fallen-tree)
        ;;; Step ID: 7
        (see-smoke bilbo cabin fallen-tree)
        ;;; Step ID: 8
        (move bilbo fallen-tree cabin)
        ;;; Step ID: 9
        (ask-for-help bilbo gollum cabin)
        ;;; Step ID: 10
        (pretend-to-help gollum bilbo cabin)
        ;;; Step ID: 11
        (stab-to-disable bilbo gollum knife cabin)
        ;;; Step ID: 12
        (escape bilbo gollum)
        ;;; Step ID: 13
        (visit-special-location bilbo meadow)
        ;;; Step ID: 14
        (end))
(:orderings (6 14)
            (6 9)
            (6 10)
            (6 7)
            (6 8)
            (3 14)
            (3 5)
            (0 1)
            (0 2)
            (0 3)
            (0 4)
            (0 5)
            (0 6)
```

(0 7)
(0 8)
(0 9)
(0 10)
(0 11)
(0 12)
(0 13)
(0 14)
(9 14)
(9 10)
(13 14)
(5 14)
(5 6)
(5 13)
(7 14)
(7 9)
(10 14)
(10 11)
(10 12)
(12 14)
(12 13)
(4 14)
(4 6)
(4 5)
(4 8)
(1 14)
(1 2)
(1 4)
(8 14)
(8 9)
(8 10)
(8 11)
(2 14)
(2 13)
(2 3)
(2 4)
(11 14)

```
            (11 12))
(:causal-links (0 (by-self bilbo fallen-tree) 6)
               (4 (by-self bilbo fallen-tree) 6)
               (0 (by-self bilbo fallen-tree) 6)
               (0 (by-self bilbo fallen-tree) 6)
               (4 (by-self bilbo fallen-tree) 6)
               (0 (by-self bilbo fallen-tree) 6)
               (0 (by-self bilbo fallen-tree) 6)
               (4 (by-self bilbo fallen-tree) 6)
               (0 (by-self bilbo fallen-tree) 6)
               (0 (by-self bilbo fallen-tree) 6)
               (4 (by-self bilbo fallen-tree) 6)
               (0 (by-self bilbo fallen-tree) 6)
               (0 (by-self bilbo fallen-tree) 6)
               (4 (by-self bilbo fallen-tree) 6)
               (0 (by-self bilbo fallen-tree) 6)
               (0 (by-self bilbo fallen-tree) 6)
               (4 (by-self bilbo fallen-tree) 6)
               (0 (by-self bilbo fallen-tree) 6)
               (0 (by-self bilbo fallen-tree) 6)
               (4 (by-self bilbo fallen-tree) 6)
               (0 (by-self bilbo fallen-tree) 6)
               (0 (by-self bilbo fallen-tree) 6)
               (4 (by-self bilbo fallen-tree) 6)
               (0 (by-self bilbo fallen-tree) 6)
               (0 (alive bilbo) 6)
               (5 (alone bilbo) 6)
               (4 (at bilbo fallen-tree) 6)
               (8 (at bilbo cabin) 9)
               (6 (lost bilbo) 9)
               (7 (have-seen-smoke bilbo) 9)
               (0 (help-exists cabin) 9)
               (0 (alive bilbo) 9)
               (0 (at gollum cabin) 9)
               (0 (alive bilbo) 10)
               (9 (requested-help bilbo) 10)
               (8 (at bilbo cabin) 10)
```

```
(6 (lost bilbo) 10)
(0 (at gollum cabin) 10)
(12 (not (alone bilbo)) 13)
(2 (cross-trail bilbo) 13)
(5 (not (tired bilbo)) 13)
(0 (alive bilbo) 13)
(5 (well-rested bilbo) 13)
(8 (at bilbo cabin) 11)
(0 (at gollum cabin) 11)
(0 (alive bilbo) 11)
(10 (in-danger bilbo) 11)
(0 (has bilbo knife) 11)
(0 (alive gollum) 11)
(0 (not (stabbed gollum)) 11)
(1 (at bilbo trail) 2)
(0 (alive bilbo) 2)
(0 (alive merry-party) 2)
(0 (at merry-party trail) 2)
(11 (disabled gollum) 12)
(0 (alive bilbo) 12)
(0 (help-exists cabin) 7)
(0 (next-to fallen-tree cabin) 7)
(6 (lost bilbo) 7)
(0 (alive bilbo) 7)
(0 (alive bilbo) 3)
(2 (cross-trail bilbo) 3)
(4 (at bilbo fallen-tree) 5)
(3 (tired bilbo) 5)
(0 (alive bilbo) 5)
(0 (alive bilbo) 1)
(0 (at bilbo town) 1)
(0 (next-to town trail) 1)
(0 (alive bilbo) 4)
(0 (next-to fallen-tree trail) 4)
(1 (at bilbo trail) 4)
(0 (alive bilbo) 8)
(0 (next-to fallen-tree cabin) 8)
```

```
                (4 (at bilbo fallen-tree) 8)
                (13 (has-visited bilbo meadow) 14)
                (9 (requested-help bilbo) 14))
  (:intention-frames (:frame
                       :agent       bilbo
                       :goal        (not (tired bilbo))
                       :motivations (3)
                       :steps       (5))
                     (:frame
                       :agent       bilbo
                       :goal        (not (in-danger bilbo))
                       :motivations (10)
                       :steps       (11 12))
                     (:frame
                       :agent       bilbo
                       :goal        (has-visited bilbo meadow)
                       :motivations (0)
                       :steps       (2 5 11 12 13))))
)
```

B.1.4 English Text Generated for High Agreeableness

```
---------------------
Story Text:
---------------------
Once upon a time...
A man named James went from the village to the nature trail
that leads to the alpine meadow.
He went hiking through the forest with friends from school.
He became tired.
He went from the nature trail that leads to the alpine meadow
to the old fallen tree.
He rested on the old fallen tree.
He fell asleep and got lost after being at the old fallen tree.
He saw smoke coming from a cabin.
He went from the old fallen tree to the cabin.
He asked for help from a scruffy woodsman.
```

```
The scruffy woodsman pretended to help and was acting very
suspiciously toward James.

At this point, James knew that he had a choice. First, he
could threaten the scruffy woodsman with the hunting knife
and escape from him.
As a result of this choice the scruffy woodsman would be alive.
Alternatively, he could stab the scruffy woodsman with
the hunting knife and escape from him. As a result of
this choice the scruffy woodsman would not be alive.
James decided on the first option: threaten the scruffy
woodsman with the hunting knife and escape from him.

He escaped from the scruffy woodsman.
He arrived at the alpine meadow.

-- The End --
```

B.1.5 Plan Generated for Low Agreeableness

```
(
(define (plan escape-cave-solution)
  (:problem escape-cave)
  (:steps ;;; Step ID: 0
          (start)
          ;;; Step ID: 1
          (move bilbo town trail)
          ;;; Step ID: 2
          (go-hiking bilbo merry-party)
          ;;; Step ID: 3
          (get-tired bilbo)
          ;;; Step ID: 4
          (move bilbo trail fallen-tree)
          ;;; Step ID: 5
          (rest bilbo fallen-tree)
          ;;; Step ID: 6
          (get-lost bilbo fallen-tree)
```

```
        ;;; Step ID: 7
        (see-smoke bilbo cabin fallen-tree)
        ;;; Step ID: 8
        (move bilbo fallen-tree cabin)
        ;;; Step ID: 9
        (ask-for-help bilbo gollum cabin)
        ;;; Step ID: 10
        (pretend-to-help gollum bilbo cabin)
        ;;; Step ID: 11
        (stab-to-death bilbo gollum knife cabin)
        ;;; Step ID: 12
        (escape bilbo gollum)
        ;;; Step ID: 13
        (visit-special-location bilbo meadow)
        ;;; Step ID: 14
        (end))
(:orderings (6 14)
            (6 9)
            (6 10)
            (6 7)
            (6 8)
            (3 14)
            (3 5)
            (0 1)
            (0 2)
            (0 3)
            (0 4)
            (0 5)
            (0 6)
            (0 7)
            (0 8)
            (0 9)
            (0 10)
            (0 11)
            (0 12)
            (0 13)
            (0 14)
```

```
            (9 14)
            (9 10)
            (13 14)
            (5 14)
            (5 6)
            (5 13)
            (7 14)
            (7 9)
            (10 14)
            (10 11)
            (10 12)
            (12 14)
            (12 13)
            (4 14)
            (4 6)
            (4 5)
            (4 8)
            (1 14)
            (1 2)
            (1 4)
            (8 14)
            (8 9)
            (8 10)
            (8 11)
            (2 14)
            (2 13)
            (2 3)
            (2 4)
            (11 14)
            (11 12))
(:causal-links (8 (at bilbo cabin) 9)
               (6 (lost bilbo) 9)
               (7 (have-seen-smoke bilbo) 9)
               (0 (help-exists cabin) 9)
               (0 (alive bilbo) 9)
               (0 (at gollum cabin) 9)
               (0 (by-self bilbo fallen-tree) 6)
```

```
(4 (by-self bilbo fallen-tree) 6)
(0 (by-self bilbo fallen-tree) 6)
(0 (by-self bilbo fallen-tree) 6)
(4 (by-self bilbo fallen-tree) 6)
(0 (by-self bilbo fallen-tree) 6)
(0 (by-self bilbo fallen-tree) 6)
(4 (by-self bilbo fallen-tree) 6)
(0 (by-self bilbo fallen-tree) 6)
(0 (by-self bilbo fallen-tree) 6)
(4 (by-self bilbo fallen-tree) 6)
(0 (by-self bilbo fallen-tree) 6)
(0 (by-self bilbo fallen-tree) 6)
(4 (by-self bilbo fallen-tree) 6)
(0 (by-self bilbo fallen-tree) 6)
(0 (by-self bilbo fallen-tree) 6)
(4 (by-self bilbo fallen-tree) 6)
(0 (by-self bilbo fallen-tree) 6)
(0 (by-self bilbo fallen-tree) 6)
(4 (by-self bilbo fallen-tree) 6)
(0 (by-self bilbo fallen-tree) 6)
(0 (by-self bilbo fallen-tree) 6)
(4 (by-self bilbo fallen-tree) 6)
(0 (by-self bilbo fallen-tree) 6)
(0 (alive bilbo) 6)
(5 (alone bilbo) 6)
(4 (at bilbo fallen-tree) 6)
(0 (alive bilbo) 10)
(9 (requested-help bilbo) 10)
(8 (at bilbo cabin) 10)
(6 (lost bilbo) 10)
(0 (at gollum cabin) 10)
(12 (not (alone bilbo)) 13)
(2 (cross-trail bilbo) 13)
(5 (not (tired bilbo)) 13)
(0 (alive bilbo) 13)
(5 (well-rested bilbo) 13)
(1 (at bilbo trail) 2)
```

```
                (0 (alive bilbo) 2)
                (0 (alive merry-party) 2)
                (0 (at merry-party trail) 2)
                (0 (help-exists cabin) 7)
                (0 (next-to fallen-tree cabin) 7)
                (6 (lost bilbo) 7)
                (0 (alive bilbo) 7)
                (0 (alive bilbo) 3)
                (2 (cross-trail bilbo) 3)
                (10 (in-danger bilbo) 11)
                (0 (alive bilbo) 11)
                (0 (at gollum cabin) 11)
                (0 (has bilbo knife) 11)
                (0 (alive gollum) 11)
                (0 (not (stabbed gollum)) 11)
                (8 (at bilbo cabin) 11)
                (4 (at bilbo fallen-tree) 5)
                (3 (tired bilbo) 5)
                (0 (alive bilbo) 5)
                (11 (disabled gollum) 12)
                (0 (alive bilbo) 12)
                (0 (alive bilbo) 8)
                (0 (next-to fallen-tree cabin) 8)
                (4 (at bilbo fallen-tree) 8)
                (0 (alive bilbo) 4)
                (0 (next-to fallen-tree trail) 4)
                (1 (at bilbo trail) 4)
                (0 (alive bilbo) 1)
                (0 (at bilbo town) 1)
                (0 (next-to town trail) 1)
                (13 (has-visited bilbo meadow) 14)
                (9 (requested-help bilbo) 14))
(:intention-frames (:frame
                     :agent       bilbo
                     :goal        (has-visited bilbo meadow)
                     :motivations (0)
                     :steps       (2 5 11 12 13))
```

```
                    (:frame
                      :agent       bilbo
                      :goal        (not (tired bilbo))
                      :motivations (3)
                      :steps       (5))
                    (:frame
                      :agent       bilbo
                      :goal        (not (in-danger bilbo))
                      :motivations (10)
                      :steps       (11 12))))
)
```

B.1.6 English Text Generated for Low Agreeableness

```
---------------------
Story Text:
---------------------
Once upon a time...
A man named James went from the village to the nature trail that
leads to the alpine meadow.
He went hiking through the forest with friends from school.
He became tired.
He went from the nature trail that leads to the alpine meadow
to the old fallen tree.
He rested on the old fallen tree.
He fell asleep and got lost after being at the old
fallen tree.
He saw smoke coming from a cabin.
He went from the old fallen tree to the cabin.
He asked for help from a scruffy woodsman.
The scruffy woodsman pretended to help and was acting
very suspiciously
toward James.

At this point, James knew that he had a choice. First, he
could stab the scruffy woodsman with the hunting knife
and escape from him. As a result of this choice the scruffy
```

```
woodsman would not be alive.
Alternatively, he could threaten the scruffy woodsman with
the hunting knife and escape from him. As a result of this
choice the scruffy woodsman would be alive.
James decided on the first option: stab the scruffy woodsman
with the hunting knife and escape from him.

He escaped from the scruffy woodsman.
He arrived at the alpine meadow.

-- The End --
```

B.2 The Kidnapping of The Princess

B.2.1 Planning Domain

```
;;;
;;; Based on the original Dragon test domain
;;; created by Stephen G. Ware for his dissertation.
;;;
;;; Modified by Julio Cesar Bahamon
;;;
(define (domain dragon)
  (:requirements :adl :equality :typing :intentionality)
  (:types lair - place hero monster - person)
  (:constants forest - place)
  (:predicates (at ?p - person ?place - place)
               (enjoying-self ?p - person)
               (distracted ?p - person)
               (kidnapped ?p1 - person ?p2 - monster)
               (home ?p - person ?h - place)
               (parent-of ?child ?parent - person)
               (weak ?person - person)
               (dangerous ?place - place)
               (intends-rescue ?hero ?victim - person)
               ; this allows for faux-delegation
```

```
                (dead ?p - person)
                (indebted-to ?p1 ?p2 - person)
                (at-home ?p - person)
                (bound ?p - person)
                (rich ?p - person)
                (pacifist ?p - person)
)

  (:action go
    :parameters   (?person - person ?from - place ?to - place)
    :precondition (and (not (= ?from ?to)) (at ?person ?from)
                  (not (bound ?person)) (not (dangerous ?to))
                  (not (dead ?person)))
    :effect       (and (not (at ?person ?from))
                       (at ?person ?to))
    :agents (?person))

  ; We create a second action here to avoid
  ; a disjunctive precondition
  (:action go-boldly
    :parameters   (?person - person ?from ?to - place)
    :precondition (and (not (= ?from ?to)) (at ?person ?from)
                  (not (bound ?person)) (not (weak ?person)))
    :effect       (and (not (at ?person ?from))
                       (at ?person ?to))
    :agents (?person))

  (:action enjoy-ones-self
    :parameters (?person - person)
    :precondition (at ?person forest)
    :effect (enjoying-self ?person))

  (:action lose-track-of-time
    :parameters (?person - person)
    :precondition (enjoying-self ?person)
    :effect (distracted ?person))
```

```
(:action stay-too-long
  :parameters (?person - person ?watcher - monster
               ?place - place)
  :precondition (and (distracted ?person)
             (at ?person ?place))
  :effect (and (intends ?watcher
                  (kidnapped ?person ?watcher))
               ; I believe it's just a bug in Glaive's
               ; heurisitic but it won't make the Dragon
               ; go to the forest unless it's explicitly a
               ;goal, even though the action is part
               ; of the kidnap motivation frame.
               ; (Note by SGW)
               (intends ?watcher (at ?watcher ?place))))

(:action drag-off
  :parameters (?kidnapper - monster ?victim - person
               ?from - place ?to - lair)
  :precondition (and (at ?victim ?from)
                 (at ?kidnapper ?from)
                 (distracted ?victim)
                 (not (= ?kidnapper ?victim)))
  :effect (and (at ?kidnapper ?to) (at ?victim ?to)
               (not (at ?kidnapper ?from))
               (not (at ?victim ?from))
               (not (enjoying-self ?victim))
               (not (distracted ?victim)))
  :agents (?kidnapper))

(:action kidnap
  :parameters (?kidnapper - monster ?victim - person
               ?place - lair)
  :precondition (and (weak ?victim) (at ?kidnapper ?place)
                     (at ?victim ?place)
                     (not (= ?kidnapper ?victim)))
  :effect (and (kidnapped ?victim ?kidnapper)
           (bound ?victim)
```

```
            (intends ?victim
            (not (kidnapped ?victim ?kidnapper))))
  :agents (?kidnapper))

(:action scream-for-help
  :parameters (?victim - person ?hearer - hero
               ?kidnapper - monster)
  :precondition (and (kidnapped ?victim ?kidnapper)
                     (not (= ?victim ?kidnapper))
                (not (= ?victim ?hearer))
                (not (= ?kidnapper ?hearer)))
  :effect (and (intends ?hearer
                 (not (kidnapped ?victim ?kidnapper)))
                 ; If we don't add this, there will be
                 ; no causal link between the princess
                 ; screaming and getting rescued, so
                 ; she will have no motivation for
                 ; screaming. This predicate allows
                 ; a form of faux-delegation of
                 ; the princess' goal to the hero.
                 ; (Note by SGW)
                 (intends-rescue ?hearer ?victim))
  :agents (?victim))

(:action fight
  :parameters (?rescuer - hero ?kidnapper - monster
               ?place - lair)
  :precondition (and (at ?rescuer ?place)
                     (at ?kidnapper ?place)
                     (not (= ?rescuer ?kidnapper))
                     (not (weak ?rescuer)))
  :effect (dead ?kidnapper)
  :agents (?rescuer))

(:action rescue
  :parameters (?rescuer - hero ?victim - person
               ?kidnapper - monster ?place - place)
```

```
    :precondition (and (kidnapped ?victim ?kidnapper)
                   (at ?rescuer ?place)
                   (intends-rescue ?rescuer ?victim)
                   (at ?victim ?place)
                   (not (= ?rescuer ?victim)))
    :effect (and (not (kidnapped ?victim ?kidnapper))
                 (indebted-to ?victim ?rescuer)
                 (intends ?rescuer (at-home ?victim))
                 (not (bound ?victim))
                 (dead ?kidnapper))
    :agents (?rescuer ?victim))


;;; The help-escape operator has the same effects
;;; as the rescue operator, except that the kidnapper
;;; does not die. Also, the kidnapper does not have
;;; to be dead as a precondition.
(:action help-escape
    :parameters (?helper - hero ?victim - person
                 ?kidnapper - monster ?place - place)
    :precondition (and (kidnapped ?victim ?kidnapper)
                    (at ?helper ?place)
                        (intends-rescue ?helper ?victim)
                        (at ?victim ?place)
                        (not (= ?helper ?victim)))
    :effect (and (not (kidnapped ?victim ?kidnapper))
                 (indebted-to ?victim ?helper)
                 (intends ?helper (at-home ?victim))
                 (not (bound ?victim)))
    :agents (?helper ?victim))


  (:action return-home
    :parameters (?rescuer - hero ?victim - person
             ?from - place ?to - place)
    :precondition (and (at ?rescuer ?from) (at ?victim ?from)
                       (not (= ?victim ?rescuer))
```

```
                    (home ?victim ?to)
                    (not (bound ?victim)))
  :effect (and (not (at ?rescuer ?from))
               (not (at ?victim ?from))
               (at ?rescuer ?to) (at ?victim ?to)
               (at-home ?victim))
  :agents (?rescuer))

(:action hear-of-rescue
  :parameters (?father - person ?rescuer - hero
               ?victim - person ?place - place)
  :precondition (and (indebted-to ?victim ?rescuer)
                     (at ?victim ?place) (at ?father ?place)
                     (at ?rescuer ?place) (at-home ?victim)
                     (parent-of ?victim ?father))
  :effect (and (not (indebted-to ?victim ?rescuer))
           (indebted-to ?father ?rescuer)
           (intends ?father
              (not (indebted-to ?father ?rescuer)))))

(:action reward
  :parameters (?giver ?taker - person ?place - place)
  :precondition (and (rich ?giver)
                     (indebted-to ?giver ?taker)
                     (at ?giver ?place) (at ?taker ?place))
  :effect (and (rich ?taker)
           (not (indebted-to ?giver ?taker)))
  :agents (?giver)))
```

B.2.2 Planning Problem

```
(define (problem dragon)
  (:domain dragon)
  (:objects princess king - person dragon - monster
            heroes - hero castle cabin - place cave - lair)
  (:init (at princess castle) (weak princess)
         (at king castle) (parent-of princess king)
```

```
        (rich king) (at dragon cave) (at heroes cabin)
        (home princess castle) (dangerous cave)
        (intends princess (at princess forest)))
  (:goal (rich heroes)))
```

B.2.3 Plan Generated for High Agreeableness

```
(
(define (plan dragon-solution)
  (:problem dragon)
  (:steps ;;; Step ID: 0
          (start)
          ;;; Step ID: 1
          (go princess castle forest)
          ;;; Step ID: 2
          (enjoy-ones-self princess)
          ;;; Step ID: 3
          (lose-track-of-time princess)
          ;;; Step ID: 4
          (stay-too-long princess dragon forest)
          ;;; Step ID: 5
          (go dragon cave forest)
          ;;; Step ID: 6
          (drag-off dragon princess forest cave)
          ;;; Step ID: 7
          (kidnap dragon princess cave)
          ;;; Step ID: 8
          (scream-for-help princess heroes dragon)
          ;;; Step ID: 9
          (go-boldly heroes cabin cave)
          ;;; Step ID: 10
          (help-escape heroes princess dragon cave)
          ;;; Step ID: 11
          (return-home heroes princess cave castle)
          ;;; Step ID: 12
          (hear-of-rescue king heroes princess castle)
```

```
        ;;; Step ID: 13
        (reward king heroes castle)
        ;;; Step ID: 14
        (end))
(:orderings (0 1)
            (0 2)
            (0 3)
            (0 4)
            (0 5)
            (0 6)
            (0 7)
            (0 8)
            (0 9)
            (0 10)
            (0 11)
            (0 12)
            (0 13)
            (0 14)
            (8 14)
            (8 10)
            (8 9)
            (11 14)
            (11 13)
            (11 12)
            (12 14)
            (12 13)
            (4 14)
            (4 6)
            (4 5)
            (4 7)
            (10 14)
            (10 11)
            (10 12)
            (6 14)
            (6 11)
            (6 10)
            (6 7)
```

```
            (2 14)
            (2 3)
            (7 14)
            (7 8)
            (7 10)
            (9 14)
            (9 11)
            (9 10)
            (5 14)
            (5 6)
            (1 14)
            (1 6)
            (1 4)
            (1 2)
            (3 14)
            (3 6)
            (3 4)
            (13 14))
(:causal-links (7 (kidnapped princess dragon) 8)
               (10 (not (bound princess)) 11)
               (0 (home princess castle) 11)
               (6 (at princess cave) 11)
               (9 (at heroes cave) 11)
               (0 (at heroes cabin) 9)
               (0 (not (weak heroes)) 9)
               (0 (not (bound heroes)) 9)
               (3 (distracted princess) 6)
               (1 (at princess forest) 6)
               (5 (at dragon forest) 6)
               (1 (at princess forest) 4)
               (3 (distracted princess) 4)
               (0 (at king castle) 13)
               (12 (indebted-to king heroes) 13)
               (0 (rich king) 13)
               (11 (at heroes castle) 13)
               (2 (enjoying-self princess) 3)
               (1 (at princess forest) 2)
```

```
                (11 (at princess castle) 12)
                (11 (at heroes castle) 12)
                (0 (parent-of princess king) 12)
                (11 (at-home princess) 12)
                (0 (at king castle) 12)
                (10 (indebted-to princess heroes) 12)
                (9 (at heroes cave) 10)
                (7 (kidnapped princess dragon) 10)
                (6 (at princess cave) 10)
                (8 (intends-rescue heroes princess) 10)
                (6 (at princess cave) 7)
                (0 (weak princess) 7)
                (6 (at dragon cave) 7)
                (0 (at dragon cave) 5)
                (0 (not (bound dragon)) 5)
                (0 (not (dead dragon)) 5)
                (0 (not (dangerous forest)) 5)
                (0 (not (dead princess)) 1)
                (0 (not (bound princess)) 1)
                (0 (at princess castle) 1)
                (0 (not (dangerous forest)) 1)
                (13 (rich heroes) 14))
(:intention-frames (:frame
                     :agent   princess
                     :goal    (not (kidnapped princess dragon))
                     :motivations (7)
                     :steps       (8 10))
                   (:frame
                     :agent   heroes
                     :goal    (not (kidnapped princess dragon))
                     :motivations (8)
                     :steps       (9 10))
                   (:frame
                     :agent   king
                     :goal    (not (indebted-to king heroes))
                     :motivations (12)
                     :steps       (13))
```

```
                    (:frame
                      :agent   dragon
                      :goal        (kidnapped princess dragon)
                      :motivations (4)
                      :steps       (5 6 7))
                    (:frame
                      :agent   dragon
                      :goal    (at dragon forest)
                      :motivations (4)
                      :steps       (5))
                    (:frame
                      :agent   heroes
                      :goal    (at-home princess)
                      :motivations (10)
                      :steps       (11))
                    (:frame
                      :agent   princess
                      :goal    (at princess forest)
                      :motivations (0)
                      :steps       (1))))
)
```

B.2.4 English Text Generated for High Agreeableness

```
---------------------
Story Text:
---------------------
Once upon a time...
A Princess went from the royal palace to the forest.
She enjoyed herself.
She lost track of time.
She stayed too long, attracting the attention of a Dragon.
The Dragon went from the cave to the forest.
He dragged off the Princess from the forest to the cave.
He kidnaped the Princess to the cave.
The Princess screamed for help, to attract the attention
```

```
of a Knight.

At this point, the Knight knew that he had a choice. First, he
could go from the cabin to the cave and help organize the
escape of the Princess from the Dragon. As a result of
this choice, the Dragon would not die.
Alternatively, he could go from the cabin to the cave,
fight to rescue the Princess from the Dragon and return
back home with the Princess. As a result of this choice,
the Dragon would die.
The Knight decided on the first option: go from the cabin
to the cave and help organize the escape of the Princess
from the Dragon.

He helped organize the escape of the Princess from
the Dragon.
He returned back home with the Princess.
The King heard about the rescue of the Princess.
He rewarded the Knight.

-- The End --
```

B.2.5 Plan Generated for Low Agreeableness

```
(
(define (plan dragon-solution)
  (:problem dragon)
  (:steps ;;; Step ID: 0
          (start)
          ;;; Step ID: 1
          (go princess castle forest)
          ;;; Step ID: 2
          (enjoy-ones-self princess)
          ;;; Step ID: 3
          (lose-track-of-time princess)
          ;;; Step ID: 4
```

```
        (stay-too-long princess dragon forest)
        ;;; Step ID: 5
        (go dragon cave forest)
        ;;; Step ID: 6
        (drag-off dragon princess forest cave)
        ;;; Step ID: 7
        (kidnap dragon princess cave)
        ;;; Step ID: 8
        (scream-for-help princess heroes dragon)
        ;;; Step ID: 9
        (go-boldly heroes cabin cave)
        ;;; Step ID: 10
        (rescue heroes princess dragon cave)
        ;;; Step ID: 11
        (return-home heroes princess cave castle)
        ;;; Step ID: 12
        (hear-of-rescue king heroes princess castle)
        ;;; Step ID: 13
        (reward king heroes castle)
        ;;; Step ID: 14
        (end))
(:orderings (0 1)
            (0 2)
            (0 3)
            (0 4)
            (0 5)
            (0 6)
            (0 7)
            (0 8)
            (0 9)
            (0 10)
            (0 11)
            (0 12)
            (0 13)
            (0 14)
            (8 14)
            (8 10)
```

```
            (8 9)
            (11 14)
            (11 13)
            (11 12)
            (12 14)
            (12 13)
            (4 14)
            (4 6)
            (4 5)
            (4 7)
            (10 14)
            (10 11)
            (10 12)
            (6 14)
            (6 11)
            (6 10)
            (6 7)
            (2 14)
            (2 3)
            (7 14)
            (7 8)
            (7 10)
            (9 14)
            (9 11)
            (9 10)
            (5 14)
            (5 6)
            (1 14)
            (1 6)
            (1 4)
            (1 2)
            (3 14)
            (3 6)
            (3 4)
            (13 14))
(:causal-links (7 (kidnapped princess dragon) 8)
               (0 (home princess castle) 11)
```

```
(6 (at princess cave) 11)
(9 (at heroes cave) 11)
(10 (not (bound princess)) 11)
(0 (at heroes cabin) 9)
(0 (not (weak heroes)) 9)
(0 (not (bound heroes)) 9)
(3 (distracted princess) 6)
(1 (at princess forest) 6)
(5 (at dragon forest) 6)
(1 (at princess forest) 4)
(3 (distracted princess) 4)
(0 (at king castle) 13)
(12 (indebted-to king heroes) 13)
(0 (rich king) 13)
(11 (at heroes castle) 13)
(2 (enjoying-self princess) 3)
(1 (at princess forest) 2)
(8 (intends-rescue heroes princess) 10)
(6 (at princess cave) 10)
(7 (kidnapped princess dragon) 10)
(9 (at heroes cave) 10)
(11 (at princess castle) 12)
(11 (at heroes castle) 12)
(0 (parent-of princess king) 12)
(11 (at-home princess) 12)
(10 (indebted-to princess heroes) 12)
(0 (at king castle) 12)
(6 (at princess cave) 7)
(0 (weak princess) 7)
(6 (at dragon cave) 7)
(0 (at dragon cave) 5)
(0 (not (bound dragon)) 5)
(0 (not (dead dragon)) 5)
(0 (not (dangerous forest)) 5)
(0 (not (dead princess)) 1)
(0 (not (bound princess)) 1)
(0 (at princess castle) 1)
```

```
                (0 (not (dangerous forest)) 1)
                (13 (rich heroes) 14))

(:intention-frames (:frame
                     :agent   king
                     :goal    (not (indebted-to king heroes))
                     :motivations (12)
                     :steps       (13))
                   (:frame
                     :agent   princess
                     :goal    (at princess forest)
                     :motivations (0)
                     :steps       (1))
                   (:frame
                     :agent   princess
                     :goal    (not (kidnapped princess dragon))
                     :motivations (7)
                     :steps       (8 10))
                   (:frame
                     :agent   dragon
                     :goal    (at dragon forest)
                     :motivations (4)
                     :steps       (5))
                   (:frame
                     :agent   heroes
                     :goal    (not (kidnapped princess dragon))
                     :motivations (8)
                     :steps       (9 10))
                   (:frame
                     :agent   dragon
                     :goal    (kidnapped princess dragon)
                     :motivations (4)
                     :steps       (5 6 7))
                   (:frame
                     :agent   heroes
                     :goal    (at-home princess)
                     :motivations (10)
```

```
                        :steps       (11))))
)
```

B.2.6 English Text Generated for Low Agreeableness

```
---------------------
Story Text:
---------------------
Once upon a time...
A Princess went from the royal palace to the forest.
She enjoyed herself.
She lost track of time.
She stayed too long, attracting the attention of a Dragon.
The Dragon went from the cave to the forest.
He dragged off the Princess from the forest to the cave.
He kidnaped the Princess to the cave.
The Princess screamed for help, to attract the attention of
a Knight.

At this point, the Knight knew that he had a choice. First,
he could go from the cabin to the cave, fight to rescue
the Princess from the Dragon and return back home with the
Princess. As a result of this choice, the Dragon would die.
Alternatively, he could go from the cabin to the cave and
help organize the escape of the Princess from the Dragon.
As a result of this choice, the Dragon would not die.
The Knight decided on the first option: go from the cabin
to the cave, fight to rescue the Princess from the Dragon
and return back home with the Princess.

He fought to rescue the Princess from the Dragon.
He returned back home with the Princess.
The King heard about the rescue of the Princess.
He rewarded the Knight.

-- The End --
```

B.3 Jane

In the case of the story titled *Jane*, the high-agreeableness version of the story was the one designed to portray inconsistent behavior (treatment version in the experiment). Conversely, the low-agreeableness version of the story was the one designed to portray consistent behavior (control version in the experiment). Note that in the planning domain, planning problem, and plan the character is named Lenny, which was changed to Jane in the version that the experiment participants read.

B.3.1 Planning Domain

```
;;;
;;; A highly simplified version of the events that take place
;;; in an excerpt of the Lazarillo de Tormes.
;;;
;;; Created by Julio C. Bahamon
;;;
(define (domain lenny-town)
  (:requirements :adl :domain-axioms :intentionality)
  (:types character place - object
          weapon - item
          monster - character
          evildoer - character
          protagonist - character
          food - item
          drink - item
          clothing - item)
  (:constants town cabin - place  soda - drink jacket - clothing)
  (:predicates (alive ?actor - character)
               (at ?actor - character ?place - place)
               (at ?food-staple - item ?place - place)
               (has ?actor - character ?item - item)
               (stabbed ?actor - character)
               (next-to ?place-x - place ?place-y - place)
               (disabled ?actor)
```

```
                (captured ?actor)
                (injured ?actor)
                (hungry ?actor)
                (thirsty ?actor)
                (cold ?actor)
                (want ?actor ?item)
                (rid-of ?actee ?actor - character)
                (upset ?actor - character)
)


(:action get-hungry
    :parameters   (?actor - protagonist)
    :precondition (not (hungry ?actor))
    :effect       (and (hungry ?actor)
                       (intends ?actor (not (hungry ?actor)))
                       )

)


(:action steal
    :parameters   (?actor - protagonist ?food-staple - item
                   ?location - place)
    :precondition (at ?food-staple ?location)
    :effect       (has ?actor ?food-staple)
    :agents (?actor)
)


(:action eat
    :parameters   (?actor - protagonist ?food-staple - food)
    :precondition (and (hungry ?actor)
                       (has ?actor ?food-staple)
                       )
    :effect       (not (hungry ?actor))
    :agents (?actor)
```

```
)



(:action get-thirsty
    :parameters   (?actor - protagonist)
    :precondition (not (thirsty ?actor))
    :effect       (and (thirsty ?actor)
                       (intends ?actor (not (thirsty ?actor)))
                       )

)


(:action drink-beverage
    :parameters   (?actor - protagonist ?beverage - drink)
    :precondition (and (thirsty ?actor)
                       (has ?actor ?beverage)
                       )
    :effect       (not  (thirsty ?actor))
    :agents (?actor)
)


(:action get-cold
    :parameters   (?actor - protagonist)
    :precondition (not (cold ?actor))
    :effect       (and (cold ?actor)
                       (intends ?actor (not (cold ?actor)))
                       )

)


(:action wear-garment
    :parameters   (?actor - protagonist ?garment - clothing)
    :precondition (and (cold ?actor)
```

```
                    (has ?actor ?garment)
                    )
    :effect       (not  (cold ?actor))
    :agents (?actor)
)


(:action ask-for
    :parameters   (?actor - character ?actee - protagonist
                   ?item - food)
    :precondition (and (want ?actor ?item)
                    (not (has ?actor ?item))
                    (has ?actee ?item)
                    (has ?actee soda)
                    (has ?actee jacket)
                    (not (thirsty ?actee))
                    )
    :effect       (and
                    (intends ?actee (rid-of ?actee ?actor))
                    (intends ?actor (not (hungry ?actor)))
                    (upset ?actee)
                    )
)


(:action share-item
    :parameters   (?actor - protagonist ?actee - character
                   ?item - food)
    :precondition (upset ?actor)
    :effect      (and (rid-of ?actor ?actee)
                    (not (want ?actee ?item))
                    (not (upset ?actor))
                    (has ?actee ?item)
                    )
    :agents (?actor)
)
```

```
(:action beat-up
    :parameters   (?actor - protagonist ?actee - character
                   ?item - food)
    :precondition (upset ?actor)
    :effect      (and (rid-of ?actor ?actee)
                      (not (want ?actee ?item))
                      (not (has ?actee ?item))
                      (not (upset ?actor))
                      )
    :agents (?actor)
)


;;; A character moves from one place to another.
;;; The places must be next to each other.
  (:action move
    :parameters   (?actor - character ?from - place ?to - place)
:precondition (and (not (= ?from ?to))
                       (alive ?actor)
                       (at ?actor ?from)
                       (or (next-to ?from ?to)
                           (next-to ?to ?from)))
:effect       (and (not (at ?actor ?from))
                       (at ?actor ?to)))
)
;;; END OF THE LENNY PLANNING DOMAIN
```

B.3.2 Planning Problem

```
;;;
;;; A highly simplified version of the events that take place
;;; in an excerpt of the Lazarillo of Tormes.
;;;
;;; Created by Julio C. Bahamon
;;;
```

```
(define (problem lenny-inconsistent)
  (:domain lenny-town)
  (:objects lenny - protagonist
            beggar - character
            bread - food
            convenience-store bakery
            department-store - place
            )

  (:init
;;; Lenny's state and intentions
         (at lenny town)



;;; General aspects of the initial state
(at bread bakery)
(at soda convenience-store)
(at jacket department-store)

(want beggar bread)
(hungry beggar)

;;; Necessary to ensure that the beggar asks
;;; Jane for bread
(intends beggar (not (hungry beggar)))

;;; END-OF-INITIAL-STATE
    )

    (:goal
     (and
      (not (hungry lenny))
      (has lenny bread)
      (has lenny soda)
      (not (thirsty lenny))
      (not (cold lenny))
      (has lenny jacket)
```

```
      (not (want beggar bread))
      (not (upset lenny))
     )
    )
)
```

B.3.3 Plan Generated for High Agreeableness

```
(
(define (plan lenny-inconsistent-solution)
  (:problem lenny-inconsistent)
  (:steps ;;; Step ID: 0
          (start)
          ;;; Step ID: 1
          (get-cold lenny)
          ;;; Step ID: 2
          (steal lenny jacket department-store)
          ;;; Step ID: 3
          (wear-garment lenny jacket)
          ;;; Step ID: 4
          (get-hungry lenny)
          ;;; Step ID: 5
          (steal lenny bread bakery)
          ;;; Step ID: 6
          (eat lenny bread)
          ;;; Step ID: 7
          (get-thirsty lenny)
          ;;; Step ID: 8
          (steal lenny soda convenience-store)
          ;;; Step ID: 9
          (drink-beverage lenny soda)
          ;;; Step ID: 10
          (ask-for beggar lenny bread)
          ;;; Step ID: 11
          (share-item lenny beggar bread)
          ;;; Step ID: 12
          (end))
```

```
(:orderings (0 1)
            (0 2)
            (0 3)
            (0 4)
            (0 5)
            (0 6)
            (0 7)
            (0 8)
            (0 9)
            (0 10)
            (0 11)
            (0 12)
            (3 12)
            (10 12)
            (10 11)
            (9 12)
            (9 10)
            (11 12)
            (5 12)
            (5 10)
            (5 6)
            (2 12)
            (2 10)
            (2 3)
            (1 12)
            (1 3)
            (1 2)
            (8 12)
            (8 10)
            (8 9)
            (6 12)
            (4 12)
            (4 6)
            (4 5)
            (7 12)
            (7 9)
            (7 8))
```

```
(:causal-links (9 (not (thirsty lenny)) 10)
               (5 (has lenny bread) 10)
               (0 (not (has beggar bread)) 10)
               (8 (has lenny soda) 10)
               (0 (want beggar bread) 10)
               (2 (has lenny jacket) 10)
               (1 (cold lenny) 3)
               (2 (has lenny jacket) 3)
               (0 (at bread bakery) 5)
               (0 (at soda convenience-store) 8)
               (0 (at jacket department-store) 2)
               (10 (upset lenny) 11)
               (5 (has lenny bread) 6)
               (4 (hungry lenny) 6)
               (0 (not (cold lenny)) 1)
               (0 (not (thirsty lenny)) 7)
               (0 (not (hungry lenny)) 4)
               (7 (thirsty lenny) 9)
               (8 (has lenny soda) 9)
               (6 (not (hungry lenny)) 12)
               (8 (has lenny soda) 12)
               (5 (has lenny bread) 12)
               (11 (not (upset lenny)) 12)
               (11 (not (want beggar bread)) 12)
               (2 (has lenny jacket) 12)
               (3 (not (cold lenny)) 12)
               (9 (not (thirsty lenny)) 12))
(:intention-frames (:frame
                     :agent       lenny
                     :goal        (not (cold lenny))
                     :motivations (1)
                     :steps       (2 3))
                   (:frame
                     :agent       lenny
                     :goal        (not (hungry lenny))
                     :motivations (4)
                     :steps       (5 6))
```

```
                    (:frame
                      :agent       lenny
                      :goal        (rid-of lenny beggar)
                      :motivations (10)
                      :steps       (11))
                    (:frame
                      :agent       lenny
                      :goal        (not (thirsty lenny))
                      :motivations (7)
                      :steps       (8 9))))
)
```

B.3.4 English Text Generated for High Agreeableness

```
---------------------
Story Text:
---------------------
Once upon a time...
A woman named Jane got cold.
She stole a winter jacket from the department store at the mall.
She wore the winter jacket.
She got hungry.
She stole bread from the neighborhood bakery.
She ate the bread.
She got thirsty.
She stole a soda pop from the convenience store at the end
of the street.
She drank the soda pop.
A homeless person asked Jane for bread.

At this point, Jane knew that she had a choice. First, she could
share with the homeless person a generous portion of bread. As a
result of this choice, the homeless person would have bread and
he would not be hungry.
Alternatively, she could beat up the homeless person. As a result
of this choice, the homeless person would not have bread and he
would be hungry.
```

```
Jane decided on the first option: share with the homeless person
a generous portion of bread.

Jane shared with the homeless person a generous portion of bread.

-- The End --
```

B.3.5 Plan Generated for Low Agreeableness

```
(
(define (plan lenny-inconsistent-solution)
  (:problem lenny-inconsistent)
  (:steps ;;; Step ID: 0
          (start)
          ;;; Step ID: 1
          (get-cold lenny)
          ;;; Step ID: 2
          (steal lenny jacket department-store)
          ;;; Step ID: 3
          (wear-garment lenny jacket)
          ;;; Step ID: 4
          (get-hungry lenny)
          ;;; Step ID: 5
          (steal lenny bread bakery)
          ;;; Step ID: 6
          (eat lenny bread)
          ;;; Step ID: 7
          (get-thirsty lenny)
          ;;; Step ID: 8
          (steal lenny soda convenience-store)
          ;;; Step ID: 9
          (drink-beverage lenny soda)
          ;;; Step ID: 10
          (ask-for beggar lenny bread)
          ;;; Step ID: 11
          (beat-up lenny beggar bread)
          ;;; Step ID: 12
```

```
        (end))
(:orderings (0 1)
            (0 2)
            (0 3)
            (0 4)
            (0 5)
            (0 6)
            (0 7)
            (0 8)
            (0 9)
            (0 10)
            (0 11)
            (0 12)
            (3 12)
            (10 12)
            (10 11)
            (9 12)
            (9 10)
            (11 12)
            (5 12)
            (5 10)
            (5 6)
            (2 12)
            (2 10)
            (2 3)
            (1 12)
            (1 3)
            (1 2)
            (8 12)
            (8 10)
            (8 9)
            (6 12)
            (4 12)
            (4 6)
            (4 5)
            (7 12)
            (7 9)
```

```
            (7 8))
(:causal-links (9 (not (thirsty lenny)) 10)
               (5 (has lenny bread) 10)
               (0 (not (has beggar bread)) 10)
               (8 (has lenny soda) 10)
               (0 (want beggar bread) 10)
               (2 (has lenny jacket) 10)
               (1 (cold lenny) 3)
               (2 (has lenny jacket) 3)
               (0 (at bread bakery) 5)
               (0 (at soda convenience-store) 8)
               (0 (at jacket department-store) 2)
               (5 (has lenny bread) 6)
               (4 (hungry lenny) 6)
               (0 (not (cold lenny)) 1)
               (0 (not (thirsty lenny)) 7)
               (0 (not (hungry lenny)) 4)
               (10 (upset lenny) 11)
               (7 (thirsty lenny) 9)
               (8 (has lenny soda) 9)
               (6 (not (hungry lenny)) 12)
               (11 (not (upset lenny)) 12)
               (8 (has lenny soda) 12)
               (5 (has lenny bread) 12)
               (2 (has lenny jacket) 12)
               (3 (not (cold lenny)) 12)
               (9 (not (thirsty lenny)) 12)
               (11 (not (want beggar bread)) 12))
(:intention-frames (:frame
                     :agent       lenny
                     :goal        (rid-of lenny beggar)
                     :motivations (10)
                     :steps       (11))
                   (:frame
                     :agent       lenny
                     :goal        (not (hungry lenny))
                     :motivations (4)
```

```
                    :steps       (5 6))
                  (:frame
                    :agent       lenny
                    :goal        (not (thirsty lenny))
                    :motivations (7)
                    :steps       (8 9))
                  (:frame
                    :agent       lenny
                    :goal        (not (cold lenny))
                    :motivations (1)
                    :steps       (2 3))))
)
```

B.3.6 English Text Generated for Low Agreeableness

```
----------------------
Story Text:
----------------------
Once upon a time...
A woman named Jane got cold.
She stole a winter jacket from the department store at the mall.
She wore the winter jacket.
She got hungry.
She stole bread from the neighborhood bakery.
She ate the bread.
She got thirsty.
She stole a soda pop from the convenience store at the end
of the street.
She drank the soda pop.
A homeless person asked Jane for bread.

At this point, Jane knew that she had a choice. First, she could
beat up the homeless person. As a result of this choice, the
homeless person would not have bread and he would be hungry.
Alternatively, she could share with the homeless person a
generous portion of bread. As a result of this choice, the
homeless person would have bread and he would not be hungry.
```

Jane decided on the first option: beat up the homeless person.

Jane beat up the homeless person.

-- The End --