ABSTRACT

CHEONG, YUN GYUNG. A Computational Model of Narrative Generation for Suspense. (Under the direction of R. Michael Young.)

The generation of stories by computers, with applications ranging from computer games to education and training, has been the focus of research by computational linguists and AI researchers since the early 1970s. Although several approaches have shown promise in their ability to generate narrative, there has been little research on the generation of stories that evoke specific cognitive and affective responses in their readers. The goal of this research is to develop a system that produces a narrative designed specifically to evoke a targeted degree of suspense, a significant contributor to the level of engagement experienced by users of interactive narrative systems. The system that I present takes as input a plan data structure representing the goals of a storyworld's characters and the actions they perform in pursuit of them. Adapting theories developed by cognitive psychologists, my system uses a plan-based model of narrative comprehension to determine the final content of the story in order to manipulate a reader's level of suspense in specific ways. In this thesis, I outline the various components of the system and describe an empirical evaluation that I used to determine the efficacy of my techniques. The evaluation provides strong support for the claim that the system is effective in generating suspenseful stories.

A COMPUTATIONAL MODEL OF NARRATIVE GENERATION FOR SUSPENSE

BY

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Dedication

To my parents, husband, and daughter

Biography

Yun Gyung Cheong grew up in Seoul, South Korea, where she developed her love of stories, mathematics, and machines. Her interests lead her to attend Sungkyunkwan University majoring in Information Engineering, which provided the curriculums of Computer Science and Computer Engineering. She earned her Bachelor's Degree in Computer Science in 1996 and she then continued her graduate study as a member of the Artificial Intelligence group run by Dr. Moon-Hyun Kim. She earned her Master's Degree in Computer Science in 1998 with her thesis, A Study on Tracking and Predicting the Face Trajectories Using a Neural Network, which presented a new way of applying a neural network technique to image processing and pattern recognition.

From 1998 to 2001, she worked at the LG Electronics R&D Center as an assistant researcher, building various programs for mobile networking environments. In 2001, she moved to the United States and entered the Ph.D. program in Computer Science at North Carolina State University. The next year, she joined the Liquid Narrative group led by Dr. R. Michael Young, and performed research in the area of automatic discourse production and narrative generation in interactive virtual worlds. In 2002, she married Byung Chull Bae, who is also an NCSU alumni and a member of the Liquid Narrative Group. She gave a birth to a beautiful baby girl, Hyunji Iris Bae, in March, 2006. After graduation, she plans to pursue a career in research.

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Chapter 1

Introduction

Since the emergence of the first computational story generation system, TALE-SPIN, developed by Meehan in 1976 (Meehan, 1976), many attempts to automate computer story creation have appeared, mostly arising from the desire to endow machines with human-level intelligence and creativity (Lebowitz, 1984; Lebowitz, 1985; Bates, 1992; Kelso et al., 1993; Turner, 1994; Bringsjord and Ferrucci, 1999). The rapid growth of computer technology and the game industry in the last decade has led both to users and researchers recognizing the power of the computer as an entertainment tool, increasing the demand for interactive narrative in their use of computers in entertainment contexts. As a result, recent AI research in story generation has concentrated on solving various problems to provide the users with high interactivity in their use of game software, training packages, and tutoring systems (Cavazza et al., 2002; Magerko and Laird, 2004; Mateas and Stern, 2003; Mott et al., 1999; Mott, 2006; Ryokai et al., 2003; Hill et al., 2003; Riedl and Young, 2004; Harris and Young, 2005; Aylett, 2004; Nelson and Mateas, 2005; Gratch and Marsella, 2004a; Swartout et al., 2001). In contrast, current research has paid less attention to aesthetic and affective properties of narrative, which are, in fact, fundamental for its appreciation by readers. For example, typical story consumers read and view literary forms expecting to feel suspense, surprise, curiosity, sadness, happiness, fun, etc. Unfortunately, it is believed that writing good stories is a difficult task even for human authors, which requires a high level of skill to keep a human's mind engrossed. My approach addresses one of the central problems in the automatic creation of stories—creating suspense in narrative, which keeps the reader engaged in the various plots, giving them high entertainment value.

1.1 Motivation

Suspense contributes significantly to the enjoyment of a narrative by its readers (Brewer and Lichtenstein, 1982; Brewer and Ohttsuka, 1988; Alwitt, 2002). Brewer and Lichtenstein's experiment sought to find the main elements that entertain story consumers. Those who participated in the experiment reported that suspense is cardinal for discerning a story from a mere series of events (Brewer and Lichtenstein, 1982). Additionally, respondents often expressed high satisfaction with their experience with narratives when suspenseful events were presented in the stories. Brewer (1996) indicates that suspense is more important to a reader's experience than is surprise since the emotional effect of suspense may last minutes while surprise may only last for seconds. Furthermore, the study of viewers' responses to commercials by Alwitt (2002) demonstrates that suspenseful commercials are favored over non-suspenseful commercials.

The diagram in Figure 1.1 is drawn by Turner (1994) to suggest the filtering process of creating a good story. As illustrated in the figure, stories are recognized as complete only when they satisfy all the major requirements integral to literary appreciation, such as theme, consistency, presentation, and suspense. In spite of the importance of suspense in creating aesthetically pleasing stories, a fair amount of research in story generation has concentrated mainly on the problems of theme, consistency, and presentation. Therefore, those systems often create stories that contain little or no suspense, a condition which generally leads to the creation of stories far inferior to those authored by human professional writers.

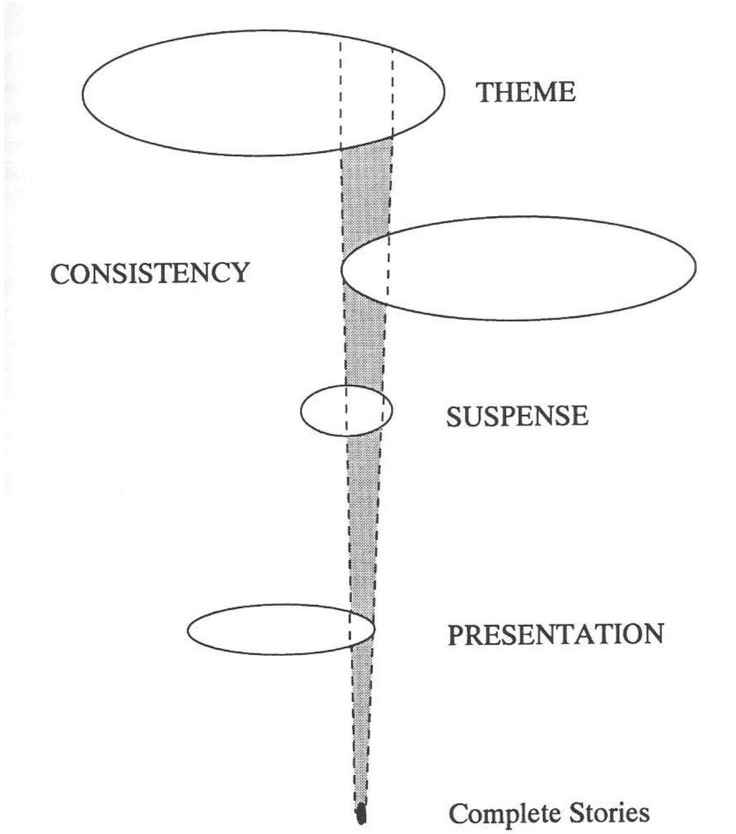


Figure 1.1: Bottlenecks in Storytelling (Turner, 1994)

1.2 Applications

The work described here yields important insight into the process of dramatic story generation by computers. As an example, consider a story generation model that demands a story with the dramatic arc depicted in Figure 1.2 (Freytag, 1863). This arc contains three dramatic moments (i.e., introduction, climax, resolution) with two constituents (i.e., rise, fall) positioned between them. In this graph, the introduction (i.e., exposition) explains the setting of the story (e.g., place, time, characters); the rising action complicates the original situation and cumulates in the climax; the climax is the point of greatest tension where the rising actions result in a strong and decisive moment; the falling action prepares the audience for the resolution (i.e., catastrophe, conclusion), which is the final closing action that reveals the significant outcome and wraps up the whole story. Freytag asserts that the climax consists of one primary scene while the other four parts may be composed of several scenes.

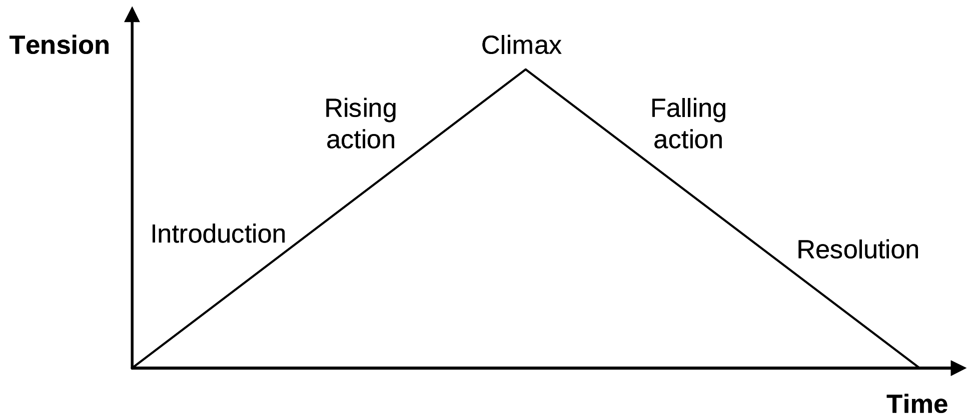


Figure 1.2: Freytag's Pyramid

The concept of tension in Freytag's pyramid relates to suspense, since suspense is treated as a special kind of tension (Zillmann, 1996). Research evidence by Brewer and Lichtenstein (1981; 1982) also suggests that readers feel more suspense when they expect the outcome of a significant event will be revealed.

A complete story generation system using the approach that I describe here to create elements of suspense would have a range of potential applications. These include the creation and control of user interfaces, entertainment software, educational software applications and corporate training tools as suggested in the symposium of Narrative Intelligence (Mateas and Sengers, 1999). For entertainment purposes, suspense is particularly effective in applications involving interactive literary, interactive drama, cinematic stories, and games. In education, narrative centered learning environments can enable the user to actively obtain knowledge through a form of story (Mott et al., 1999; Mott, 2006; Riedl and Young, 2004). In addition, the use of narrative in training soldiers to improve their decision-making skills has been successfully implemented (Hill et at., 2003).

1.3 Problem Statement

The main goals of my research are two-fold: to a) develop a computational model of suspense, and to b) build a system that manifests the computational model for validation. In this context, I define suspense as follows:

Concept 1.1 (Suspense). *Suspense is the feeling of excitement or anxiety that audience members feel when they are waiting for something to happen within an unfolding story and are uncertain about a significant outcome within that story*.

My approach attempts to manipulate the level of suspense experienced by a story's reader by elaborating on the story structure—making decisions regarding what story elements to tell and when to tell them—that can influence the reader's narrative comprehension process at a specific point in her reading. To this end, I make use of a computational model of that comprehension process based on evidence from previous psychological studies, exploring the concept that a reader's suspense level is affected by the number of solutions available to the problems faced by a narrative's protagonists (Brewer, 1996; Gerrig and Bernardo 1994; Comisky and Bryant 1982; Carroll, 1984; Carroll, 1996; de Wied, 1994; Zillmann, 1996). Adapting theories developed by cognitive psychologists, my approach uses a plan-based model of narrative comprehension to determine the final content of the story in order to manipulate a reader's comprehension process. The type of suspense dealt with in this work falls under the category of plot-based suspense (Toolan, 2001), which differs from action-based suspense in that the former is generated from plot development and the latter is evoked from the reader simply observing physical action scenes such as car chases in film. As an example of plot-suspense is described by Alfred Hitchcock in his interviews with the filmmaker Truffaut (Truffaut, 1967): a scene where several men are playing cards around a table would not typically evoke suspense from the viewers; the same scene would invoke a strong sense of suspense should the viewers be made aware of a bomb underneath the card players' table set to go off in 60 seconds.

1.4 Contributions

There are three central contributions of this dissertation. First, I define a computational model of story generation for suspense. Second, I describe an implement of this computational model. Third, I empirically evaluate the stories that it produces.

To generate suspenseful stories, I set out a basic approach built on a tripartite model adapted from narrative theory that involves the following narrative elements: the *fabula*, the *sjuzhet*, and the discourse (Rimmon-Kenan; 2002). A *fabula* is a story world that includes all the events, characters, and situations in a story. In my approach, the *fabula* is represented as a plan structure generated by Crossbow—a hierarchical, partial-order causal link planner based on the Longbow planning system (Young et al., 1994). A *sjuzhet* is a series of events selected from the *fabula*. The final layer, a discourse, can be thought of as a set of constraints on the use of the medium of presentation itself (e.g., text, film) intended to convey the narrative to its reader.

I also present Suspenser, a framework that constructs a narrative structure (i.e., *sjuzhet*) from a given story world (i.e., *fabula*) intended to evoke the given level of suspense (i.e., either high or low) from the reader. Adapting theories developed by cognitive psychologists, my system uses a plan-based model of narrative comprehension to determine the final *sjuzhet*, the content of the story, in order to manipulate a reader's level of suspense in specific ways. To this end, the system takes as input a *fabula*, plan data structure representing the goals of a storyworld's characters and the actions they perform to achieve their goals. In order to maintain the output *sjuzhet* maintains the essential storyline, the system first identifies a set of core story events that cannot be eliminated without harming the understandability of a story. To determine the content of the final *sjuzhet*, the system finds actions that can harm the protagonist's goals and tests if the addition of these actions intensifies the reader suspense by modeling the reader's inference process and anticipation of the protagonists' success using Crossbow. The core story events and harmful actions compose the final content of the *sjuzhet*. Formal evaluations strongly support the claim that the stories produced by the system are comparable to those produced by a human author in terms of suspense. Details on the experiments can be found in Chapter 4.

The contributions that this thesis makes for AI research are listed below.

- *Designing a framework for suspenseful stories*: I describe my architecture for creating suspenseful stories based on tripartite-model of story analysis suggested by narrative theorists. My model first extracts a coherent summary of the input story to be used as the content of a story structure, and completes the structure by adding story elements that control the suspense level experienced by the reader.

- *Planning-based modeling of reader's narrative understanding process*: my approach employs a hierarchical partial-order planning algorithm to model the human reader's plan-related reasoning process that is triggered in his effort to solve a problem given to the protagonist of a story.
- *Devising functions for estimating suspense*: my approach defines a) a function to measure the intensity of suspense that a reader experience from a given story based on psychological evidence on suspense, and b) a function to estimate the amount of threat that an event of a story invoke in the reader.
- *Experimental validation*: The results from my formal evaluation, testing the functionality of the current implementation of Suspenser, strongly support the claim that my model is effective in selecting story elements that contribute to the reader's suspense level.

1.5 Dissertation Organization

This paper is organized as follows. Chapter 2 reviews relevant work in narrative psychology and computer science, addressing the challenges in creating aesthetically pleasing stories. Chapter 3 presents a story generation model in which Suspenser can be situated and details the Suspenser framework. Chapter 4 presents my evaluation that assesses the performance of Suspenser compared with that of a human. Lastly, Chapter 5 concludes with a discussion of the limitations of my system and my plans for future work in this area.

Chapter 2

Related Work

This chapter reviews previous research related to narrative focusing on the computational modeling of story generation and suspense. First, I illustrate the aspects of narrative studied by narratologists. I then discuss psychological models of the creation of suspense based on individuals' experiences reading fictional text. In the subsequent section, I present relevant projects by computer scientists seeking to automate the process of story generation, with applications ranging from computer games to education and training (Cavazza, 2002; Riedl and Young, 2004; Mateas and Stern, 2003; Hill et al., 2003; Gratch and Marsella, 2004a; Swartout et al., 2001). Finally, I point to several problems that have been overlooked by many of the computational approaches to story generation.

2.1 Narrative

This section defines various terms referring to stories. While many of these terms are generally interchangeable, narrative theorists often draw subtle distinctions among them. For example, Prince (2003) makes differentiations among three primitive notions: narrative, story, and plot. He defines narrative as the representation of a series of more than one or two events in a context involving both tellers and listeners. A story is a subset of narrative containing elements of causality. A narrative may consist of several events that have no causal connection; a story's events must be causally connected. Prince describes plot as a story in which the causal relationships between events are made explicit in text.

> **Concept 2.1 (Narrative).** *The representation (as product and process, object and act, structure and structuration) of one or more real or fictive events communicated by one, two, or several (more or less overt) narrators to narratees* (Prince, 2003).

> **Concept 2.2 (Plot).** *The main incidents of a narrative; the outline of situations and events* (Prince, 2003).

> **Concept 2.3 (Story).** *The content plane of narrative as opposed to its expression plane or discourse* (Prince, 2003).

In contrast to Prince's distinctions, I adopt a definition more similar to that of Rimmon-Kenan (2002) in which a story is defined as the description of a sequence of two or more temporally successive events, some of which are causally related. Indeed this simple definition implies the following two important requirements for a story: causal relationship and state change. For instance, the story 'A young boy died. His mother died' exhibits state changes without explicit causal relationship. Yet, from this story, it is believed that the reader would infer implicit causality between the two sentences, 'A young boy died. As a result, his mother died of grief.'

> **Concept 2.4 (Minimal Story)**. *A narrative recounting only two states and one event such that (1) one state precedes the other state in time (and causes it); (2) the second state constitutes the inverse (or the modification, including the "zero" modification) of the first* (Prince, 2003).

As building blocks for creating and understanding a story, many narratologists have suggested various concepts analogous to the distinctions drawn by linguists between the deep structure and the surface structure of a text. While surface structures can be thought as the specific syntactic structure of sentences, the deep structures are understood as the sentences' underlying meanings.

In his oft-cited analysis of Russian folk-tales, Propp (1958) suggests a functional model of story analysis, characterizing story elements by their function on the state of the story. Propp maintains a view that there are a limited number of roles a character may fill within the genre he studied (i.e., villain, donor, helper, hero, false hero, dispatcher, sought-for person) and precisely 31 functions that characters in these roles can perform. Even though his theory is limited by its origin based on a corpus of Russian folktales, it is important that this theory is the first to identify the abstract structure of story. This functional theory has been directly translated into the computational system by Díaz-Agudo et al. (2004). In addition, the function theory of Propp was also developed into an actantial model by Greimas (1983). In this model, the function theory's roles are generalized into a smaller set (i.e., sender, object, receiver, helper, subject, and opponent). In an anlysis similar to that of Propp, Labov (1972) identifies a series of patterns from a corpus of African-American oral narratives. He has observed that their stories contain elements that can typically be characterized as either referential components (i.e., abstraction, orientation, complicating action) or functional components (i.e., evaluation, resolution, and coda). Abstract elements review the story as a whole; orientation elements describe characters; evaluation elements explain why the story is worth telling; coda elements compose story endings.

The employment of the bipartite model—story and discourse—in analyzing narrative has a long history in narratology (Chatman, 1978). In this model, *story* refers to the content plane of narrative whereas *discourse* represents its expression plane. Then, later narrative theorists have raised issues regarding the narrator's role in the bipartite model. Considering that the primary function of a story is to entertain its receivers, a same story shall be delivered in different fashions according to the needs of those receivers in a specific context they are in. For instance, a version of the *Bible* written for children is different from a version written for adults; children's *Bible* versions vary by length, choice of events, use of words, etc. Some narrative theorists (Genette, 1980; Bal, 1985; Rimmon-Kenan, 2002; Toolan, 2001) view that this phenomenon—different stories from the same story material—is rooted in the existence of an abstract entity called the narrator who decides what to tell and when to tell it. To separate the narrator's role from the discourse, they suggest a three-tiered model of narrative composed of the *fabula*, the *sjuzhet*, and the narrative discourse. As defined in the previous chapter, a *fabula* is a story world which includes all the events, characters, and situations (place and time) in a story. A *sjuzhet* corresponds to a series of events and situations selected from the *fabula* to present to readers. Discourse refers to the manner of use of the medium of presentation, for example, the use of text, images or film. The benefit of this tripartite model is the clear distinction it provides between narrative construction tasks at each layer: story material design, story structure design, and surface realization.

> **Concept 2.5 (*Fabula*).** *The set of narrated situations and events in their chronological sequence; the basic story material (as opposed to plot or sjuzhet)* (Prince, 2003).

> **Concept 2.6 (*Sjuzhet*).** *The set of narrated situations and events in the order of their presentation to the receiver (as opposed to fabula); the arrangement of incidents* (Prince, 2003).

> **Concept 2.7 (Discourse).** *The expression plane of narrative as opposed to its content plane of story* (Prince, 2003).

Although the specific roles at the *sjuzhet* layer are not unanimously agreed upon by narrative theorists, some (Bal, 1985; Rimmon-Kenan, 2002; Toolan, 2001) agree that presentation time, characterization, and focalization are fundamental aspects of stories determined at the intermediate layer. The first aspect, characterization, ascribes certain traits to the characters of a story. Focalization sets the point of view employed in conveying a story. The decisions regarding the narrative presentation time include the order of presentation of events, the narrative speed, and the frequency (Genette, 1988). The order of presentation of events deals with setting the presentation of story events which can differ from their chronological orders. The narrative speed is concerned with the duration allotted to recount events; an event may occupy a long duration or none at its discourse. The frequency is related to the number of times an event and its happenings is told; for example, an event that happened once can be recounted once (i.e., singular narrative) or several times (i.e., repeating narrative).

Since *sjuzhet* presents only a part of *fabula*, some information that exists in the *fabula* is omitted in the processing of generating *sjuzhet*. This information can is deleted because the author believes it unnecessary for the reader to know or believes that this information can be inferred by the reader. For example, Bruce Wayne, the protagonist of the film *Batman* wears the Batman suit when he presents himself as Batman. Obviously, he needs to change his clothes before he serves as Batman, yet those clothes-changing scenes are not shown to viewers. In this example, those scenes are present in the *fabula* of Batman but absent its *sjuzhet*.

When creating a *sjuzhet*, a *fabula* can be tailored for various purposes. Redundant events that can be readily reasoned such as daily activities (e.g., brushing teeth, having breakfast) are excluded from presentation because they are unnecessary for the reader to know and their omission does not hinder readers from apprehending the story. This kind of narrative omission has been recognized; Nieding et al. (1996) call the easily inferred ellipsis in a story as a *weak gap* and label the type of ellipsis that is unexpected by the reader without following information referring to it as a *strong gap*.

2.2 Suspense

This section explores narrative and psychological theories relevant to suspense created during narrative comprehension. I begin with descriptions of suspense and present a number of research results characterizing the methods used by film directors to manipulate story presentation for the experience of suspense. Finally, I discuss psychological attempts to characterize the reader’s comprehension process when reading a story.

2.2.1 What is Suspense?

My work here views suspense as “the feeling of excitement or anxiety that readers feel when they are waiting for something to happen and are uncertain about a significant outcome in their experience of unfolding events of a narrative." However, differing aspects of suspense are studied from a number of perspectives.

Vorderer (1996) describes suspense as a psychological phenomenon associated with three dimensions—type of text, the user, and an individual's emotional process. The first dimension, type of text, suggests that the reader will experience a higher level of suspense when reading text describing physical actions rather than when reading text describing a character's thought and emotion. Vorderer hypothesizes that the second factor, the user, affects the level of suspense that a text evokes based on his or her inter-individual and intra-individual factors. For example, different people will experience different levels of suspense while reading the same text depending on their age, gender, or social situation. Likewise, a person may experience different suspense levels when reading the same story in different locations or moods or with intentions. The last dimension, the receiver's emotional process, influences the experience of suspense based on the reader's attitude of acceptance towards the experience itself. By this, Vorderer means that a reader would not feel suspense if her emotional preferences for the outcome of the story precluded negative, suspense-laden consequences. More specifically, a reader will imagine a preferred outcome for a character within a story that she identifies with; a reader in this state will hope for the realization of the preferable outcome at the end of story. As a result, in a situation where the preferred outcome looks unachievable, the reader feels suspense. Similarly, the reader feels suspense in a situation that benefits a character that the reader conflicts with.

Ortony, Clore, and Collins (1988) classify suspense as a specific type of prospect-based emotion, one which is evoked when an individual anticipates the occurrence of events whose outcome is uncertain. Their account of suspense involves hope and fear emotions; a person hopes his favorable consequence will be realized while he fears the occurrence of undesirable consequences. The view of positioning suspense between hope and fear is further supported by other researchers. In her study of viewers' responses to commercials, Alwitt (2002) observes that the number of alternations between hope and fear as well as the range of hope/fear intensities are related to the experience of suspense. The view of suspense as an alternation between hope and fear is also supported by the conceptual model of suspense in the context of consumption (Guidry, 2004). Guidry's model, as illustrated in Figure 2.1, defines suspense as "the overall arousal associated with the anticipatory emotions of hope and/or fear." In the model, she identifies approach and/or avoidance appraisal as necessary conditions for evoking suspense, and three parameters (i.e., degree of probability change, frequency of probability changed, and anticipation time) that moderate suspense, and the consequences (i.e., satisfaction/disappointment, anguish/relief) when the resolution is presented to the consumers.

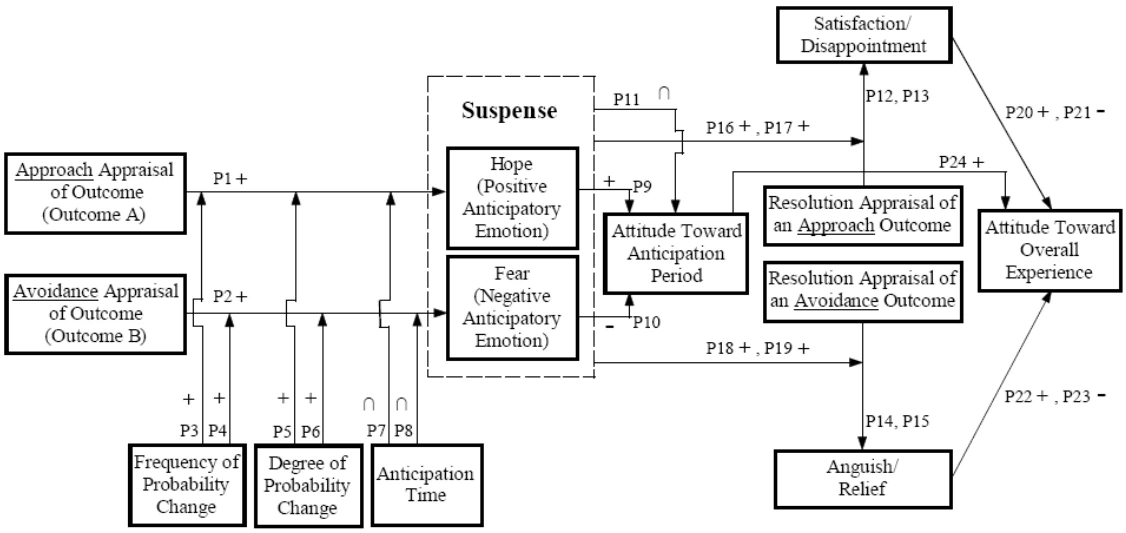


Figure 2.1: A conceptual model of the antecedents and consequences of suspense (Guidry, 2004)

2.2.2 Antecedents of suspense

While theorists disagree on the exact definition of suspense, there is wide agreement that the following elements of narrative are necessary for a reader to experience the affect of suspense:

1. Uncertainty about significant outcome. However, the inclusion of uncertainty as an antecedent for evoking suspense has been questioned by suspense theories in the context of re-reading when the reader is certain about what the outcome (Carroll, 1996; Gerrig, 1996; Prieto-Pablos, 1998; Yanal, 1996). They explain this paradox by the fact that uncertainty is not limited to just outcomes, it can refer to how the

outcome is realized (Alwitt, 2002). However, the discussion of paradox of suspense is beyond the scope of this work. I focus, instead, on the affect of suspense experienced by readers upon their first exposure to a narrative.

2. The intensity of suspense experienced by a reader heightens as she feels disposition toward protagonists or outcomes (Zillmann, 1991; Yanal, 1996; Guidry, 2004; Ortony, Clore, and Collins, 1988)
3. Conflicting outcomes of an event (Alwitt, 2002)
4. Likelihood of undesirable outcome over preferred outcome (Brewer, 1996; Gerrig and Bernardo 1994; Comisky and Bryant 1982; Carroll, 1984; Carroll, 1996; de Wied, 1994; Zillmann, 1996).
5. Duration of harmful anticipation (de Wied, 1994)
6. Discrepancy in the knowledge between characters and viewers (Gerrig, 1996;Wuss, 1996; Alwitt, 2002).

While suspense is a complicated phenomenon affected by various factors, my work focuses on the class of suspense associated with the fourth element, *likelihood of undesirable outcome over preferred outcome*. More specifically, implicit in much of the work I present here is the notion articulated by Gerrig and Bernardo (1994) in which they view an audience as problem-solvers. In their model of narrative comprehension, they hypothesize that a reader's level of suspense is affected by the number of potential solutions for the dilemma faced by the protagonist. Under this model, an audience will feel an increased measure of suspense as the number of options for the protagonist's successful outcome(s) decreases. To confirm this hypothesis Gerrig and Bernardo performed seven experiments with a group of human subjects. Human subjects were provided different text versions of a story where a protagonist is in danger and tries to escape. The various versions of the story differed in the number of solutions available to the protagonist. After reading the text, subjects were asked to rate their estimation of the likelihood of the protagonist's escape as well as their suspense levels. The data from the experiments showed that the readers reported high suspense when the number of solutions decreased.

2.2.3 Suspense from Story Structure

Since suspense arises primarily in response to a reader learning of the unfolding events of a narrative, storytellers working with various media employ specific devices to create suspense, manipulating the way elements of the medium present a series of events to viewers. For instance, Gerrig (1996) has investigated the film idioms used to create the affect of suspense. From his interviews with directors, it is revealed that they create suspense by: a) letting the audience know more than characters in the story and b) decreasing the number of solutions available to a protagonist for a given problem. Directors arrange the filming of story elements to manipulate the reader's beliefs, generating suspense. An exemplar of this kind of film technique is McGuffin (or MacGuffin), a term coined by Alfred Hitchcock. The term McGuffin refers to a film trick where unimportant objects, facts, or characters are seemingly highlighted by the selection and composition of shots, as a result, the audience assumes these objects must be somehow significant and their sense of fear, suspense, and confusion increases in anticipation of that significance. For example, a briefcase that is constantly carried by a protagonist in a film would create curiosity (about the base's contents and purpose) in an audience. In fact – as is revealed later in the film – the case contains only a journal written by a character, of which contents are unrelated to the story. Although the use of a McGuffin is an extreme case, it indicates that some suspense can be aroused not only by the aspects of story's content but also by the way that the story is shown.

Brewer (1996) explicates these phenomena in his structural-affect theory, a key model for characterizing the mental state of those experiencing narrative. The structural-affect theory argues that affective states in a reader are provoked by the particular temporal ordering of the events underlying a story world. According to his theory, suspense could be evoked by presenting the events chronologically to the reader while the affects of surprise and curiosity could be caused by hiding a critical fact or event early in the story world and disclosing it later in the text. The structural-affect theory as an effective model of a reader's emotional response has been empirically supported by experimentation (Hoeken and Vliet, 2000).

2.3 Computational Story Generation Models

This chapter discusses several computational models of story generation. I divide the current story generation systems into two classes in terms of the presence of controlling aesthetic and dramatic effects such as tragedy, surprise, suspense, flashback, foreshadowing and so forth. Traditional story generation systems are first reviewed, and then models with dramatic effects are briefed.

2.3.1 Story Generation Systems

2.3.1.1 UNIVERSE

Lebowitz (1985) presents UNIVERSE, a story plot generation system that uses a planning technique to generate stories. The system begins when an author's goal is posed, and replaces the author goal with a sequence of subgoals using plot fragments. As shown in Figure 2.2, a plot fragment contains goals, characters (i.e., binding variables in planning), constraints (i.e., constraints and preconditions), and ordered subgoals (i.e., subactions for an abstract action) which can be directly converted into text. He employs a simple recursive planning algorithm that picks a goal and decomposes it with a series of sub-goals using plot fragments. Finally, the algorithm builds a story graph composed of concrete actions and their temporal ordering relationships.

```
PLOT FRAGMENT: Forced-Marriage
CHARACTERS: ?him ?her ?husband ?parent
CONSTRAINTS: (has-husband ?her)       {the husband character}
             (has-parent ?husband)    {the parent character}
             (< (trait-value ?parent 'niceness) -5)
             (female-adult ?her)
             (male-adult ?him)
GOALS: (churn ?him ?her)
SUBGOALS: (do-threaten ?parent ?her "forget it") {threaten her}
          (dump-lover ?her ?him)      {have ?her dump ?him}
          (worry-about ?him)          {have someone worry about ?him}
          (together * ?him)           {get ?him involved with someone else}
          (eliminate ?parent)         {get rid of ?parent}
          (do-divorce ?husband ?her)  {end the unhappy marriage}
          (or (churn ?him ?her)       {either keep churning or}
              (together ?her ?him))   {try and get ?her and ?him together}
```

Figure 2.2: A UNIVERSE Plot Fragment

2.3.1.2 Interactive Storytelling

A research group lead by Cavazza (Cavazza, Charles, and Mead, 2002; Charles et al., 2003) has developed a prototype story generation system that builds a storyline by modeling interactions between autonomous agents. The behavior of autonomous agents is generated using Hierarchical Task Network (HTN) planning techniques and realized in real-time as a 3D animation using the Unreal Tournament game engine. HTN planning represents a plan as a collection of possible sub-tasks to achieve a higher level goal. By employing total-order HTN planning, their system is able to interleave planning and execution, providing a high degree of responsiveness in the face of user interaction in the plan's run-time environment.

For each task in an HTN plan, the task is encoded with its precondition and postconditions and this information is used by the run-time manager to allow characters to alter their current plans according to dynamic situations.

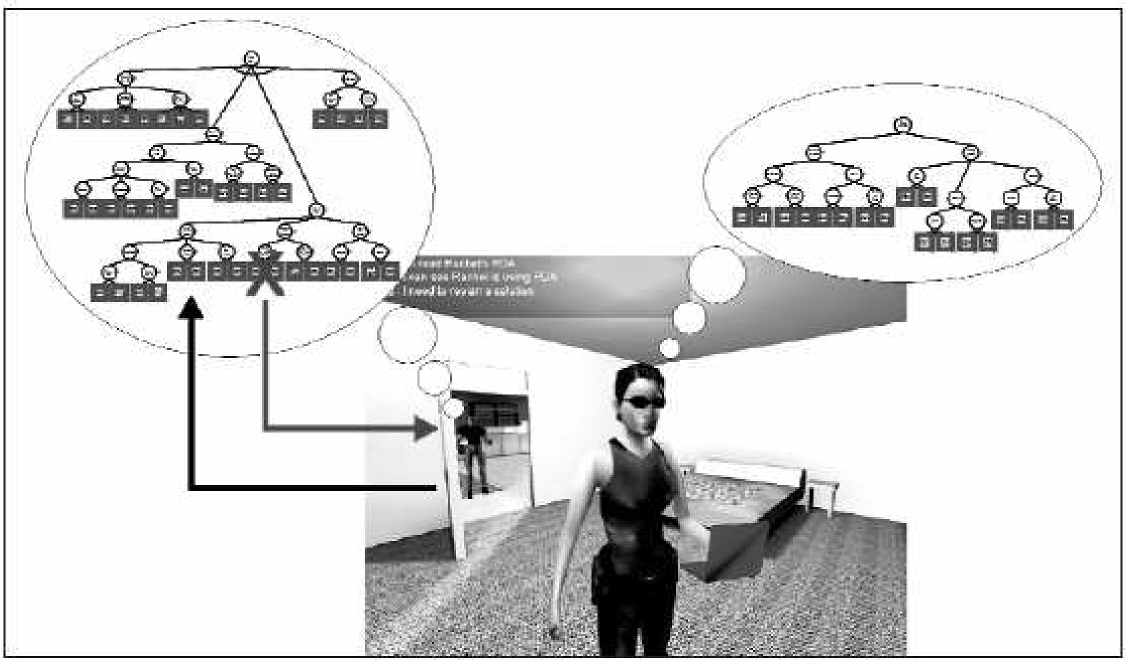


Figure 2.3: A HTN plan and a replanned plan performed by a character in I-Storytelling

As illustrated in Figure 2.3, the applicability of the current plan of the character is checked relative to the current state before its execution and the plan is withdrawn if the preconditions of the action to be performed next are not satisfied. The capability to adapt plans enables the system to generate different storylines and endings in different situations. The system uses the preconditions of a task conjoined with the preconditions of its sub-actions to check if the task can be performed in a specific situation.

The approach used in the Interactive Storytelling project has several limitations, however. First, the author's role is limited in their system. The author designs an HTN for each character and is thus engaged in the construction of the character's goals, sub-goals, and possible actions; anticipating a tellable narrative in their system involves using a "bottom-up" approach based on character interactions. However, there is no way to specify a director's view of the desired story or provide top-down input in the plan construction process. Although they show that it is feasible to generate dramatic tension from autonomous actors in a small setting, in a larger setting such as a theme park or a small city users may need to wait a fair amount of time to see dramatic events happen (as in real-life), potentially decreasing the overall narrative nature of the user experience. Further, the type of user interaction allowed in their systems is constrained to simple actions such as moving objects from one point to another. Finally, since they employ forward-chaining planning, giving their system the benefit of real-time interleaved planning, the plans generated from HTN technique can be redundant or non-optimal unless all the possible combinations of terminal actions are fabricated into separate plans beforehand.

2.3.1.3 Façade

Mateas and Stern (2003) have developed Façade, a system that situates the user as a guest character in interactive drama set at a dinner party. Their story generation mechanism adopts a hybrid approach between script-based and dynamic story generation. Story units, or beat, along with its preconditions and effects, are encoded by a human author so that a series of beats for a specific situation can be automatically selected by the system. The combinations of beats form a complex story graph, which leads to dynamic plot generation. As a result, the story that the user experiences is likely to be a complete traversal from a starting beat of the graph to an ending beat. When the current beat is chosen, a drama manager selects relevant behaviors that the behavior-based autonomous agents perform.

Kelso et al. (1993) suggest that strong characters, effective aesthetic presentation and a long-term dramatic structure are requirements for interactive drama. They also propose the use of a plot graph for guiding a dynamic story. They claim that a user's dramatic experience is guaranteed if the user traverses from a beginning node to a final node of a plot graph which carefully designed by an author. Secondly, they claim that an interactor's dramatic experience can effectively be managed by monitoring the user's interaction with the system and controlling the pace of her experience by using hints or obstacles encoded as edges of the plot graph. To confirm their assumptions, they performed two live experiments involving real (amateur) actors, a director and interactors. From the tests, they conclude that, unlike they asserted in their assumptions, a character's inconsistent behavior does not interfere with the interactor's dramatic experience. The interactors are immersed in the story and remain so even when the characters in the story sometimes act inconsistently. From the result of these experiments, they designed the Oz system architecture composed of a drama manager, presentation models (i.e., text or animation), characters, and the (virtual) physical world they inhabit. However, since the Oz project targets interactors rather than an audience, its dramatic quality is not properly compared to a good play or a good story. As the authors indicated, observers generally commented that the experiments were boring and felt like nothing happened for a specific period time while the interactors reported that they felt absolutely engaged in the play, commenting that many of the exiting moments in the experience caused them to feel emotions similar to those they'd feel in a real-world dangerous situation. Thus, their loose story structure and presentation does not fit with my system.

2.3.1.4 Fabulist

The approaches to automated story generation can be classified in one of two categories: autonomous agent approaches and author-centric approaches. The autonomous approach, involving the creation of a story by a process of interaction between autonomous agents, has a relatively long history, dating back to the 1970's (Meehan, 1976). The approach uses several agents acting as characters in the story, each given specific goals to achieve. These agents generate plans for their goals and execute the plans. The advantages of this approach are that a) the process is fairly simple because the system's job is to distribute goals to each individual agent and b) the process is likely to generate believable stories, since each agent plans its own actions in order to achieve its own goals. However, it is less likely that the generated story would be interesting without a story manager that is in charge of creating dramatic situation such as posing a global goal that needs the collaboration between the agents or arranging goals for agents that conflict each other. On the other hand, the author-centric approach provides plot coherency, since a global planning process is used to construct the actions of all characters in a story over the story's entire duration. In this approach, however, it is difficult to ensure that each character acts according to its own internal nature, since actions are prescribed by a central planning system.

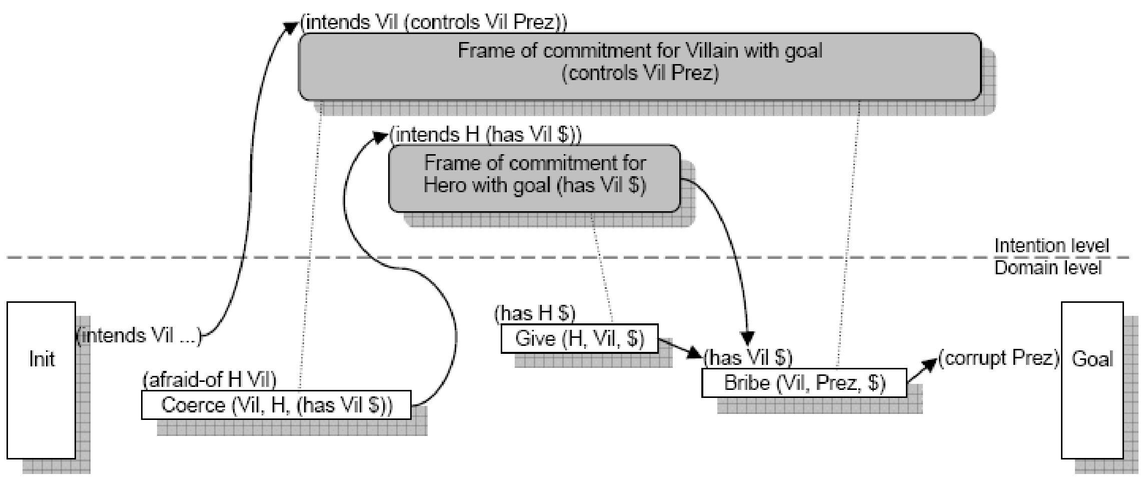


Figure 2.4: A partial IPOCL plan with interrelated frames of commitment (Riedl, 2004)

To address the problem, Riedl and Young (Riedl, 2004; Riedl and Young, 2004) have developed Fabulist, a story generation system using an Intent-driven Partial-Order Causal Link planner (IPOCL). Fabulist plans a storyline with a given story goal describing a subset of character goals. While planning, it inserts actions into the plan in service of the story goals, but assigns specific characters as the agents of the actions. Fabulist then checks if each action is consistent with the assigned character's intentions. If it is, the system continues standard planning. Otherwise, it creates a new intention to explain the character performing the action, then plans a series of actions for the agent to achieve the intention. In this manner, Fabulist can maintain the balance between plot coherency and character believability.

2.3.1.5 U-DIRECTOR

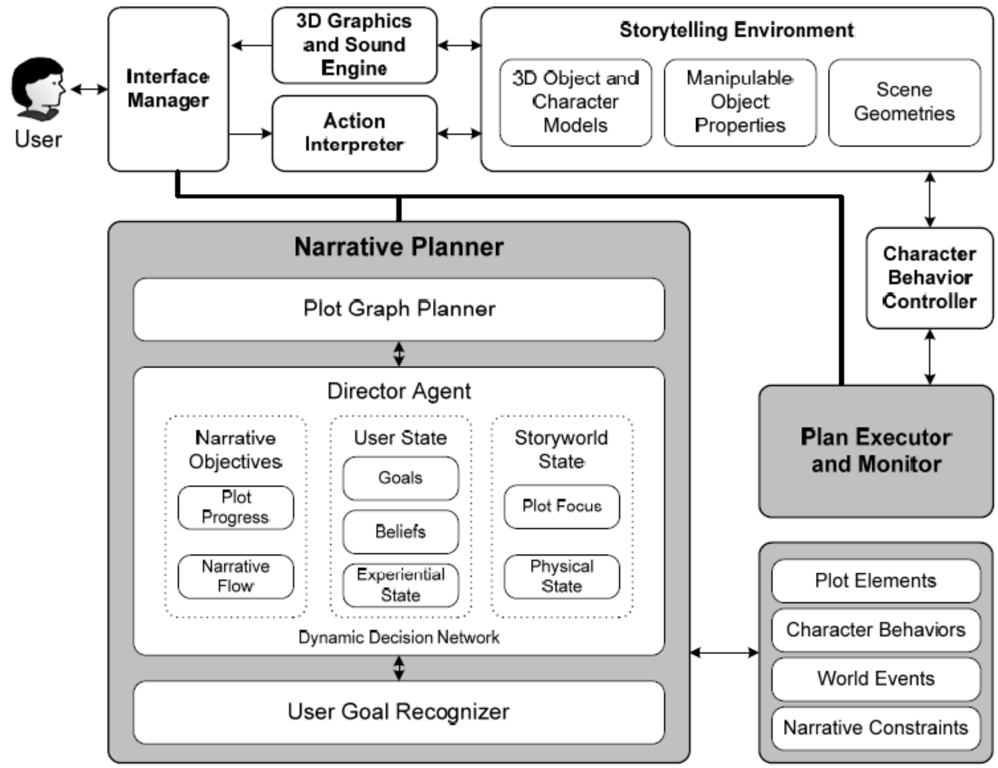


Figure 2.5: U-DIRECTOR Architecture

Mott (2006) presents U-DIRECTOR (Figure 2.5), a complete system that guides the user toward a better learning performance in 3D interactive narrative environment. In his system, a tutorial planning space that specifies the learning goals is first generated by a HTN (hierarchical task network) planning technique. Then, the same algorithm is used to produce a plot graph which serves as a blueprint for the non-player characters and the objects in the environment shall act upon it. When a learning goal in the tutorial planning space is chosen, a series of events unfold in accordance with the selected learning goal. To assist the user to achieve the given learning goal, U-DIRECTOR provides her director actions, e.g., hint. For instance, a character can give information advantageous to the user, or a lamp in a room can flicker to draw attention from the user. The director actions are selected to maximize the narrative utility that rates the user’s overall experience in a narrative-centered learning environment using a dynamic decision network (DDN). In his system, the DDN extends a

Bayesian network in a way to provide utility-based decision making and timely changed attribute modeling. U-DIRECTR has been experimentally approved that the users guided by the system have completed a given mission with a smaller number of user actions than the users without its guidance.

2.3.2 Story Generation Systems with Dramatic Effects

In my work, I assume that the quality of a narrative experience can be directly enhanced by a system that takes the reader's response to the experience into account during its generation. While narrative theories presuppose the existence of a narratee (Chatman, 1978), the cognitive role of a reader's participation in the generation of story has been ignored by the most story generation systems. The following sections briefly illustrate a number of approaches that focus upon the reader in story generation and presentation.

2.3.2.1 DEFACTO

Sgouros (1999) presents a rule-based approach to construct a plot according to concepts first described by Aristotle. In Sgouros' approach, the user plays the role of a protagonist in a story, and a plot manager builds a plot so that the user can experience dramatic situations such as an initial situation, a climax, a conflict and a resolution.

The plot manager (Figure 2.6) begins story construction when it receives initial plot conditions specifying characters, their goals, roles, and motivations, and the relations between the characters. The processing done by the plot manager is composed of three phases: generation, evaluation, and resolution. In the generation phase, the plot manager constructs possible sequences of actions for each character relevant to his or her goal and roles. In the evaluation stage, it determines whether each series of actions is among the four dramatic situations of lifeline, rising-complication, reversal-of-fortune, and irony. The system then selects a dramatic situation that gives the user a greater degree of participation as the next plot element. These phases of generation and evaluation repeat sequentially until no new interesting interactions are found. Finally, the resolution phase determines the outcome of each action, success or failure. Sgouros' research proposes a user-centric view to story generation. Particularly, his evaluation phase conforms to the observations by the Oz project team (Kelso et al., 1993), reports that a user is strongly engaged when she actively participates in the story even when the audience observing the action might feel bored. However, Sgouros' evaluation mechanism has the following two limitations. First, its absence of the user model confines the application of the system to a case of a story in which the user acts as a protagonist. Accordingly, it is not clear how the system might be adapted to work in multi-player environments or in interactive drama where the user takes a position as a viewer. Sgouros also mentions that his plot manager can generate suspense by twisting the outcome, yet the details involved in maintaining the plausibility of the story are not provided.

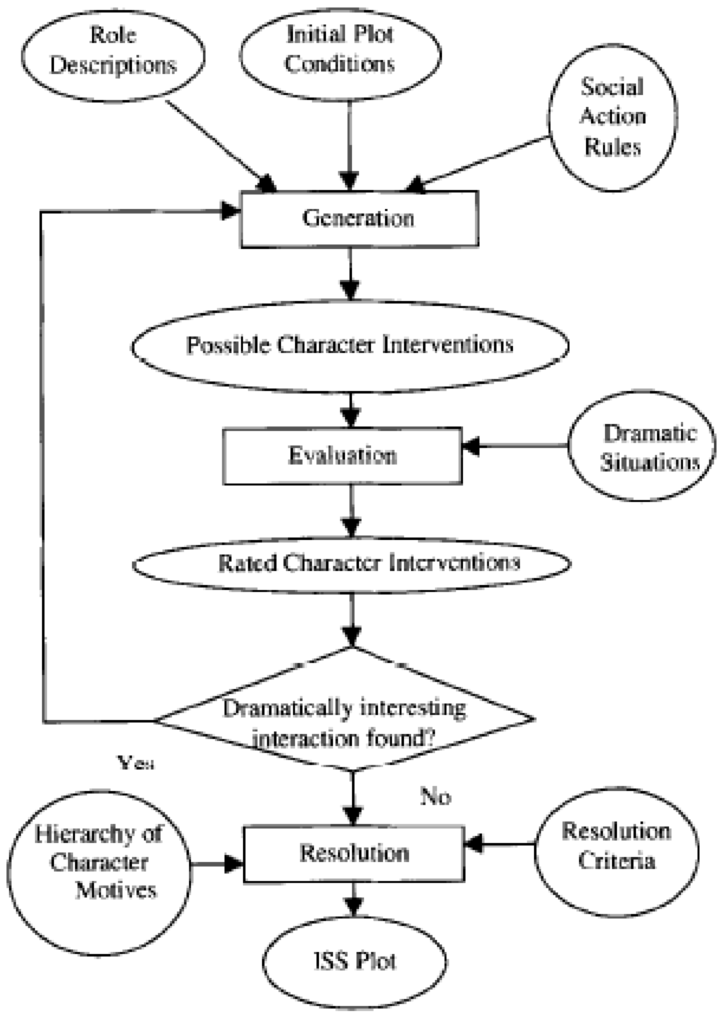


Figure 2.6: DEFACTO: Plot Manager Architecture

2.3.2.2 Story Generation Model by Bailey

Bailey (1999) suggests an approach to generating stories considered interesting by the reader that involves accessing the reader's knowledge-base. His system follows a cycle composed of the following four stages. First, it generates candidates for the next story segment by manipulation (i.e., generalization, specialization, detachment, join) of a knowledge base. Second, the effect of each candidate story unit is calculated by considering the story-so-far, and the reader's expectations and questions. Third, a segment resulting in a good pattern of question and expectation based on a storiness heuristics is selected. Last, the selected story unit is picked as the next story segment, and the reader's model is updated accordingly. This research significant especially since it exploits the reader's role in story generation. Unfortunately, Bailey does not suggest a solution to the formalization of his storiness heuristics; as a result, the plausibility of this approach is difficult to gauge.

2.3.2.3 Moe

In an interactive narrative system where the user participates as a character in the story, choices made by the user influence the story development. To provide the user with an effective experience while she interacts with a virtual story world that the Oz system (Kelso et al., 1993) presents, Weyhrauch (1997) develops the Moe architecture, which views the interaction between the user and the system as a form of an adversarial search. Moe consists of two main components: an evaluation function and an adversarial search process. The evaluation function rates the quality of a sequence of user moves generated in the course of her experiencing the story world. The result of his experiment shows that the evaluation function correctly approximates two human experts' aesthetic evaluation on a user's experience. In addition, the article shows the effectiveness of the shallow searching method from the result of the experiments with simulated users which are parameterized by confirmation to the system's guidance. And yet, the universal application of the shallow searching method is questionable. Nelson and Mateas (2005) report that the Moe system has little impact on improving the user's experience in an interactive world based on an interactive mystery fiction *Anchorhead*. In the article, they ascribed the dissatisfactory result to the sallow searching method that the Moe architecture employs.

2.3.2.4 TWISTER

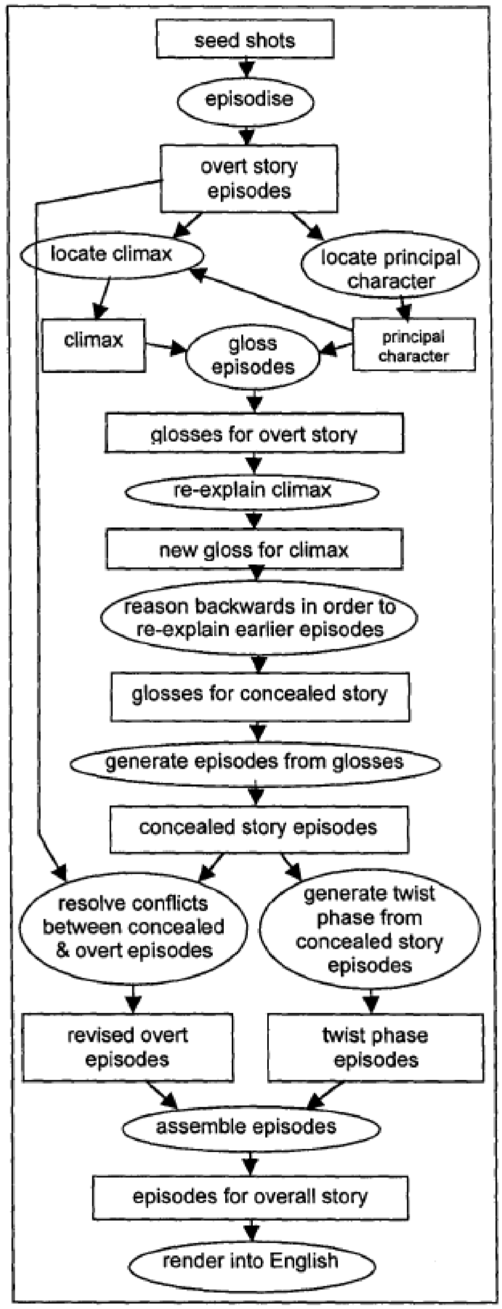


Figure 2.7: TWISTER architecture. Ellipses denote inference processes and boxes represent data produced by inferences processes.

As a theoretical model of affective storytelling, Platts, Blandford, and Huyck (2002) describe a reasoning-based approach that produces a twisted story. As shown in Figure 2.7, when a seed story is given as input, their approach first divides the story into episodes and identifies its climax. By the multiple application of backward reasoning to the climax, the system generates two distinct versions of the seed story, an overt story and a concealed story. Then, a twist phase is created by reasoning forward from the climax episode of the concealed story that explains the transition from the overt story to concealed story. Finally, the overt story and twist phase episodes are assembled into a complete final story. Posing a twisted story generating process as synthesizing two different stories that share a climax, their study identifies essential processes for twisted story generation. However, those processes are only partially specified, and their implementation is under development. As a result, it is difficult to measure the effectiveness of their approach.

2.3.2.5 MINSTREL

MINSTREL (Turner, 1994), a cased-based approach to modeling human creativity, is probably the most comparable system to Suspenser. The system basically adopts a transform-recall-adapt method as illustrated in Figure 2.8.

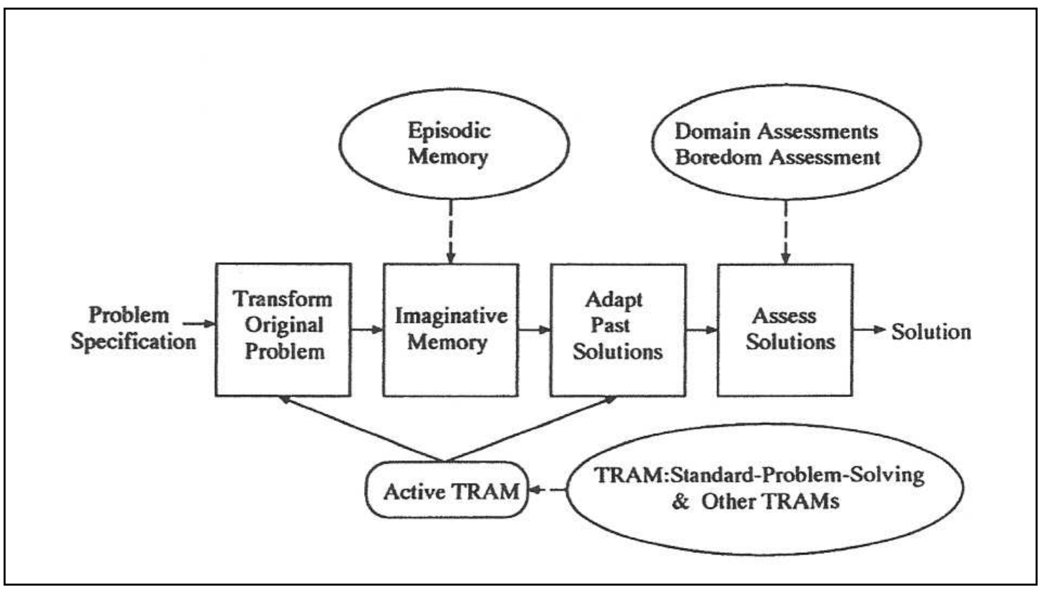


Figure 2.8: MINSTREL's Process Model of Creativity (Turner, 1994)

On receiving a problem specification as input, MINSTREL retrieves a case from its memory that is similar to the problem. If the case is identical to the problem, then the original solution is used. If the case is different form the input problem, the original solution is modified to overcome this difference. Finally, the validity of the solution is checked by the assessing module.

As an end-to-end system, MINSTREL extensively attempts to solve a number of story-generation related issues such as themes, coherency, characterization, tragedy, suspense, foreshadowing and so forth. In MINSTREL suspenseful effect is created by description and *fabula*-level event generation, relying on the psychological evidence that readers feel more suspense when they strongly care the character and when the presentation of a significant outcome is prolonged. For the readers to induce sympathy for the character, the system details the character's fear emotion. To postpone the story resolution, the system inserts the scenes of character's making a plan and its failure into important (character-level goal related or story-theme related) events. A story targeting the effect of suspense in the reader produced by MINSTREL using techniques described above is illustrated in Figure 2.9.

Once upon a time, there was a hermit named Bebe and a knight named Cedric. One day, Cedric was wounded when he was attacked by a dragon. Bebe, who was in the woods picking berries, healed Cedric. Cedric was grateful and vowed to return the favor.

Later, Bebe believed that he would die because he saw a dragon moving towards him and believed it would eat him. Bebe was very scared. Bebe tried to run away but failed! …

Figure 2.9: A story example created by MINSTREL for suspense

2.4 The position of my thesis with this research

As outlined above, traditional story generation systems have concentrated on the thematic and coherent aspects of interactive narrative. Although some of those systems have correctly recognized the aesthetic properties of stories as substantive for the high quality of narrative appreciated by story consumers, it has been recognized as a significantly challenging task, some even suggesting that the task is not amenable to formalization within computer programs.

On the other hand, a number of AI researchers have specifically concentrated on the computational properties of dramatic effects and interestingness in narrative. Their attempts are in line with the observation from several story excerpts by Schank (1979), claming that literary interestingness is generally accompanied with unexpected events or personal relatedness. However, their approaches to interesting stories are often limited by their simplified user models that regard the user's literary appreciation as a combination of several factors. As a result, those approaches elaborate on maximizing the intended story aspects, rather than estimating the user's apprehending process.

In the meantime, the need of the user model in narrative generation has been affirmed by narrative theorists, psychologist, and cognitive scientists. Britton (1983) points out that engaging the reader in narrative needs more than the task of analyzing the story structure; indeed, it requires the access to the reader's complicated reasoning process such as predicting a character's actions in the story. Psychological research has also indicated that the role of the reader and his process of comprehension while reading are central to the enjoyment of his experiencing narrative; therefore, the reader's role shall be not passive but active in the story generation process.

To bridge this gap between the restricted role of a reader in computational story generation systems and the need of the reader's active role in creating a story—I present a computational model that creates a suspenseful story structure by modeling the reader's planning-related reasoning process using a planning technique.

Chapter 3

A Suspense Story Generation Model

3.1 A Tripartite Model of Story Generation

A recent trend in the story generation research community has shown growing interests in the tasks involved in the creation of the *sjuzhet*. Szilas (2001) presents a storytelling system architecture that incorporates a narrating agent which filters a series of tellable events that shapes the overall story satisfying various constraints such as consistency, conflict, surprise, and impressiveness. Lönneker (2005) uses narrative frames—data structures containing facts and relations about narratives—to construct embedded narratives which narrate a story embedded within another story. Montfort (2006) implements a mechanism that recounts a story by altering the order in which events are presented. Computational linguists have also proposed the need for an intermediate layer in story generation that is in charge of narration.

I present a three-stage pipelined architecture for story generation as shown in Figure 3.1. The first element is the *fabula* creator that receives a story request containing the initial and goal states of the story world and the operators available for the actions in the story world domain. Then, it produces a *fabula*, structured as a partial-order plan that achieves the set of story-world goals in a given planning domain. Additional information, such as the act-type of each action is represented as needed. The specific act-type information in the current system is described in Section 3.2.2.1. The story-world plan is sent as input to the second component in the pipeline, Suspenser, which plays a role as the *sjuzhet* generator. Given three input elements – the *fabula*, a desired suspense level and a given point X in the story plan – Suspenser determines the content of the story discourse conveying the story up to point X intended to create the specified level of suspense in the reader at point X. Finally, the output from Suspenser (the *sjuzhet*) is provided to the discourse generator for media realization.

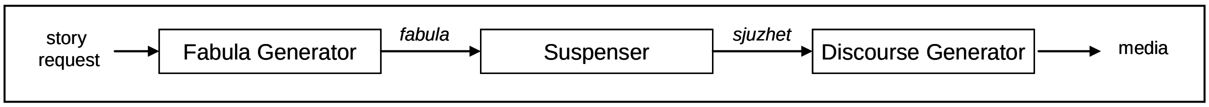


Figure 3.1: A tripartite suspense story generation model

The unidirectional interaction between the *fabula* and *sjuzhet* levels of this model assumes that the *fabula* layer creates an ideal *fabula* for suspense. An iterative process involving collaboration between the components allowing the integration of various additional suspense devices shall be considered in the future work. Ideas for the extension of the current architecture to address this iterative process are described in Section 5.1.

Each component of this model is outlined in the subsequent sections.

3.1.1 The *Fabula* Creator

The *fabula* that is sent to Suspenser is represented as a plan data structure created in response to a story request specifying the initial and goal states of the story world and the operators available for the actions in the story world domain. To generate the *fabula* plan, I use Crossbow—a C# implementation of the hierarchical, partial-order causal link planner Longbow (Young et al., 1994; Young and Moore, 1994). The plan structure used by Crossbow is similar to those used in partial-order, causal link (Penberty and Weld, 1992) and HTN-style planning systems (McAllester and Rosenblitt, 1991). A plan structure used in my approach is defined below.

> **Definition 3.1: *Fabula*.** A *fabula* F is a tuple $<S, B, O, C, D>$ where S is a series of plan steps, B is a set of binding constraints, O is temporal ordering information, C is a list of causal links, and D is a list of decompositional links. S is represented as $<s_1, s_2, \ldots, s_n>$ where s_i is an instantiation of a plan operator

contained in a plan library. A plan operator *op* is a tuple $<N, P, E>$ where N is a unique string, P is a set of preconditions representing just those conditions that must hold for *op* to be able to happen, and E is a set of effects denoting just those conditions that changed by the action's successful execution. A causal link is represented as ($s_i \rightarrow s_j; e$), meaning, plan step s_i establishes e, a precondition of a subsequent step s_j. A decompositional link is shown as (s; s_1, s_2, …, s_n), meaning, an abstract plan step s is decomposed into sub-actions s_1,s_2, …, s_n. Temporal ordering information is denoted as ($s_i < s_j$) where s_i precedes s_j. A binding constraint is denoted as $<s_i; (p, c) >$, where a plan step s_i binds constant c for the step's parameter p.

Each step in the plan is an instantiation of a plan operator. The binding information for its variables and its causal links and temporal constraints related to other actions are stored as separate sets in the plan.

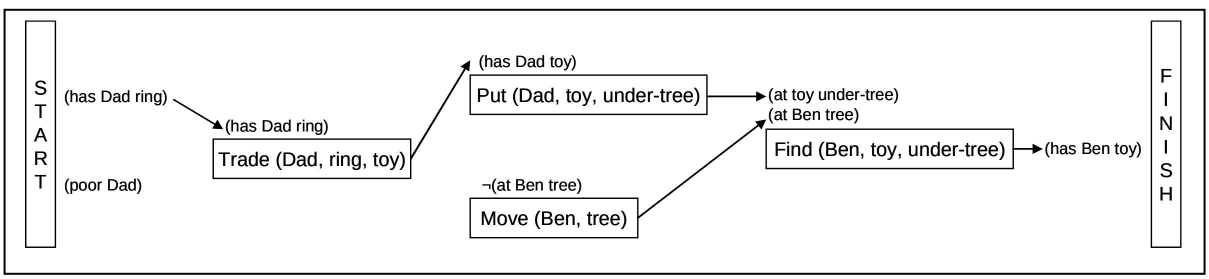


Figure 3.2: An example *fabula* as a plan structure

The plan representation in Figure 3.2 illustrates a *fabula* of a father getting a toy for his seven-year old son Ben as a Christmas gift (an example domain that I use later in the evaluation sections). In the diagram, time proceeds roughly from the left to the right. Rectangles represent actions, with each action's preconditions enumerated above its rectangle. An arrow between two actions indicates a causal relationship that holds between the two, meaning that the action at the starting point of the arrow establishes a precondition for the action at the arrow's end point. Given an initial state (i.e., the father is poor and he has a valuable ring), the plan in Figure 3.2 is constructed to achieve the goal (i.e., Ben's having a toy). The plan can roughly be described in text as: “A poor father traded his wedding ring for the toy that his son Ben wants to have. He then put the toy under their Christmas tree. The next day Ben walked to the tree and found the toy that his father left.”

To find a plan for a given planning problem, Crossbow uses *refinement search* (Kambhampati et al., 1995). Refinement search views the planning process as search through a directed acyclic graph composed of nodes representing plans. The root node of the graph consists of an empty plan containing only the initial state and the goal state of the planning problem; leaf nodes are either complete plans without flaws or plans with flaws that cannot be repaired due to inconsistency in the plan; internal nodes are partial plans with some number of flaws. A flaw in Crossbow is either a precondition of a step that has not been established by a prior step in the plan, a causal link that is threatened (i.e., undone) by the effect of some other step in the plan or an abstract step that needs to be decomposed into more primitive plan steps. In the graph, a parent node and its children are in a refinement relationship, represented graphically here as an arc from the parent to each of the children. Each child node is a refinement of its parent node; that is, the child differs from the parent in that the child has been altered to repair a single flaw in the parent plan. When the repaired flaw is an open precondition, a causal link is added in the child plan from either an existing step in the plan or an instantiated operator in the plan library such that the source action contributing the new causal link has an effect that can be unified with the open precondition of the second step. When the repaired flaw is a threatened causal link, either a temporal ordering (i.e., either demotion or promotion) is added to resolve the threat or binding constraints are added to variables involved in the threat to eliminate the conflict between the steps and causal links involved. If the repaired flaw is an abstract step, then the step is decomposed in the child plan into a series of more-primitive plan steps as encoded in a decomposition schema. This refinement search process continues until either it finds all the complete plans for the given planning problem or the number of searches exceeds a resource bound that represents the reader’s cognitive limit.

3.1.2 Suspenser

Suspenser determines content selection for suspense at the *sjuzhet* layer that is consistent with the views by several narratologists. According to Bal (1985) and Toolan (2001), the experience of suspense in the reader arises from the discrepancy of knowledge between the reader and the characters of a story. In their view, the storyteller (corresponding to the *sjuzhet* level component in my system) selects specific events and determines their narrative time for presentation specifically in order to create this knowledge discrepancy, which in turn gives rise to the experience of suspense in the reader.

> **Definition 3.2: *Sjuzhet*.** A *sjuzhet* Z is a tuple $<F, S>$ where F is a *fabula*, and S is a subset of the plan steps of F to be presented to the user. Z uses the ordering information of F.

Suspenser receives a story plan sent from the *fabula* generator, and it constructs a story structure (*sjuzhet*). Suspenser is composed of three components: the skeleton builder, the suspense creator, and the reader model. Using quantitative and qualitative metrics described in Section 3.2.2.1, the skeleton builder identifies kernels (Barthes, 1975; Chatman, 1978) in the story — important events in a story that cannot be eliminated without harming the story. The reader model takes the sequence of kernels selected by the skeleton builder and checks them for coherency. If the sequence does not satisfy coherency requirements, supplementary story elements are added to the skeleton. The sequence is then passed to the suspense creator that uses a model of the reader's comprehension process to predict which story elements from the *sjuzhet* can serve to contribute to manipulate suspense. The selected events are added to the story skeleton to generate a story structure. The story structure is given as input to the discourse generator for the actual text to be presented.

3.1.3 The Discourse Generator

Upon receiving the story structure from Suspenser, the discourse generator produces surface structure, i.e., text. The current discourse generator uses a template based approach which maps a plan structure into a text. As the surface realization component, FUF and SURGE

(Elhadad and Robin, 1996) can be used. FUF is an extension of the functional unification formalism, and SURGE, written in FUF, is a grammar used for text generation in English. The discourse generator first creates a functional descriptor (FD) from each plan of the input story structure. Then SURGE creates English text from the FD. However, I believe that employing a complex discourse generator (Callaway and Lester, 2002) which takes into account various discourse level problems (e.g., word choice, pronominalization, and rhetoric structure) would generate a qualitatively good text.

3.1.4 Underlying Assumptions and Limitations

In this work, there are a number of specific assumptions that I make which serve to focus the context of the research but also constrain its scope. I list these here as a framing context for the details provided in the following section.

- First, I assume in the work described here that the underlying *fabulas* I deal with all contain conflict. For example, characters' individual goals may be negations of each others', or the plans formed by characters to achieve their goals may interfere with the plans of other characters. While other dramatic devices such as the delaying of resolution are also useful in creating suspense, I focus here on suspense that arises as a result of users' consideration of these conflicts and their consequence on the protagonist's goals.
- This work focuses on the modeling of suspense that is experienced by the reader, not model the suspense felt by characters in the story.
- I focus on plot-suspense (e.g., suspense that arises from plot development) rather than action-suspense (e.g., suspense that is created from action scenes such as a car chase).
- I use a simplified model of the quantitative nature of the levels of suspense. That is, suspense levels are discretized into two extremes: high and low. Although discourse is important for the effective presentation of a story for the reader, the issues that arise in creating text from a given story structure are not directly discussed in this paper.
- This work focuses on non-interactive narrative environments. However, I expect that the extension of my model to interactive environments would be feasible by

expanding the replanning techniques (Riedl, Saretto, and Young, 2003; Harris and Young, 2005).

- While there are a range of means that authors may use to create and manipulate the sense of suspense in readers (e.g., by retarding the resolution of story, focusing on the passage of time approaching critical deadlines, detailing the protagonist to arouse sympathy from the reader, or manipulating the reader's state of knowledge relative to the protagonist), this research only concerns creating suspense by manipulating the number of solutions perceived by the reader.

3.2 The Suspenser Architecture

This section describes the Suspenser architecture as illustrated in Figure 3.3. The system takes three elements as input: a *fabula*, a desired suspense level (i.e., either high-suspense or low-suspense), and a given point *t* in the story plan that corresponds to the point where the reader's suspense is measured. Then Suspenser determines the *sjuzhet*, the content to be used to convey the story up to *t* to a reader.

The three main components of Suspenser are: the skeleton builder, the suspense creator, and the reader model. The skeleton builder selects important events and constructs it as a partial plan, the skeleton of the story, based on the user's needs and knowledge. The skeleton is then passed to the suspense creator to produce the story structure to create suspense for the reader. The reader model provides the individual's mental representation to the coherency evaluator of the skeleton builder and the suspense measurer of the suspense creator.

More details on each component are explained in the following sections. I discuss the reader model first because the model is used by both the skeleton builder and the suspense creator.

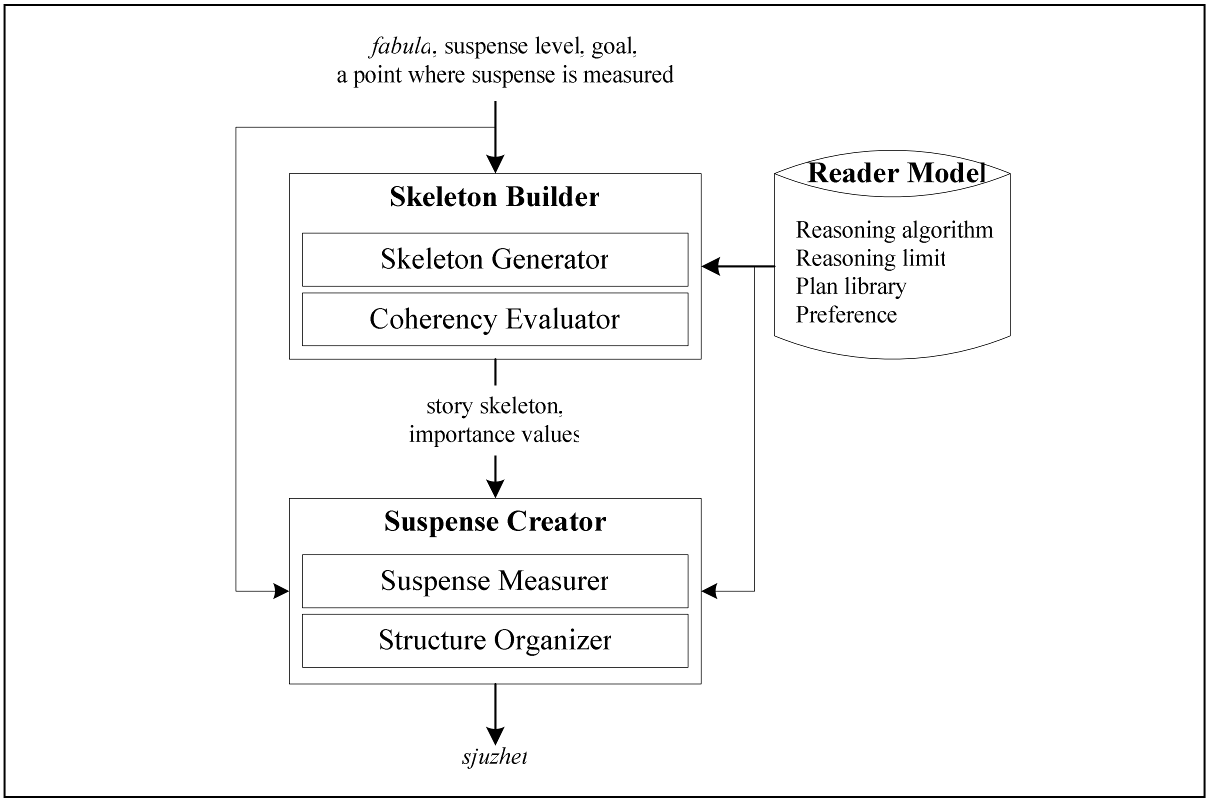


Figure 3.3: The Suspenser Architecture

3.2.1 The Reader Model

The reader model of Suspenser represents the individual's reasoning algorithm, reasoning capacity, knowledge, and preference. For simulating the human reader's reasoning process in this paper, Crossbow—a C# implementation of the hierarchical partial-order causal link planner Longbow (Young et al., 1994; Young and Moore, 1994) is used. As a form of reasoning limit, an integer is used to constrain the number of nodes to be searched during the planning process. To represent the reader's knowledge, a set of operators is defined as a plan library. Each operator has a unique name, a set of preconditions and effects, and a set of variables that are instantiated in the planning process. Preference stores the reader's heuristic function for planning process, and the reader's needs such as parameters that control the content selection processes or a preferable story length.

The following sections discuss the knowledge representation, the story structure, and reasoning algorithm employed in my reader model.

3.2.1.1 Plan Schema as Cognitive Structures of Narrative Comprehension

A large number of attempts have been made to understand the comprehension process of a story reader. Emmott (1997) focuses on the role of a reader's inferences grounded in the context provided by the story. She describes the contextual frame – composed of the information about the subject, location, and time attached to an event – and uses this description to explain a number of phenomena related to narrative comprehension (e.g., pronoun reference). She defines four major types of knowledge representation for making sense of narrative: general knowledge representation, text schemata, text specific knowledge, and text specific stylistic knowledge. Her theory acknowledges that modeling the reader's understanding mechanism is essential in the process of story generation.

Among a number of theories explaining the cognitive process of story comprehension, the resonance model and the constructionist model are commonly accepted by psychologists. The resonance model explains the unconscious process of story understanding such as anaphora resolution or the process of uploading concepts activated by recently read text into short-term memory. When the resonance model fails to resonate a necessary concept needed in order to understand some segment of text, explicit or conscious reasoning on the part of the reader is triggered. This reasoning is directed at finding the information needed to comprehend the text. This conscious process is explained by the constructionist model (Graesser and Wiemer-Hastings, 1999). The reasoning process explained by the constructionist model involves the reader's attempt to maintain the coherency of the story. Graesser et al. (2002) suggest five dimensions (protagonist, temporality, causality, motivation, spatiality) of coherence that the reader is concerned with during reading. If the coherency in any of those dimensions is broken, e.g., if the reader finds no information about one of these dimensions in the current text, then explicit reasoning is again triggered (with a corresponding increase in reading time).

Unlike other genres which need little participation from their readers, reading suspense fiction requires high cognitive elaboration that involves predictive inference (Tan and Diteweg, 1996). Yanal (1998) claims that the author intentionally presents obvious gaps to the reader, as well as information that the reader can use to fill the gap. He proposes that readers use schemas or templates to represent knowledge. A schema, a global semantic framework representing various aspects of reality and guiding perception and comprehension of these (or related) aspects (Prince, 2003), can be obtained from the reader's experiences (event schema) or from knowledge provided in the story (story schema). Many researchers support the use of plan schema to represent reader knowledge in narrative comprehension (Brewer and Lichtenstein, 1981).

> **Concept 4.1 (Schema).** *A global semantic framework representing various aspects of reality and guiding perception and comprehension of these (or related) aspects.* (Prince, 2003).

To represent the knowledge of the reader in my system, a set of plan schema is defined as a *plan library* in my approach. Each operator in a plan library, as shown in Figure 3.4, has its unique name, a set of preconditions and effects, and a set of variables that shall be instantiated in the planning process. The preconditions of an action (i.e., an instantiated operator) represent just those conditions that must hold for the action to be able to happen while the set of effects denotes just those conditions that change by the action's successful execution.

Component Type	**Example Operator Components**	**Textual Description**
Name	trade	
Parameters	?agent1, ?agent2, ?object1, ?object2	
Preconditions	(has ?agent1 ?object1)	?agent1 has ?object1
	(has ?agent2 ?object2)	?agent2 has ?object2
Effects	(has ?agent1 ?object2)	?agent1 has ?object2
	(has ?agent2 ?object1)	?agent2 has ?object1
	¬(has ?agent1 ?object1)	?agent1 does not have ?object1
	¬(has ?agent2 ?object2)	?agent2 does not have ?object2

Figure 3.4: A sample set of plan schema

3.2.1.2 Plan structures as Cognitive Structures of Stories

Cognitive scientists have studied the cognitive structure that a human builds in reading a story. Trabasso et al. (1985) suggest a causal network (Figure 3.5) consisting of nodes and arcs to capture the reader's comprehending process. In their network, a node expresses a story event, and a direction arc denotes that the source node event is a necessary condition for the destination node event to occur. This means that the pair of events connected by an arc is causally related. A similar structure has been employed by Graesser et al. (1991) for their question-answering model, QUEST, in the context of stories. Their story graph contains *statement nodes* and *relational arcs* where a node indicates either an event or a goal. A directional arc is annotated with labels indicating the relationships between source and destination nodes. The types of relation used in QUEST are Reason, Consequence, Implies, Outcome, and Initiate. QUEST predicts candidate nodes that make good answers to queries that fall in one of five categories of open-class questions—why, how, when, enablement, and consequence.

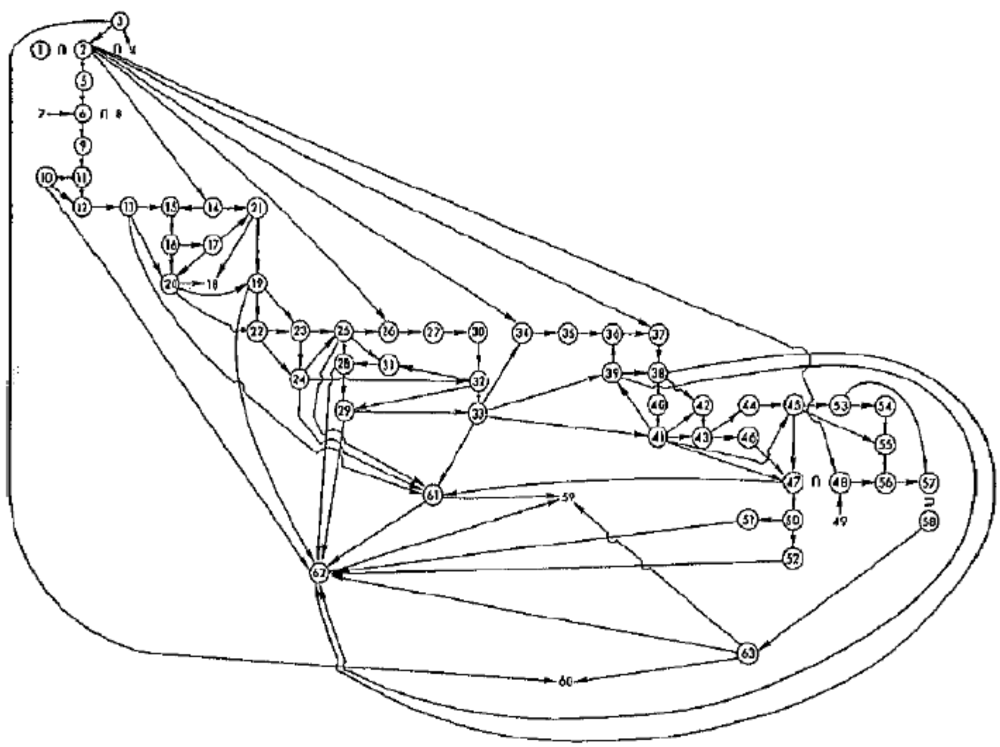


Figure 3.5: A story representation as a causal network (Trabasso and Sperry, 1985)

As an on-line conceptual model of a story built by its reader, Suspense uses a decompositional partial-order causal link (DPOCL) plan structure that is sent from the *fabula* creator. As shown in the Figure 3.6, a story plan contains events as well as their causal, temporal, and hierarchical relationships. This information presented by a plan structure will adequately serve to construct a causal network of a story used in the work of Trabasso and Sperry (1985). Christian and Young (2004) report preliminary results that suggest the expressiveness of the DPOCL plan structure is comparable to the story graph in QUEST. Figure 3.6 shows that 4 out of the 6 arc types used in QUEST are mapped into DPOCL plan structure components.

Arc Type	Description (A -> B)	DPOCL Plan Structure Equivalent
Consequence	A causes or enables B	Actions have effects, which are state changes. Events cannot cause other events.
Implies	A implies B, semi-logical reasoning	Syllogistic reasoning is outside of scope, goal equivalency is handled through causal links from actions to goal states
Reason	B is a reason or motive for A B is a superordinate goal of A	Causal links, a basic plan components, embody reasons for actions
Outcome	B specifies whether or not the goal A is achieved	In simple plan structures, goals are always achieved
Initiate	A initiates or triggers the goal in B	Not covered (plans for future coverage)
Manner	B specifies the manner in which A occurs	Not covered (plans for future coverage)

Figure 3.6: QUEST arc type and its equivalence in DPOCL plan structure (Christian and Young, 2004)

3.2.1.3 Modeling the Reasoning Process

Suspenser uses Crossbow to model the reader's plan-related reasoning processes, modeling the reader's inference process and anticipation of the protagonists' success. Prior work has provided strong evidence that human task reasoning is closely related to partial-order planning algorithms (Rattermann, 2001) and that refinement search (Kambhampati et al., 1995), the type of plan construction process performed by Crossbow, can be used as an effective model of the plan reasoning process (Young, 1999).

In refinement searches (Kambhampati, 1995), the planning process is a search through the plan space, which is represented as a directed acyclic graph of partial plan nodes. In my approach, the root node of the graph is a partial plan taken from the skeleton builder or the suspense creator. The leaf nodes of the graph are either complete plans without flaws or plans with flaws that cannot be repairable due to inconsistency in the plan; internal nodes are partial plans with flaws.

A flaw in Crossbow is either a precondition of some step that has not been established by prior step in the plan, or a causal link that is threatened (i.e., undone) by the effect of some other step in the plan. In the graph, a child node is a refinement of its parent node to repair a single flaw in the parent plan. When the flaw is an open precondition, a causal link is established from either an existing step in the plan or an instantiated operator in the plan library which has an effect that can be unified with the precondition; in the second case, the instantiated step is added to the parent plan. When the flaw is a threatened causal link, a temporal constraint (i.e., either demotion or promotion) to resolve the threat is added or binding constraints are added to separate the threat involved steps so that no conflicts arise. If the flaw is an abstract step, then the step is decomposed into a series primitive plan steps as encoded a decomposition schema. Figure 3.7 shows a plan space resulting from expanding partial plan #1 into three different complete plans (#4, #7, #9) by refining flaws in parent nodes.

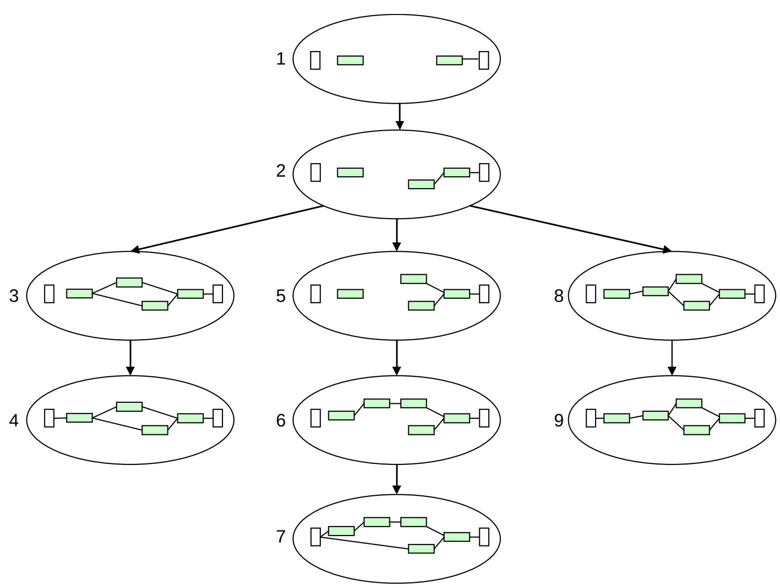


Figure 3.7: A plan space modeling the reader's forwarding inference to find solutions

3.2.2 The Skeleton Builder

Suspenser's primary task, selecting which story elements to tell, is likely to result in some of the story plan's elements being excluded from the discourse describing the story. As more and more elements are excluded from the discourse, however, the resulting gaps in the plan may make the underlying *fabula* difficult to identify. For example, a story without the events of Cinderella losing her shoe and Cinderella meeting the prince would not be readily identified as the well-known version of the Cinderella story.

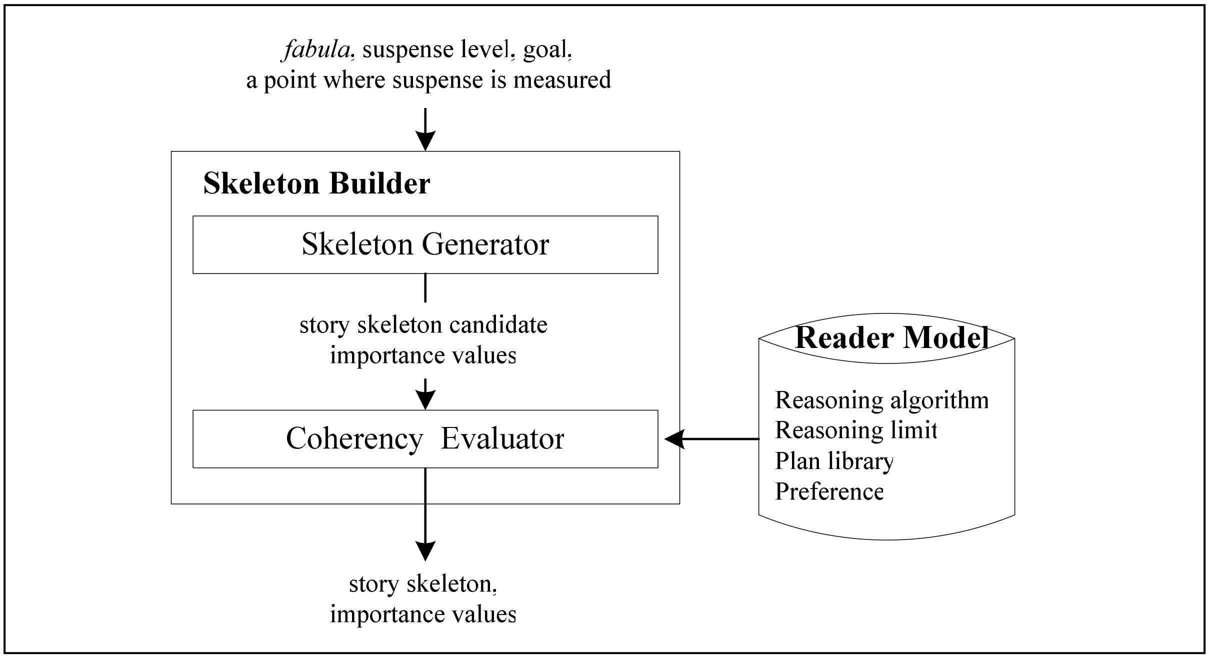


Figure 3.8: The skeleton builder component design

To maintain the identity of the input story, my approach uses techniques that exploit results from narrative comprehension studies by cognitive psychologists to identify a subset of the full *fabula* plan. This subset of the story elements is called the *skeleton*. A partial plan is constructed from the skeleton builder by first generating a candidate skeleton, then testing the skeleton to ensure that its content is coherent, that is, that it can be understood as an integral story. The skeleton builder component design is presented in Figure 3.8.

> **Concept 4.2: Skeleton**. *A partial plan that specifies its plan steps as a set of core story events that cannot be eliminated without harming the understandability of a story*.

To generate a candidate skeleton, the skeleton generator—a subcomponent of the skeleton builder—takes plan as input from the *fabula* creator and selects those actions that have high causal connectivity (e.g., that have a large number of incoming and outgoing causal links) and have an important role in the story (e.g., a step that establishes the goal state). Once an initial candidate skeleton is generated, the coherency evaluator tests to see if the skeleton is coherent from the reader's perspective using a model of a reader's plan-related narrative comprehension process.

The subsequent sections explain the two subcomponent of the skeleton builder: the skeleton generator and the coherency evaluator respectively. The final section discusses the problem of extracting a skeleton that distinguishes a story from others.

3.2.2.1 The Skeleton Generator

Narrative theorists characterize elements of a story as either kernels or satellites (Barthes, 1975; Chatman, 1978). *Kernels* are those events in a story that are so important that they cannot be excluded from the story's telling without harming the story's coherency and identity; *satellites* are less important events that enrich or elaborate upon the kernels and can be omitted without damaging the storyline. Similar distinctions have been also made by computational linguists. Mann and Thompson (1988) describe Rhetoric Structure Theory, a model of discourse in which certain relationships exist between discourse segments in multi-sentential text in a way that a set of satellites support the nucleus.

> **Concept 4.3: Kernel (Nucleus, Cardinal function)**. *As opposed to satellites, kernels are logically essential to the narrative action and cannot be eliminated without destroying its causal-chronological coherence* (Prince, 2003).

Concept 4.4: Satellite (Catalysis). *A minor plot event. As opposed to kernels, satellites are not logically essential to the narrative action, and their elimination does not destroy its causal-chronological coherence: rather than constituting crucial nodes in the action, they fill in the narrative space between these nodes* (Prince, 2003).

In my system, I define a kernel extractor component that rates the importance of each event of the input story plan, identifies the most important *N* events as *kernels* and labels the rest as *satellites*. The kernel generator rates the importance of each event based on a method devised by Trabasso et al. (1984) for extracting important actions that are likely to be included in the story recall. To determine an individual story event's importance, their approach counts the number of causal relationships with other steps the event plays a role in. Further, they measure each event's importance by analyzing its role in the causal chains. Causal chains are a series of actions in the story that are causally related. Causal chains contain actions that can be characterized as either opening events, closing events, or continuing events. Opening events introduce characters and the setting and initiate the story. Closing events determine whether the protagonists' main goals are achieved or not. Continuing events causally connect opening events to the closing events via sequences (or causal chains) of one or more continuing events. In my approach, causal relationships can be approximated by counting the number of incoming and outgoing causal links a step plays a role in. The quantitative importance of an event is calculated using the number of causal links. The qualitative importance is determined by its type. This approach to computing the quantitative significance of individual steps follows that defined in the CPI model (Young, 1999) used to create concise instructional texts.

The skeleton generator approximates causal relationships by counting the number of incoming and outgoing causal links of a plan step and measuring the qualitative importance of events which are determined by their roles in the plan. I define three important roles of events in a story plan: an opening act, a closing act, and a motivated act. An opening act is the first action in the plan. A closing act is the last action that occurs in the story. Motivated acts are actions that establish a literal of the goal state. I apply a simple linearization routine to the *fabula* to detect the opening act and the closing act in a plan. After computing each event's importance, the top *N* events are selected. The value for *N* can be set as either an integer that has been specified by the system operator or a ratio against the total number of actions in the plan. From these chosen events the system builds a skeleton, a partial plan that specifies those events as its plan steps. Equation 1 shows how the importance of each event is calculated.

$$w(a,p) = \frac{(k_i In(a,p) + k_j Init(a,p) + k_o Out(a,p) + k_c cc(a,p))}{DistEffect(a,p)} \quad \text{(Eq. 1)}$$

(where $k_i, k_j, k_o, k_c \geq 0$ and $k_i < k_o, k_j < k_i$)

Here *In(a, p)* returns the number of incoming causal links to *a* coming from steps of the plan *p* other than the initial step, *Init(a, p)* returns the number of incoming causal links to *a* from the plan's initial step, and *Out(a, p)* returns the number of *a*'s outgoing causal links, *cc(a, p)* returns the causal chain value of *a* in the plan, and *DistEffect(a, p)* returns a value associated with the causal distance between the step *a* and the goal step of the plan *p* where the causal distance refers to (the minimum number of causal link chains that connect the plan step *a* and the goal step in the plan *p*). All scaling factors in Eq. (1) are constrained to be real numbers no less than 0.

In the formula, the causal chain value of an event (that *cc(a, p)* returns) is determined by the event's causal chain type. Similar to the Trabasso's causal chain categories, the kernel extractor define five types of elements that can participate in a causal chain: an opening act, a closing act, a motivated act, a dead-end act and other. Opening acts are the first actions in the story – those that connect propositions from the initial state to later events in the text; Closing acts are the last actions that occur in the story; motivated acts are plan steps that are in causal relationship with a precondition of the goal state; Dead-end acts are plan steps that have no outgoing causal links; other is an annotation used for steps that are not in any of the above four categories. Important categories (i.e., opening acts, motivating acts) are assigned high integer values to give increased likelihood for those acts to be included in the skeleton. Less important categories (i.e., dead-end, other) are assigned low integer value. The assigned values are determined empirically through informal experiments. In summary, for a given step in the story plan, the importance of an event is calculated by the number of causal links multiplied by a parameter determined by its causal chain type value.

With these information related to each event, the kernels of a story are identified as illustrated in Figure 3.9. In the figure, when *DistEffect(a, p)* is assumed to return 1 in Eq. (1), the actions with relatively large number of causal links (i.e., *G* and *E*) or goal motivated events (i.e., *A* and *B*) are identified as kernels. After computing each event's importance based on the above equation, the top *N* events are identified as kernels. The value for *N* cannot be greater than the number of steps in the input *fabula*. Since choosing too large or too small a value for *N* would result in an ineffective discourse, *N* shall be carefully tuned through empirical analysis for a specific domain. Some factors, such as the number of steps or the degree of causality of a story, may influence the value for *N*. For example, a domain where every step of a plan plays an important role in achieving the story goal may require a fair amount of steps to be understood as a coherent story, which will restrict *N* to be a relatively large number. This issue is not addressed in this thesis. Instead, the value for *N* can be set by the user as a desired story length, or it can be calculated from a predefined ratio against the total number of actions in the input story world.

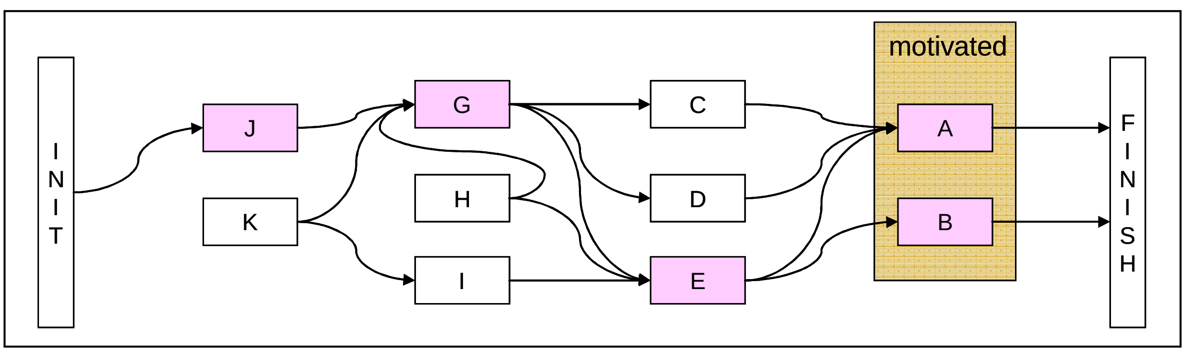


Figure 3.9: Identifying kernels in a story plan. An event is represented as a box. A causal link is denoted as an arrow.

In Eq. (1) a normalization function *DistEffect(a, p)* is incorporated in order to simulate the *psychological distance effect*, which says that an action in an episode is more readily understood when it is nearer to the episode goal (Foss and Bower, 1986). Foss and Bower define the distance from an action to a goal as the number of actions interposed between them in a subgoal hierarchy (a plan) constructed in the reader's mind, In Figure 3.10, the distance between the action, *embezzlement,* and the goal, *steal money*, is estimated nearer than that between the action, *training,* and the goal.

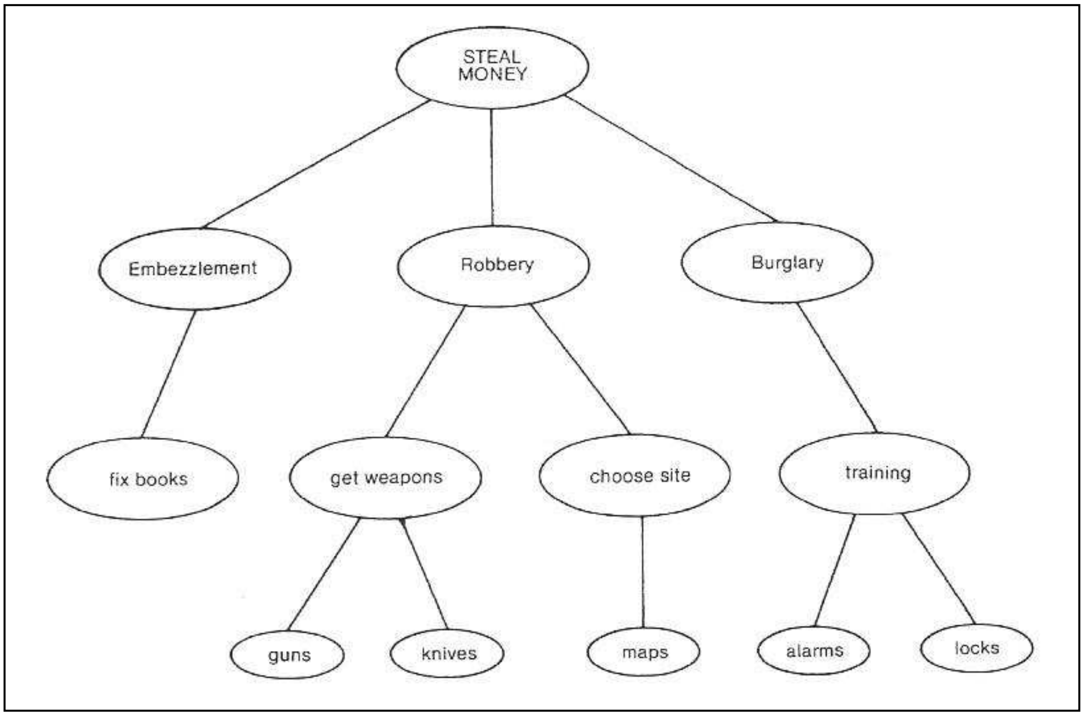


Figure 3.10: An example of a goal hierarchy (Foss and Bower, 1986)

In my system, the distance from an action to the goal is defined as the minimum number of causal links that relate an action to the goal in a plan. While various functions can be designed for *DistEffect(a, p),* the *psychological distance effect* can be maintained when the following condition is satisfied.

If $Dist(a, p) \le Dist(b, p)$, then $DistEffect(a, p) \le DistEffect(b, p)$

(where *Dist(x, p)* is the causal distance from the action *x* to the goal of the plan *p*)

This condition requires the causal distance magnitude ordering of action-goal pairs to be retained in *DistEffect(a, p)* pair magnitudes, as well. For example, in Figure 3.9 the causal distance between the action *A* and *goal step* is 1, and the distance between the action *D* and the goal is 2, which makes the distance of the action *A-goal* pair nearer than that of the action *D-goal* pair. Therefore, a function suitable for *DistEffect(a, p)* would yield a value for the *A-goal* pair smaller that that for the *D-goal* pair.

The skeleton builder sends the *N* kernels and the importance value for each event in the input story to the coherency evaluator to check if the skeleton is coherent based on a model of the reader's comprehension process.

3.2.2.2 The Coherency Evaluator

Once an initial candidate skeleton is generated, the coherency evaluator tests to see if the skeleton is coherent from the reader's perspective using an algorithm which is a cycle composed of two phases: coherency check and event selection. The coherency check step uses the reasoning algorithm in the reader model built using Crossbow, to find complete plans which are consistent with the candidate skeleton to achieve the protagonist's goals. If such a plan is found, the story skeleton is coherent and the program exits. Otherwise, the *fabula* event with the highest importance value is selected from the set of event excluded from the initial skeleton and added to a new candidate skeleton. Then, the recursive coherency check phase begins again. Finally, the story skeleton and the importance rating for each event of the input *fabula* are passed to the suspense creator.

In the coherency check, the evaluator employs a user model to represent the user's reasoning capacity (i.e., a reasoning algorithm, a reasoning resource bound, knowledge and preferences). To model a user's plan-related reasoning, I use *Crossbow*, a version of the Longbow planning system (Young et al., 1994) discussed in Section 3.2.1.3.

Figure 3.11 shows the iteration over the two phases of the coherency checking algorithm. In the coherency check phase, the framework employs the reasoning algorithm in the user model to find a complete plan to achieve the goal by setting the events of the skeleton as its root node. If such a plan is found as one of the leaf node plans in the resulting plan space, the story skeleton is coherent and the program exits. Otherwise, it begins the second phase, in which an event excluded from the current skeleton with the highest importance value is added to the skeleton. Then, these two phases iterate until a complete plan is found. Finally, the coherent story skeleton is passed to the discourse generator to be realized into text.

Input <G, F, PL, K, W> where

- G is the protagonist's goal state.
- F=(SP, B, CL, O) where SP={s_1, s_2, …, s_l} where s_i is a step, B={b_1, b_2, …, b_n} where b_i is a tuple of < s_l, p_1, v_1> when $s_l \in$ SP, which means that the plan step s_l binds the parameter p_1 to a literal v_1, CL={c_1, c_2, …, c_n} where c_i is a causal link information represented as a tuple <e, s_1, s_2> where *e* is a condition, and $s_1 \in$ SP and $s_2 \in$ SP, which means that plan step s_1 enables the precondition *e* of s_2, O={ o_1, o_2, …, o_n } where o_i is a tuple of <s_k s_j> when $s_k \in$ SP and $s_j \in$ SP
- PL is the reader's plan library
- K={s_1, s_2, …, s_k} where s_i is a kernel and $s_i \in$ SP.
- W={i_1, i_2, …, i_n} where i_j is a tuple of <s_j, w_j> when $s_j \in$ SP and $s_j \notin$ K and w_j is a real number representing the weight of s_j

1 Initialization
- Set SK=<K, SB, SCL, SO> where SB={b_1, b_2, …, b_n} where b_i is a tuple of <s_i, p_i, v_i> when $s_i \in$ K and $b_i \in$ B, SCL={c_1, c_2, …, c_n} where c_i is a tuple of <e, s_1, s_2> when $c_i \in$ CL and $s_1 \in$ K and $s_2 \in$ K, and SO={ o_1, o_2, …, o_n } where o_i is a tuple of <s_k s_j> when $s_k \in$ K and $s_j \in$ K and $o_i \in$ O.
- Set the satellite SL=SP-K

2 Find complete plans built up from the skeleton

2.1 Crossbow plans to find a set of solutions R starting from the root node which represents the partial plan SK using PL for G.
- If the set R is not empty, return "*coherent*" and exit, otherwise
- If SL is empty, Return "*incoherent*" and exit, otherwise
- Find a tuple <s_i, w_i> when w_i is the maximum value in W.
  - Add s_i to K
  - Add all the binding constraints in B that contains s_i to SB
  - Add all the causal links in CL that contains s_i to SCL.
  - Add all the temporal constraints in O that contains s_i to SO.
  - Remove s_i from SL
  - Remove <s_i, w_i> from W.
  - Goto step 2.1

Figure 3.11: Coherency Checking Algorithm

This skeleton builder model follows the principle of the CPI (cooperative plan identification) architecture, a computational model that generates concise textual descriptions of plans developed by Young (1999). In the CPI architecture, speakers build candidate partial plans by leaving out unnecessary information. A partial plan is characterized as cooperative if a hearer can reconstruct a complete plan from the given partial plan using her reasoning processes. The skeleton builder and the CPI model are similar in that both extract a partial plan that enables the recipient to generate a complete plan. However, the skeleton builder differs from the CPI model in two ways. First, the skeleton builder considers the qualitative importance of an event using the event type, which is not considered in the CPI model. Second, the CPI model requires the hearer's complete plan be similar to the original plan within a given threshold, which is not demanded by the skeleton builder. Those distinctions are due to their different domains; the skeleton builder is for narrative that the reader enjoys; the CPI model is for the generation of instructions for the user to follow to achieve her specific goal.

3.2.2.3 A Skeleton Distinguishing a Story from Others

The two previous sections discuss how the skeleton builder takes one *fabula* and extracts essential events from which the reader constructs a new *fabula*. In this section, I extend the skeleton builder to take multiple *fabulas* and return a skeleton that is shared by some of those *fabulas*.

Up to this point, no constraints have been applied to the complete *fabula* that the reader builds from the given skeleton. Thus, an extreme case could occur where the reader misunderstands the *sjuzhet* created from *fabula A* as a very different *fabula*, *B* or *C*. Particularly, this may occur when *N* is not properly set, because the skeleton is extracted from *fabula A* without considering the features which distinguish it from other *fabulas*. For instance, the skeleton "A pretty girl was ill-treated by her stepmother. She met a charming prince. The prince proposed her to marry her. She agreed, and they lived happily ever after" does not provide enough information for readers to infer if this is *Cinderella* or *Shrek*. It will get even harder when the *fabulas* describe an original film and its sequels where a fair amount of the *fabulas*' story world material, such as, characters, settings, and events, can be shared.

This problem can be viewed in terms of the related problem of generating concise communicative content. These approaches search for a minimal set of features that allow the subject to be uniquely identified. For example, imagine a situation where two people can see a white dog, a black dog, and a black cat. It is enough for a speaker to say "the cat" when she refers to the black cat, or she may say "the white one" to specify the white dog. But, she wouldn't say "the dog" when referring to the black dog, since this feature is shared by the white dog, which is not speaker's intended subject.

Generating concise communicative content has been investigated by a number of computational linguistics researchers (Appelt, 1985; Dale and Reiter, 1995; Young, 1999). The well-known Maxim of Quantity, "Do not tell more than what is needed," proposed by Grice plays a significant role in this research. The CPI (cooperative plan identification) architecture by Young (1999) generates concise textual descriptions of desirable plans for completing a user's task by leaving out unnecessary information. The work of Appelt (1985) and Dale and Reiter (1995) produces an expression describing a group of target objects that will be identifiable by hearers.

For my purposes, the CPI approach provides a key benefit: while the others extract just the information that discriminate a target set from the others, CPI also provides information that is essential for the target set because it serves the additional purpose of enabling the hearer to complete her task.

To examine those aspects of the CPI Architecture used in this thesis, consider Figure 3.12, which illustrates a plan space built with CPI. It solves the problem of contacting a user in the America Online (AOL) domain. Four different plans are available in the AOL domain—entering a chat room where the person is connected (#6), sending an email (#9), sending an instant message to pop up on the person's screen (#11), and posting a message board that the person regularly monitors (#13). Suppose preferred ways of communicating in the AOL are assumed to be sending an email (#9) and sending an instant message (#11). Then the task of CPI is to provide a user with just enough information to guide her to construct these two successful plans. When too little information is provided, her plan space includes undesirable plans. For example, instructional texts based on the content of partial plan #4 will make all four plans (#6, #9, #11, and #13) available to her although some of them are not intended. On the other hand, too much information will cause her to exclude some good options. For example, given partial plan #8, the hearer will construct only one plan (#9). In this example, partial plan #7 makes an ideal candidate since it correctly confines her options to the successful plans.

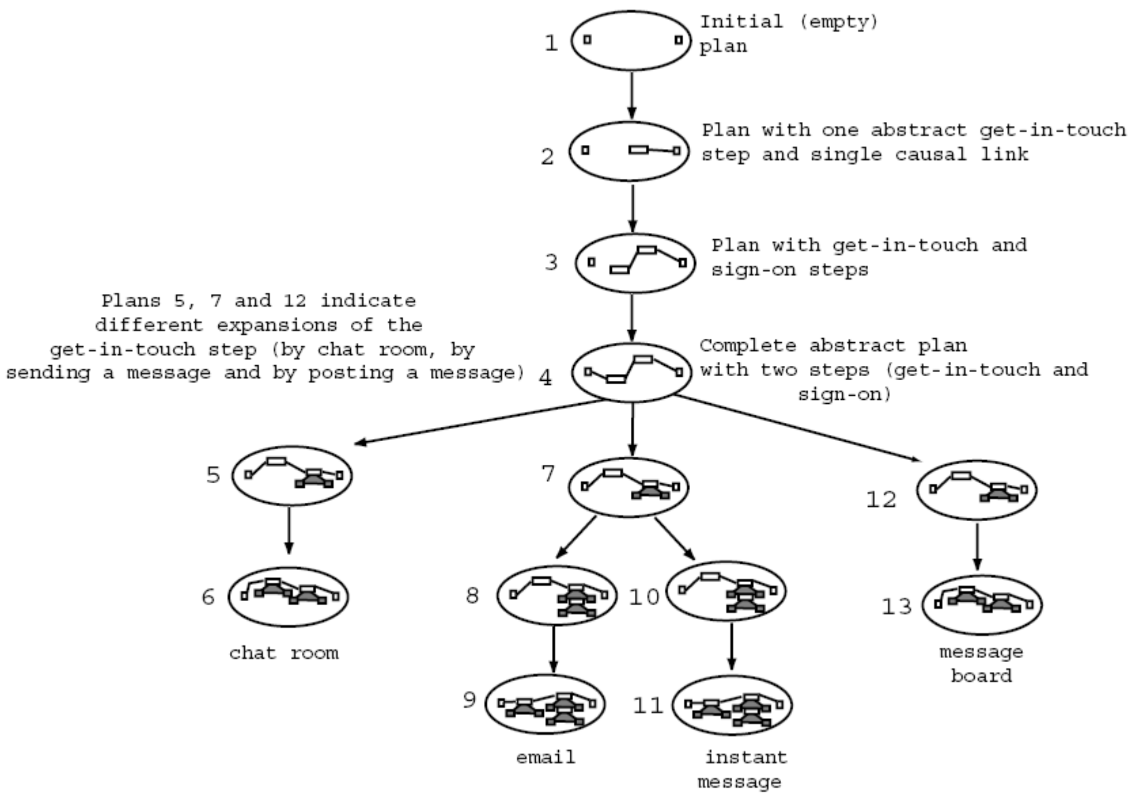


Figure 3.12: A Complete Plan Space for AOL Problem (Young, 1999)

Elements of the approach used by the CPI architecture are readily transferable to solving the problem of extracting a skeleton that identifies a story from the rest. By replacing the AOL domain with a story domain, the above example can demonstrate the process of extracting an identifying skeleton.

Input $<DF, UF, F, K, W, G, PL>$ where

- A set of desirable *fabulas* $DF = \{F_1, F_2, \ldots, F_n\}$ where F_i is a *fabula*
- A set of undesirable *fabulas* $UF=\{F_1, F_2, \ldots, F_n\}$ where F_i is a *fabula*
- An input *fabula* $F=(SP, B, CL, O)$ where $SP=\{s_1, s_2, \ldots, s_l\}$ where s_i is a step, $B=\{b_1, b_2, \ldots, b_n\}$ where b_i is a tuple of $< s_l, p_1, v_1>$ when $s_l \in SP$, which means that the plan step s_l binds the parameter p_1 to a literal v_1, $CL=\{c_1, c_2, \ldots, c_n\}$ where c_i is a causal link information represented as a tuple $<e, s_1, s_2>$ where e is a condition, and $s_1 \in SP$ and $s_2 \in SP$, which means that plan step s_1 enables the precondition e of s_2, $O=\{ o_1, o_2, \ldots, o_n \}$ where o_i is a ordering constraint represented as a tuple of $<s_k\ s_j>$ when $s_k \in SP$ and $s_j \in SP$
- $K=\{s_1, s_2, \ldots, s_k\}$ where s_i is a kernel and $s_i \in SP$.
- $W=\{i_1, i_2, \ldots, i_n\}$ where i_j is a tuple of $<s_j, w_j>$ when $s_j \in SP$ and $s_j \notin K$ and w_j is a real number representing the weight of s_j.
- G is the protagonist's goal state.
- PL is the reader's plan library.

1 Initialization

- Set $SK=<K, SB, SCL, SO>$ where $SB=\{b_1, b_2, \ldots, b_n\}$ where b_i is a tuple of $<s_l, p_1, v_1>$ when $s_l \in K$ and $b_i \in B$, $SCL=\{c_1, c_2, \ldots, c_n\}$ where c_i is a tuple of $<e, s_1, s_2>$ and $c_i \in CL$ when $s_1 \in K$ and $s_2 \in K$, and $SO=\{ o_1, o_2, \ldots, o_n \}$ where o_i is a tuple of $<s_k\ s_j>$ when $s_k \in K$ and $s_j \in K$ and $o_i \in O$.
- Set the satellite SL=SP-K

2 Finds complete plans built up from the skeleton

2.1 Crossbow plans to find a set of solutions R starting from the root node which represents the partial plan SK using PL for G.

- o If ($R \not\subset DF$), return "not found" and exit, otherwise
- o If ($R = DF$)
  - o If ($r_i \notin UF$) for all $r_i \in R$, return SK and exit, otherwise
  - o return "not found" and exit
- o If ($R \subset DF$)
  - o If ($r_i \notin UF$) for all $r_i \in R$, Goto step 2.1, otherwise,
  - o If SL is empty, return "not found" and exit, otherwise
  - o Find a tuple $<s_i, w_i>$ when w_i is the maximum value in W
    - Add s_i to K
    - Add all the binding constraints in B that contains si to SB
    - Add all the causal links in CL that contains s_i to SCL.
    - Add all the temporal constraints in O that contains s_i to SO.
    - Remove s_i from SL
    - Remove $<s_i, w_i>$ from W.
    - Goto step 2.1

Figure 3.13: Algorithm that extracts a skeleton that enables a story to be identified from others

For example, imagine that the plans #9 and #11 are desirable *fabulas* representing *Shrek* which the storyteller intends to deliver to the reader, while the plans #6 and #13 are undesirable *fabulas* delegating *Cinderella*. When being told partial plan #7, a skeleton, the reader would correctly build her story world as the teller intends.

Adopting the Local Brevity Algorithm used in the CPI model which iteratively adds a plan step to the partial plan conveyed to the user until the plan correctly abstracts only the successful plans, the skeleton extraction algorithm presented in the previous section is revised as in Figure 3.13 to enable a set of target *fabulas* to be distinguished from the rest.

3.2.3 The Suspense Creator

The suspense creator takes as input the story skeleton and importance value of each *fabula* action received from the skeleton builder. The suspense creator constructs a *sjuzhet* to evoke the intended suspense level from the reader at *t*, the point where the reader's suspense level is measured. The suspense creator consists of two components: the structure organizer and the suspense measurer (see Figure 3.14). The *sjuzhet* is initialized with the given story skeleton. Then the structure organizer updates the *sjuzhet* with story content, elements that can influence the reader's suspense level, iterating based on the corresponding suspense level returned from the suspense measurer.

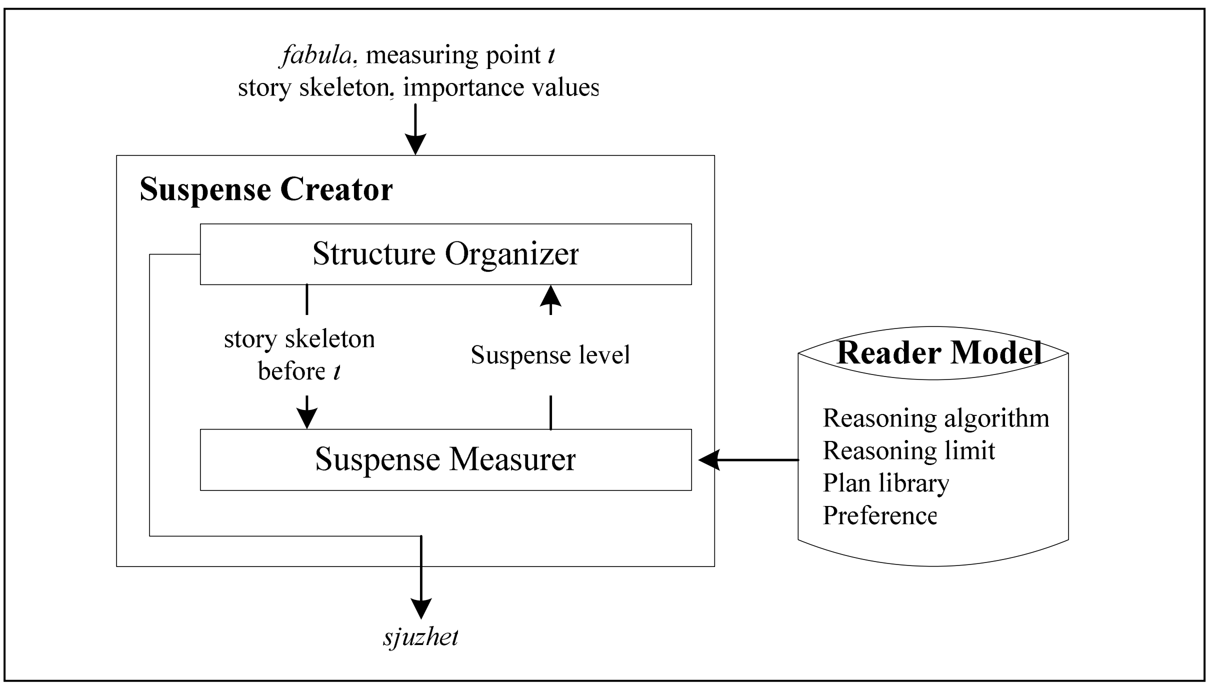
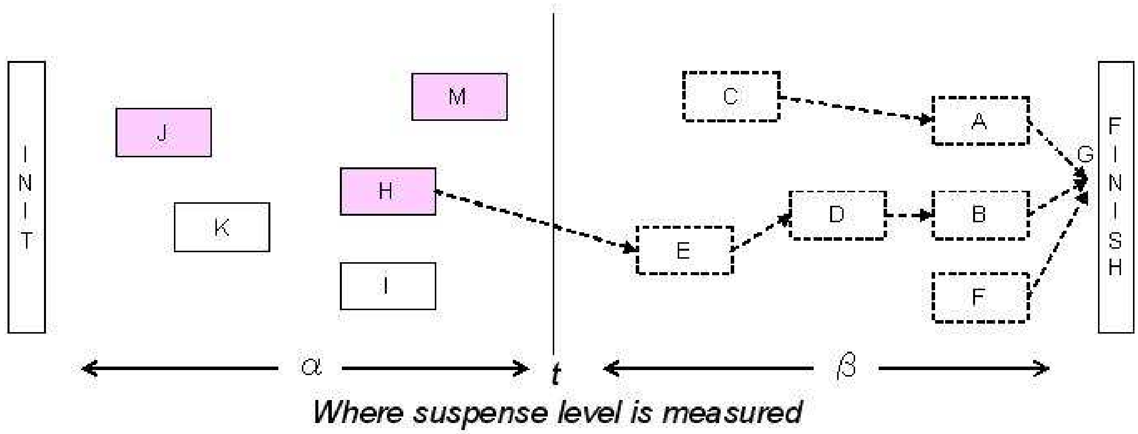
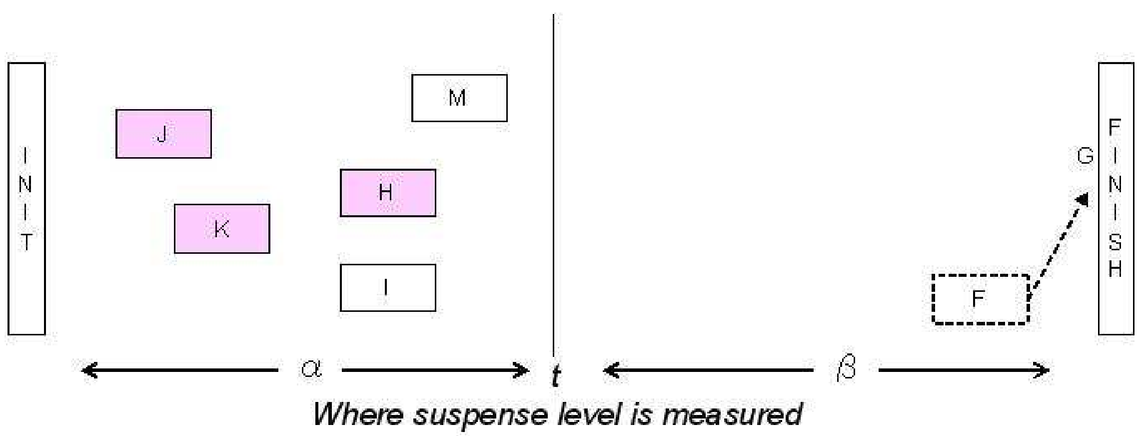


Figure 3.14: The suspense creator component

To find story elements that can invoke the intended suspense level from the reader, I follow the hypothesis that an audience will feel an increased measure of suspense as the number of solutions that lead to the protagonist's goal is restricted (Gerrig and Bernardo, 1994).



(a) A *sjuzhet* that results in three options in the reader's model



(b) A *sjuzhet* that results in only one option in the reader's model

Figure 3.15: A story plan. Colored boxes denote actions in the story to be told, dotted-lined boxes denote the inferred actions in the reader's mind, and dotted-lines are causal links inferred by the reader.

Figure 3.15 illustrates the central task of the suspense creator. Given a story skeleton (S_K), the satellites (S), the goal state (G), and a target step (t), the suspense creator's job is to find a series of plan steps α from a portion of the satellites preceding the plan step *t*, which enables the reader to infer an adequate number of solutions for *G*, given (S_K + α). The system finds an *α* that results in more than one solution which according to Gerrig and Bernado, will invoke a high level of suspense in the reader. In Figure 3.15, for example, telling subsets *J*, *H*, and *M* results in three solutions being inferred by the reader model, while telling the set *J*, *K*, and *H* results in one solution. Then, the combination of *J*, *K*, and *H* that minimizes the solutions would constitute *sjuzhet* in the high-suspense mode.

Input: <F, K, t, N> where F is a tuple <A, B, O, C, D> where A is a set of plan steps, B is a set of binding constraints, O is temporal ordering information, C is a list of causal links, and D is a list of decompositional links, K is a set of kernels, t is a step in S, NE and NO are integers.

1. Initialization: a *sjuzhet* Z = <F, S, O> where S = K, and O = {}, i = 0, j = 0, ST = A−K.

2. Termination: If i = N, or *ST* is empty or no candidates satisfying the following conditions are found, then return *Z*.

3. Event Selection

- If i ≥ N, then return Z.
- Select an action *e* in ST which has the greatest positive *potential suspense*. If several candidates are found, non-deterministically select an action with the greatest *importance value*.
- If the suspense level from the partial plan which has all the plans steps *(S + e)* is greater than the suspense level with the partial plan which has all the plan steps in *S*, then add *e* to *S* and subtract *e* from *ST*.
- i = i + 1.
- Goto step 3.

Figure 3.16: Algorithm for content selection in the high-suspense mode

The overall algorithm that the suspense creator performs to produce a highly suspenseful story is illustrated in Figure 3.16. In the algorithm, I introduce the term *potential suspense* that refers to the amount of each event's contribution to the suspense level increase, computed using Heuristic Function 2, as will be described in Section 3.2.3.2. The algorithm selects an action with the greatest potential suspense is chosen as *α*, and creates a partial plan

P composed of *α* along with the steps in the skeleton. If the suspense level from *P* is greater than the suspense from the skeleton, then the current skeleton is replaced with *P*. This process repeats for a specified times or until there is no candidate for *α*. When the first phase terminates, the system specifies the output *sjuzhet* as the current skeleton.

The algorithm in the low-suspense mode is similar to that in the high-suspense model. However, in low-suspense mode, the first phase selects an action with the lowest potential suspense as *α*, and checks if the suspense level is lowered by adding *α* to the skeleton.

The following sections describe the details of how the suspense creator effectively constructs a *sjuzhet* that results in a few or a large number of solutions in the reader's cognitive model. I first discuss uncertainty checking and suspense measuring performed by the suspense measurer. Then I explain the two heuristic functions used by the structure organizer. Finally, I describe the event selection process performed by the structure organizer.

3.2.3.1 Measuring Suspense Level

3.2.3.1.1 Uncertainty Checking

As discussed in Chapter 2, one critical condition for a reader to feel suspense is to keep her uncertain about the outcome of a significant event. When the reader is certain about the negative outcome, she feels disappointment or sadness rather than suspense (Zilllmann, 1996). To meet the uncertainty condition of suspense, the reader model checks if the reader would be uncertain about the goal state using the planning space. In logical terms, an agent is uncertain about a proposition *p* when the agent makes two kinds of inferences, one leading to *p* and the other leading to ~*p* (van der Hoek and Lomuscio, 2004). In other words, the agent is uncertain if the proposition is true or false.

To determine uncertainty in my planning domain, however, my system uses certainty, the opposite concept. The planning space represents the reader's reasoning and an inference corresponds to a path from the root node to a terminal node in the planning space. Therefore certainty is obtained when either the planning space has only complete plans or the planning space has only failed plans. For example, if the protagonist has a goal to get a signature from Shakespeare who is dead in the story, it is obvious that the protagonist will fail when the reader has no plan operator to resurrect him because the open precondition, (alive

Shakespeare), cannot be established. In contrast, the reader is uncertain about the goal state when the planning space has successful plans and failed plans, as depicted in Figure 3.17a or when the planning exceeds the searching limit (Figure 3.17b). Finally, in the certain cases, the reader model informs the suspense measurer certainty. Otherwise, it returns the number of solutions inferred by the reader model.

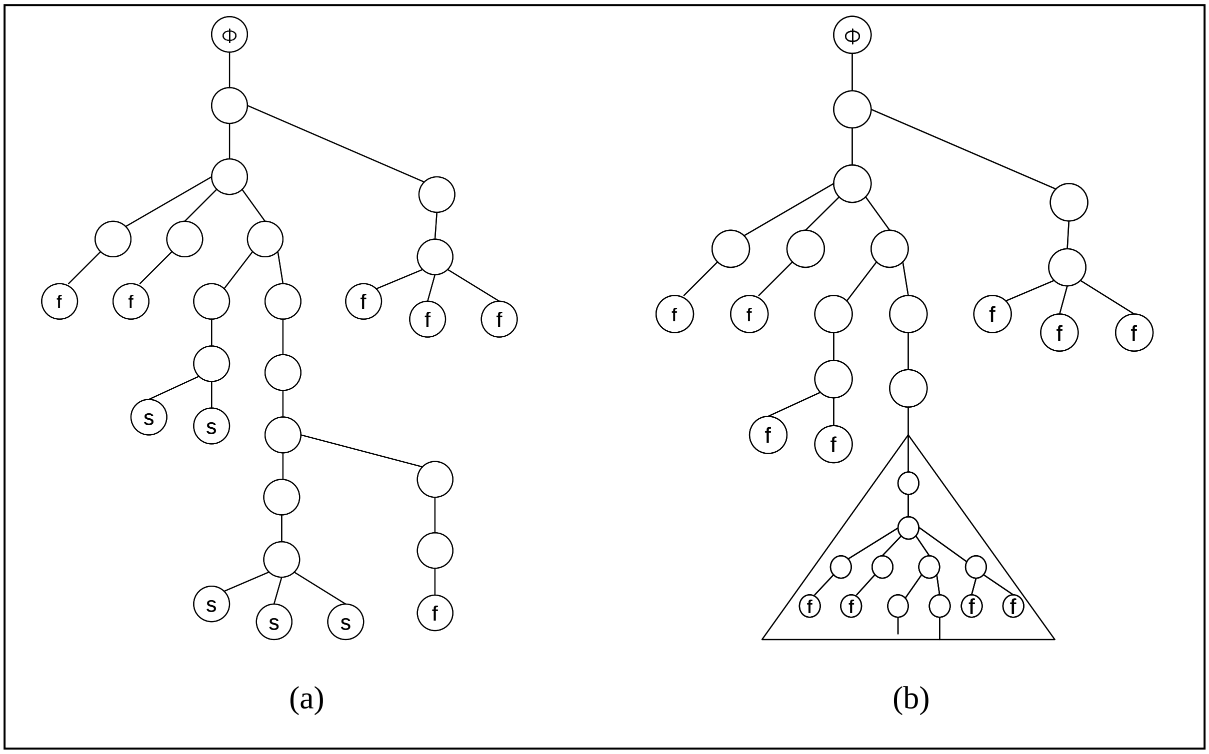


Figure 3.17: Uncertainty about the goal state in planning space. The terminal node with the symbol f means failed node. The terminal node with the symbol s means failed node. a) The planning space has both successful and failed nodes. (b) The planning space is not completed after searching over than searching limit

3.2.3.1.2 Suspense Level Function

In measuring the reader's suspense level, the system follows the notion articulated by Gerrig and Bernardo (1994), in which they view an audience as problem-solvers: an audience will feel an increased measure of suspense as the number of options for the protagonist's successful outcome(s) decreases. In experiments by Comisky and Bryant (1982), participants have shown optimal story reading suspense when they have a positive disposition toward the protagonists and the probability of the protagonists' success is 1/100.

Adopting these models, I devise Heuristic Function 1 for measuring the *level of suspense*. The function computes the reader's suspense level as the inverse of the number of planned solutions that achieve the protagonists' goal using her reasoning algorithm and her plan library within her reasoning limit. The function sets a minimum level of suspense when no usable solutions are found in her plan space, as is supported by psychological research.

Heuristic Function 1 (*Level of suspense*) In the Suspense level function *SL(G, Z, L, P, R)*. *G* is a set of literals representing the goal of a narrative's protagonist, *Z* is a partial plan, *L* is a plan library, *P* is a planning algorithm, *R* is an integer representing a reasoning bound, and *success(G, Z, L, P, R)* returns the number of paths to make *G* true with given *Z* and *R*.
SL(G, Z, L, P, R) is set to (1/*success(G, Z, L, P, R))* when *success(G, Z, L, P, R)* returns a non-zero value and zero when *success(G, Z, L, P, R)* returns 0.

If $(success(G,Z,L,P,R) == 0)$, then $sl(G,Z,L,P,R) = 0$
Otherwise,

$$sl(G,Z,L,P,R) = \frac{1}{success(G,Z,L,P,R)} \tag{2}$$

where *success(G, Z, L, P, R)* returns the number of paths to make *G* true with given *Z, L, P, R*.

To illustrate the level of suspense measured by my heuristic function, Figure 3.18 shows different plan spaces built from two distinct partial plans. The diagram on the left contains three successful plans while the one on the right generates only one. In this case, the plan space on the right is preferred since it creates more suspense than the left one, according to Heuristic Function 1. Thus, the partial plan used to build the right plan space is also selected for constructing a *sjuzhet* to be presented to the reader.

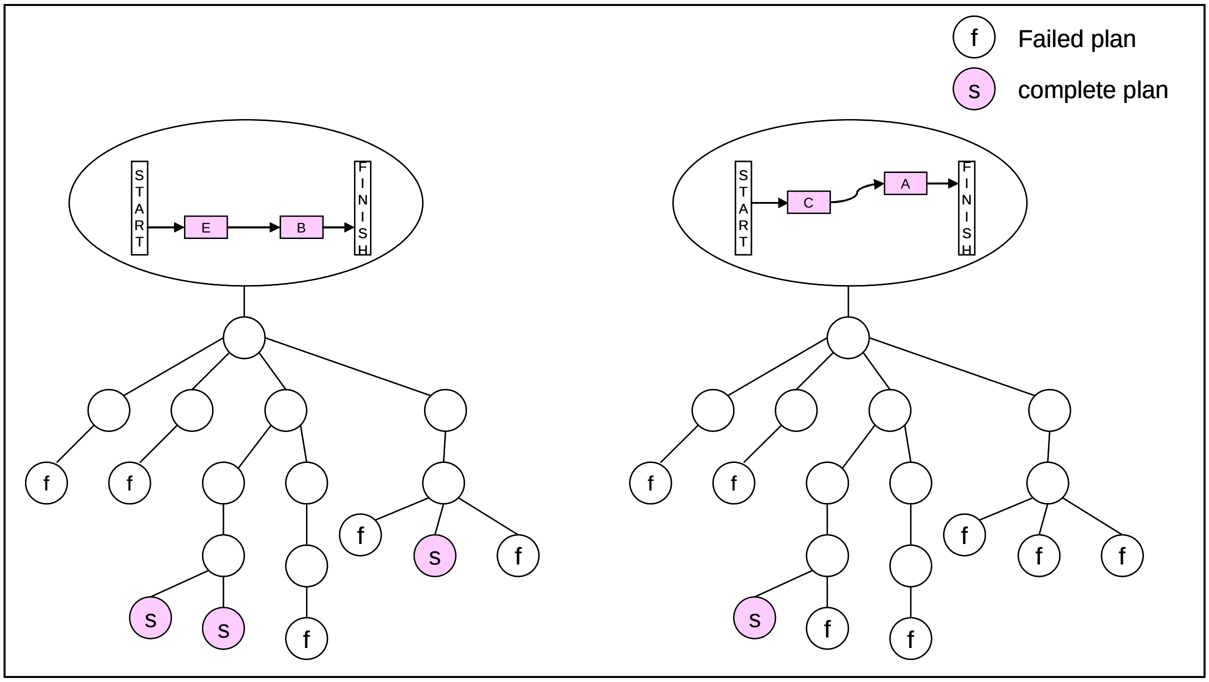


Figure 3.18: Two example plan spaces that the reader model builds to infer the protagonist's mission

3.2.3.2 Measuring Potential Suspense for an Action

The structure organizer finds additional elements from the set of the given satellites that influence the suspense level in the reader's model. In selecting additional events to be presented, I use a heuristic function that examines the syntactical properties of a plan structure. The function is based on the following rules that can alter the human reader's suspense level in her reading:

a) Presenting an action whose effects negate the protagonist's goal/plan before the reader is informed that his mission is achieved would increase the amount of her suspense.

b) Presenting an action whose effects unify with the protagonist's goal/plan before the reader is informed that his mission is achieved would decrease her suspense.

For example, in the thriller movie *The Fugitive* the protagonist falsely, accused of a false charge of murdering his wife, hid in an apartment house which the police raided to arrest a criminal living in the same building. This fact was unknown to the spectators, which undermined their estimated certainty about the protagonist's safety and maintained the spectators' suspense until the police left the house with the captured criminal. The beginning of *Diplomatic Immunity* provides another example. While a man and a woman were diving under the sea, the man suddenly snatched her oxygen mask off her face. Spectators worried about her while she struggled to breathe and the man stayed behind her back. A minute later, it was revealed that the man is her father, and he was teaching his daughter how to deal with emergency scuba diving situations. In summary, these examples demonstrate that spectators can get the imminent sense of threat from seemingly dangerous actions that are (eventually) ineffective in completing the protagonist's mission.

According to the rules suggested above, the elements of α would be composed of goal-threatening actions to invoke high reader suspense and α would be composed of *goal-supporting actions* to invoke low reader suspense. To determine whether an event is goal threatening or not, I devise Heuristic Function 2 that computes the potential suspense for an action by counting the number of its effects that negate the protagonist's goal and the number of its effects that reinforce the goal considering the audience's partial knowledge. An event is classified as a *goal-threatening action* if its potential suspense is greater than a predefined threshold. Conversely, an event is labeled as a *goal-supporting action* if its potential suspense is less than a predefined value. The heuristic function returns the plan step's potential suspense weighted by its corresponding importance value computed by the Heuristic Function 3 formula.

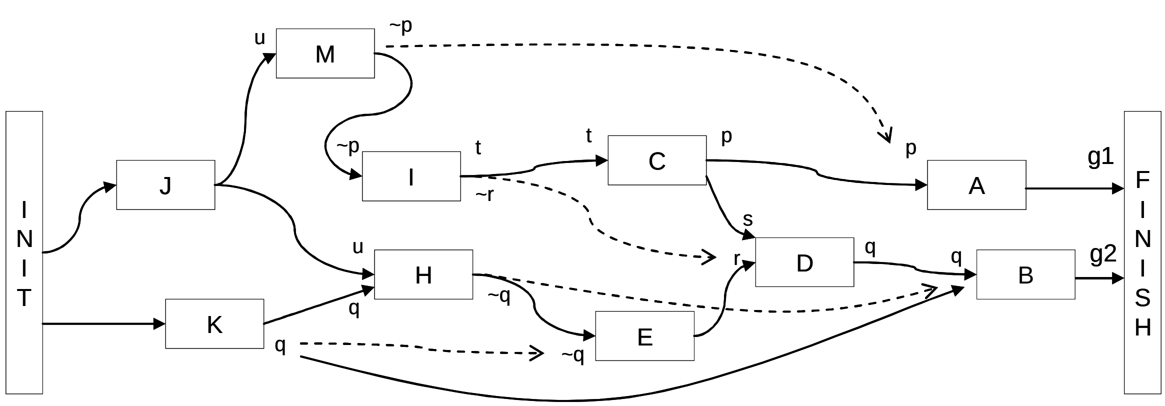


Figure 3.19: Threatening links in a story plan. A box represents an action, with its preconditions on the left and effects on the right. Solid arrows denote causal links. Dotted arrows are threatening links which represent an action's effect negates a precondition of other actions.

In computing the potential suspense of an action's effect, I consider all of the action's possible causal relationships to accomplishing the protagonist's goal from the reader's point of view. As an illustration, Figure 3.19 shows that action *M* has an effect ¬*p*, which is the negation of action A's precondition *p*. I call this type of temporary threats a *threatening link*, referring to an action's effect negating another step's precondition in the plan. In contrast, the suspense creator establishes a *supporting link* when the effect of an action unifies with a precondition of an action in the plan. One effect can have multiple threatening links or supporting links in a single plan. The potential suspense of an effect is computed as the supporting link summation subtracted from the threatening link summation as formalized in Heuristic Function 3.

Heuristic Function 2 (Potential Suspense of an action) *h(a, p)* returns the summation of *ps(e, a, p)* where *ps(e, a, p)* is the potential suspense of an effect *e* of an action *a* in plan *p*.

$$h(a, p) = \sum_{e \in effects(a)} ps(e, a, p) \quad (3)$$

Heuristic Function 3 (Potential Suspense of an effect) *ps(e, a, p)* returns the potential suspense of an effect *e* of an action *a* in plan *p*. which is the summation of the potential threat of all *e*'s supporting links subtracted from the summation of the potential threat of all *e*'s threatening links as formalized as the following equation.

$$ps(e, a, p) = \sum_{t \in Tlink(e)} \frac{w_t}{DistEffect(d_t, p)} - \sum_{s \in Slink(e)} \frac{w_s}{DistEffect(d_s, p)} \quad (4)$$

In Eq. (4), *Tlink(e)* returns all the threatening links of an effect *e*, *Slink(e)* returns all the supporting links of *e*, w_t and w_s are coefficients, d_t and d_s denote the destination step of the threatening and supporting links, respectively, and *DistEffect(a, p)* returns a value associated with the causal distance between step *a* and the goal step of plan *p*. All scaling factors in Eq. (4) are constrained to be nonnegative real numbers.

With these heuristic functions, the structure organizer measures an event's potential suspense in two phases: threatening link analysis and strength computation. In the first phase, all the possible threatening links are identified for each of the action's effects. A threatening link is denoted as (*c*, *s*) where the condition *c* is the negation of a precondition of the plan step *s*. To illustrate the process of computing the potential suspense of an action, suppose that w_t is 1 and *DistEffect(s, p)* returns the causal distance between the step *s* to the goal step of the plan *p* incremented by 1. Under this setting, if the threatening link *(c, s)* undermines a precondition of an action that establishes a condition of the goal state, then the strength corresponding to this link is 0.5 because its distance between the step *s* and the goal state is 1 and later incremented by 1 according to *DistEffect(s, p)*. In the strength computation phase, the potential suspense, *ps(e, a, p)*, of effect *e* is the summation of the potential threat of all *e*'s supporting links subtracted from the summation of the potential threat of all *e*'s threatening links. When the potential suspense for an effect is computed, the potential suspense for the plan step is the summation of the potential suspense of its effects.

The way that my heuristic functions to assess a potential suspense of an action is, in essence, consistent with the EMA model of emotional appraisal in the Mission Rehearsal Exercise system (Gratch, 2000; Gratch and Marsella, 2004a; Gratch and Marsella, 2004b). Appraisal theory (Lazarus, 1991; Ortony et al., 1988) explains an emotional response to an event by its relationship with his goals and expectations. Here an agent's hope and fear are modeled by the probability of achieving his goals. The agent views goal attainment as more likely when he witnesses events whose effects correspond with the preconditions of the actions in his plan for achieving his goal. Conversely, the agent views goal attainment as less likely when the presented actions can negate those preconditions. The EMA model further relates the probability of an agent achieving his goal to his emotional intensity, stating that the probability of a goal is proportional to the intensity of his hop and is in an inverse relationship to that of his fear.

3.2.3.3 Event Selection

As previously discussed, the role of the structure organizer is to select additional story elements (event) α that control suspense according to the suspense mode. The next two subsections detail the even selection algorithms in the high-suspense and the low-suspense modes.

3.2.3.3.1 Event Selection Algorithm in High-Suspense Mode

This section details the algorithm to select the plan steps that constitute the *sjuzhet* for creating high suspense. The algorithm is modified from the initially proposed algorithm presented in Figure 3.16, due to a finding from a number of informal experiments that I conducted: the number of solutions built from a partial plan tends to be constrained when the partial plan gets larger. Suppose, for example, that the agent James Bond is given a mission to disarm a nuclear bomb which is installed in an isolated island. To get to the island James considers two options; he can use a ship or a private jet. At this point, an assumption of K reasonable ways to complete the mission from getting to the island would leave viewers $2K$ possible solutions. Then, showing a scene that James is boarding one of the carriers would let the viewers eliminate K solutions that involve the other one. In other words, solutions available to the protagonists tend to be constrained as the story progresses. In planning terms, the addition of any plan steps to the initial partial plan may reduce the number of complete plans.

To prevent this from happening, the modified algorithm initializes the content of the *sjuzhet* with N steps instead of using only the steps that constitute the skeleton. The algorithm in Figure 3.20 first asks the suspense measurer the suspense level at t when the initial *sjuzhet* is given and then sets it to the highest suspense level. Next, it selects $e_{S,}$, the action with the greatest potential suspense, from the events in the input *fabula* that are not included in the current S_T, where S_T is a series of events to be presented to the reader. If the potential suspense of e_S is smaller than a predefined threshold, then the program returns and creates a partial plan P composed of the steps in S_T. If the potential suspense of e_S passes the threshold, the system chooses an action e_K with the lowest importance in S_T, and replaces it with the action e_S. Then the system queries the suspense measurer for the suspense level of the newly updated *sjuzhet*. If this substitution lowers the suspense level, the system brings back the previous value of S_T; otherwise, the update is maintained. This process continues until there is no candidate is found or for a specified times. When it terminates, the system specifies the content of the output *sjuzhet* as S_T.

Input <t, k, F, W, G, S_K, T_h , R, P, L> where

- *t* is the step where the reader's suspense is measured
- *k* is an integer
- An input *fabula* F=(SP, B, CL, O) where SP={s_1, s_2, …, s_l} where s_i is a step, B={b_1, b_2, …, b_n} where b_i is a tuple of < s_l, p_1, v_1> when $s_l \in$ SP, which means that the plan step s_l binds the parameter p_1 to a literal v_1, CL={c_1, c_2, …, c_n} where c_i is a causal link information represented as a tuple <e, s_1, s_2> where *e* is a condition, and $s_1 \in$ SP and $s_2 \in$ SP, which means that plan step s_1 enables the precondition *e* of s_2, O={ o_1, o_2, …, o_n } where o_i is a temporal constraints represented as a tuple of <s_i s_j> when $s_i \in$ SP and $s_j \in$ SP
- W = {i_1, i_2, …, i_n} where i_j is a tuple of <s_j, w_j> when $s_j \in$ SP where w_j is the importance weight of s_j.
- S_K is the portion of the skeleton preceding *t*
- *G* is the protagonist's goals
- T_h is an integer
- R is an integer representing the reader's resource bound
- P is a planning algorithm
- L is a plan library representing the reader's knowledge

1 Initialization

- Set $S_T = S_K$.
- Set *BSP* = the portion of *SP* preceding *t*
- Set $S = BSP - S_T$.
- Set NZ = {}, PZ = {}

2 (Construct S_T.) Repeat this step for *k* times

2.1 If *S* is empty, return S_T and exit, otherwise

- Pick the action e_S in *S* generating the highest $h(e_S, F)$. If several candidates are found, non-deterministically select an action with the greatest importance value.
  - If $h(e_S, F) < T_h$, return S_T and exit, otherwise
  - Remove e_S from *S*.
- Pick the action e_K in S_T with the lowest importance value. If several candidates are found, non-deterministically select an action.
- Replace e_K with e_S
  - If $h(e_K, F) < h(e_S, F)$
    - Construct a partial plan *NZ* that only contains information in F which has s where s $\in$ $(S_T - e_K + e_S)$.
    - Construct a partial plan *PZ* that only contains information in F which has s where s $\in$ S_T.
    - If *sl*(G, NZ, *L, P, R*) > *sl(G, PZ, L, P, R)*
      - $S_T = S_T - e_K + e_S$
      - Add e_K to *S*
      - Goto step 2.1
  - Add e_S to *S*.
  - Goto step 2.1

Figure 3.20: Algorithm for content selection for the portion preceding t in the *fabula* in the high-suspense mode

To see this algorithm in the context of a story, consider the film *Back to the Future*. In one scene, Marty McFly came back to 1985, found his car totaled and Dr. Brown's killers driving toward Dr. Brown. Then he saw Dr. Brown being killed again. A moment later, however, it was revealed that Dr. Brown was still alive because he was wearing a bullet-proof vest. The common film device used in this scene exhibits how my algorithm creates suspense. My algorithm selects events that seem to go against the protagonist's goals, as the film does in the outset of this scene, presenting events that prohibit Marty from saving Dr. Brown. If the director omitted the scenes with damaged car or the approach of the killers, the audience's suspense level would be greatly reduced.

3.2.3.3.2 Event Selection Algorithm in Low-Suspense mode

The algorithm in the low-suspense mode is similar to that in the high-suspense model. However, this algorithm selects an action with the lowest potential suspense e_S, and checks if the suspense level is lowered by replacing e_K with e_S.

The algorithm in Figure 3.21 first asks the suspense measurer the suspense level when the story skeleton preceding the measuring point t is given and sets it as the lowest suspense level. Next, it selects an action with the smallest potential suspense as e_S from a set of events in the input *fabula* that are not included in the current S_T, which denotes a series of events to be presented to the reader. If the potential suspense of e_S is greater than a predefined threshold, the program returns and creates a partial plan P composed of the plan steps in S_T. If the potential suspense of e_S passes the threshold, the system chooses $e_{K,}$ the action with the lowest importance in S_T, and replaces it with the action e_S. Then the system asks the suspense measurer the suspense level from the newly updated *sjuzhet*. If this substitution raises the suspense level, the system brings back the previous value of S_T; otherwise, the update is maintained. This process continues either until there is no candidate is found or for a specified number of times. When it terminates, the system specifies the content of the output *sjuzhet* as S_T.

Input <$t, k, F, W, G, S_K, T_h, R, P, L$> where

- t is the step where the reader's suspense is measured
- k is an integer
- An input *fabula* F=(SP, B, CL, O) where SP={s_1, s_2, …, s_l} where s_i is a step, B={b_1, b_2, …, b_n} where b_i is a tuple of < s_l, p_1, v_1> when $s_l \in$ SP, which means that the plan step s_l binds the parameter p_1 to a literal v_1, CL={c_1, c_2, …, c_n} where c_i is a causal link information represented as a tuple <e, s_1, s_2> where e is a condition, and $s_1 \in$ SP and $s_2 \in$ SP, which means that plan step s_1 enables the precondition e of s_2, O={ o_1, o_2, …, o_n } where o_i is a temporal constraint represented as a tuple of <s_k s_j> when $s_k \in$ SP and $s_j \in$ SP
- W={i_1, i_2, …, i_n} where i_j is a tuple of <s_j, w_j> when $s_j \in$ SP where w_j is the importance weight of s_j.
- S_K is the portion of the skeleton preceding t
- G is the protagonist's goals
- T_h is an integer
- R is an integer representing the reader's resource bound
- P is a planning algorithm
- L is a plan library representing the reader's knowledge

1 Initialization

- Set $S_T = S_K$.
- Set BSP = the portion of SP preceding t
- Set $S = BSP - S_T$.
- Set NZ = {}, PZ = {}

2 (Construct S_T.) Repeat this step for k times

2.1 If S is empty, return S_T and exit, otherwise

- o Pick the action e_S in S generating the highest $h(e_S, F)$. If several candidates are found, non-deterministically select an action with the greatest importance value.
  - o If $h(e_S, F) > T_h$, return S_T and exit, otherwise
  - o Remove e_S from S.
- o Pick the action e_K in S_T with the lowest importance value. If several candidates are found, non-deterministically select an action.
- o Replace e_K with e_S
  - o If $h(e_K, F) > h(e_S, F)$
    - ▪ Construct a partial plan NZ that only contains information in F which has s where $s \in (S_T - e_K + e_S)$.
    - ▪ Construct a partial plan PZ that only contains information in F which has s where $s \in S_T$.
    - ▪ If sl(G, NZ, L, P, R) < $sl(G, PZ, L, P, R)$
      - ▪ $S_T = S_T - e_K + e_S$
      - ▪ Add e_K to S
      - ▪ Goto step 2.1
  - o Add e_S to S.
  - o Goto step 2.1

Figure 3.21: Algorithm for content selection in the low-suspense mode

3.2.4 Implementation

Suspenser is implemented using Microsoft Visual Studio .NET 2003 C# version. The program ran on a 1.2 GHz Pentium M Processor laptop with 376M of RAM running Windows XP.

Figure 3.22 shows the interface to set the parameters of the skeleton builder. Figure 3.23 shows the interface to set the parameters of the suspense creator.

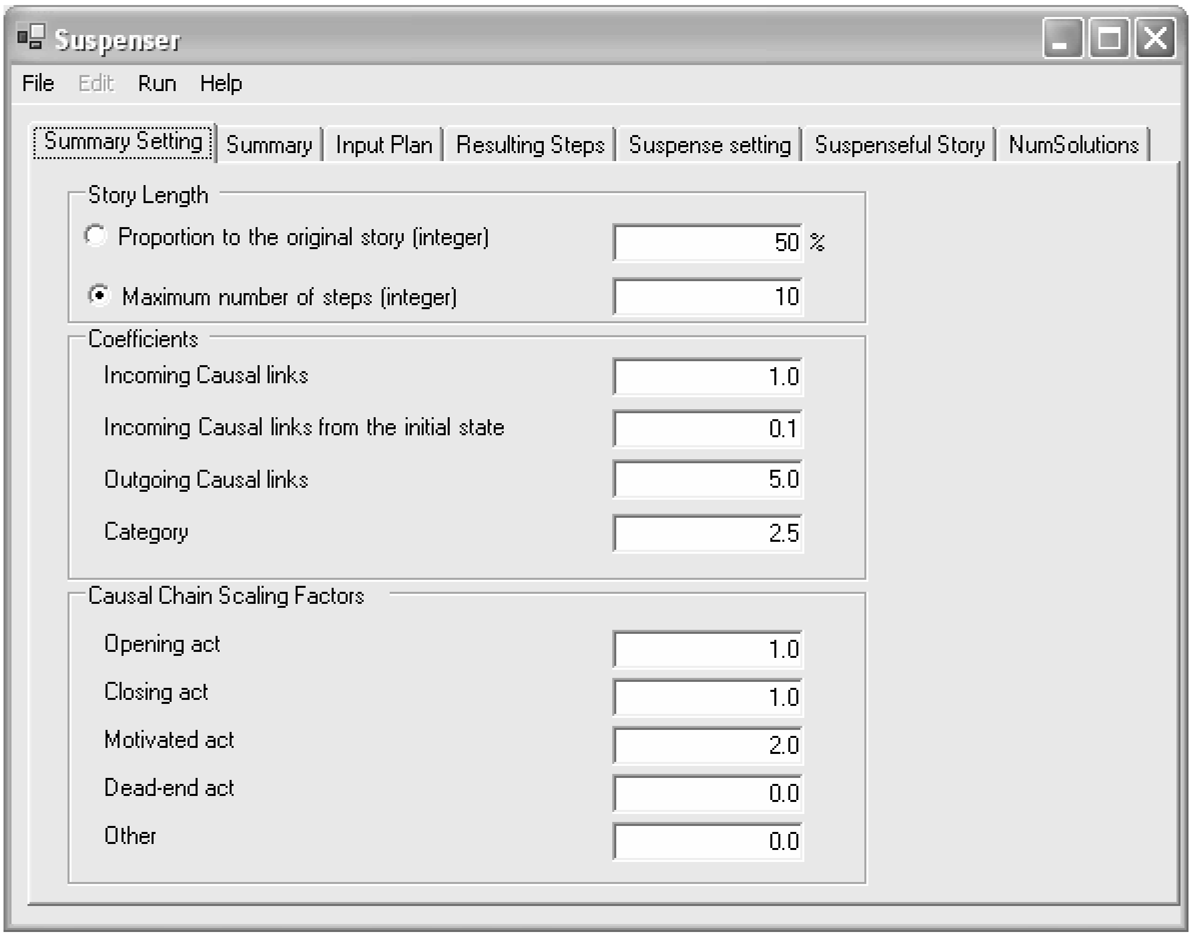


Figure 3.22: Program Interface for Skeleton Builder Parameterization

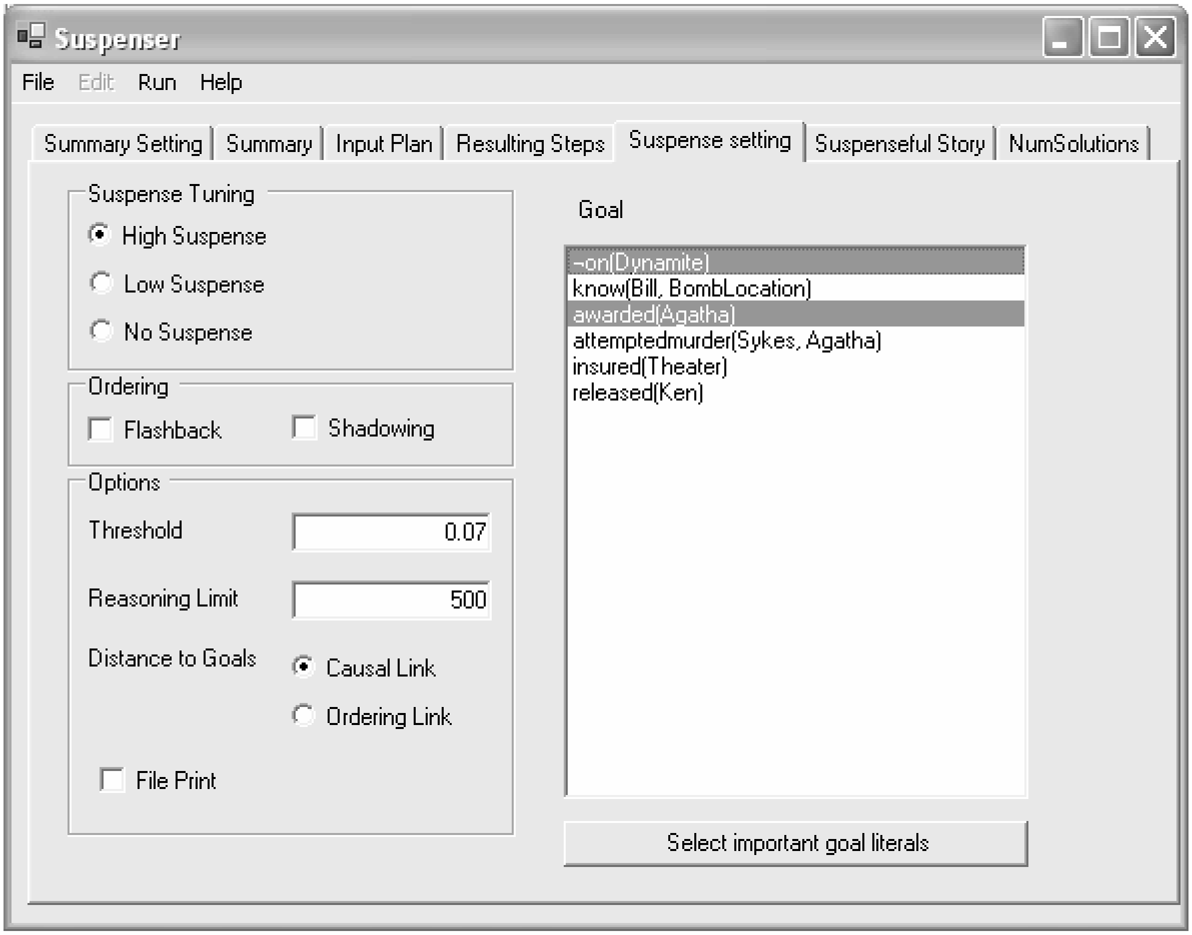


Figure 3.23: Program Interface for Suspense Creator Parameterization

3.2.5 Summary

This chapter described Suspenser which is composed of two main components: the skeleton builder and the suspense creator. The skeleton builder extracts a sequence of actions that maintain the identity of the input story, and the suspense creator produces a story structure which specifies what to tell and when to tell it. The suspense creator first selects story elements that control the suspense level, and then models the reader’s inferring processing to estimate the suspense level created from the events. This process determines a series of events, which constitute the *sjuzhet*.

Chapter 4

Evaluation

This chapter explains four experimental studies that I conducted to evaluate the performance of Suspenser. In the first three sections, I describe pilot studies designed to evaluate parts of Suspenser, the skeleton builder and the potential suspense measuring functions. The last section describes a formal study that evaluated the complete Suspenser system compared with the capability of a human author.

The measurement of suspense is a complicated problem. While researches agree that a reader's suspense experienced during her exposure to the narrative contains elements of both physiological and cognitive phenomena, it is not clearly defined in terms of physiologically or cognitively measurable data (Friedrichsen, 1996; Mattenklott, 1996). Motivated by the traditional three-system approach to emotion devised by Lang (1971), Mattenklott (1966) investigates methodologies to measure emotions relevant to the emotional experience of suspense (e.g., distress) within three categories: physiological activity, facial expression, and self-report. In their study, several types of physiological data (e.g., blood pressure, heart rate, and skin conductance) have shown distinct patterns for different emotions (e.g., fear, anger, sadness). However, no reliable way to extract and measure the emotions only related to suspense (empathetic distress named by Zillmann, 1991) has yet been suggested. Similarly, this issue applies to methodologies for measuring suspense relying on a subject's facial expressions, because it has been found that human subjects tend to not express their emotions on their faces even when they verbally answered they felt those emotions. Thus, the measurements of emotion using current technologies inevitably necessitate respondents to self-report their emotion subjected to their own subjective evaluations. Owing to these limitations of physiological and expressive behavioral measurements, I employed a survey type that asks subjects to self-report for measuring their suspense levels, similar to most previous experimental approaches (Friedrichsen, 1996).

The story examples that were employed for my research studies were carefully designed so that the story materials contain suspense elements. As cardinal conditions of a story that invokes suspense from readers, Zillmann (1996) suggests three requirements. First, the reader shall have a strong positive disposition toward the protagonist so that she feels sympathy about the situation that the hero undergoes. Second, the harm threatening the protagonist must be a very serious one—such as a matter of life and death—for the reader to care about the protagonist's destiny. Third, the story should allow the reader to have high subjective certainty about the possibility that harm will be realized. Since the third condition is controlled by my approach, I designed the story to satisfy the first two conditions. In order to meet the first condition—positive disposition toward the protagonist, I established a detailed story background that describes its protagonist as a morally good person who is wiling to sacrifice himself for a just and righteous cause. As for the second consideration, I set up in a dangerous situation that can deprive the protagonist of his life.

4.1 Pilot Study 1: The Skeleton Builder Evaluation

This section examines a pilot study was designed to determine whether a skeleton extracted by the skeleton builder can serve as a qualitatively good summary by human readers. The reader model was not used in this study; thus, the coherency of a summary was not checked either.

Through this pilot study, I intended to test three hypotheses. The first hypothesis for this pilot study stated that the events selected by the skeleton builder would be overlapped with the events chosen by the majority of the subjects. The second hypothesis stated that the events selected by the skeleton builder would be rated high in importance in the story by the subjects. The third hypothesis stated that the summary generated by the skeleton builder would be assessed as good as the summary created by the human subjects.

4.1.1 Configuring the Experimental System

As described in Chapter 3, the skeleton builder uses weighting functions to assign a weight to each step in a plan; the weighting functions appear in Eq. (1) in Section 3.2.2. The values of the constant scaling factors that were used in the pilot study are shown in Table 4.1. The values of the constant factors in Eq. (1) were determined empirically from some informal experiments that examined the similarity between the skeleton generated using these values and that produced by a human. In this study the value for k_i and k_o, were initialized as 1 and 5 respectively following the techniques used in Young's CPI model (1999). k_j and k_c were adjusted as 0.3 and 2.5 respectively. The setting of these coefficients placed more importance on the value of outgoing causal links than the incoming causal links, which is consistent with the views discussed in the research by Trabasso and Sperry (1985) and by Graesser et al. (1991).

Table 4.1: Experimental values for weighting constants

Constant	Description	Value
k_i	Incoming causal links	1.0
k_j	Incoming causal links from the initial state	0.3
k_o	Outgoing causal links	5.0
k_c	Category	2.5

In this study, the causal chain value of an event was assigned 2.0 when the event's act type was a *motivated act* that was in causal relationship with a precondition of the goal state in the story plan; the value of an event of other act types was assigned 0.0. The function that reflects an event's distance effect, *DistEffect(a, p)* in Eq. (1), returned 1 in this study.

4.1.2 Method

4.1.2.1 Participants and design

A total of 25 subjects, all recruited from the North Carolina State University community voluntarily participated in this study. Their ages ranged from 20 to 49 years old. There were 8 females and 17 males.

4.1.2.2 Materials and apparatus

The text presented to the subjects is shown in Figure 4.1. To produce the text, I first ran Crossbow to produce a partial-order plan composed of 14 steps which serves as an input *fabula*. The *fabula* was manually linearized and realized into text in two phases for presentation. First, each step in the plan was automatically mapped into one sentence. In the second phase, several descriptions explaining steps' postconditions and items were manually added to facilitate the reader's comprehending process. The text used in this study is shown in Figure 4.1.

> [1] Tom traveled to Dr. Evil's castle. [2] Tom traded his ring for Dr. Evil's toy. As a result, Tom obtained the toy that Ben wants to have and Dr. Evil obtained the ring of absolute power. [3] Tom traveled back to his house, and went up to the Christmas tree. [4] Tom put the toy under the Christmas tree. [5] Ben walked from his room to the Christmas tree. [6] Ben found his Christmas present—the toy that Tom left. [7] Dr. Evil went to the Wachovia bank to withdraw money from his bank account. [8] Dr. Evil withdrew enough cash from his account to buy a gun. [9] Dr. Evil traveled to a gun store. [10] Dr. Evil bought a gun. [11] The President invited Dr. Evil to the fund-raising event at the White House. [12] Dr. Evil traveled to the White House. [13] Dr. Evil used the ring of absolute power to put all the Secret Service agents to sleep; as a result, there was no one around the president. [14] Dr. Evil shot the president with his gun and became the ruler of the world.

Figure 4.1: A story created by Crossbow realized into a text

4.1.2.3 Procedure

Each subject participated individually in the experiment, with the experimenter was present at all times during the experiment session. Subjects were asked to read printed materials containing the texts of short stories followed by questions about the stories. The survey that was used in this study can be found in Appendix A.1. Each subject first read a paragraph describing the background and the goals of the three main characters in the story. They were then asked to read story text composed of 14 events and the causal relationships between them. After reading the text, the subjects were asked to select five events from the story that they felt best served as a summary of the story. They were also asked to write a short explanation for their selection. Next, each subject was asked to rank order the 14 events in the story indicating their estimation of the events' relative importance. Finally, subjects were asked to evaluate their own summary relative to a summary that had been generated by the skeleton builder. The fact that the given summary was generated by my system was not revealed to them.

4.1.3 Result

Table 4.2: The chance of being in the summary of each event. Each column represents an event id and its chance of being included in the subjects' summaries, its mean ranking evaluated by subjects, and its standard deviation of ranking. Shaded cells represent the events selected by the skeleton builder

Id	1	2	3	4	5	6	7	8	9	10	11	12	13	14
%	20	96	0	16	0	52	0	8	0	48	64	8	88	100
Mean Rank	7.7	2.1	11.0	10.0	11.6	7.2	10.4	9.5	10.2	7.1	4.4	8.8	2.8	2.2
Rank stdev	3.7	0.9	2.7	2.9	1.9	3.5	2.4	2.5	2.2	2.9	2.1	3.1	1.2	1.4

From the collected data, I calculated the percentage for each event of its inclusion in the subjects' summaries, and the mean ranking for each event's importance measured by the subjects and the deviation of ranking, rounded off to the first decimal place as shown in Table 4.2. For example with event 1, it was included in five summaries among the total 25 summaries: the chance of inclusion in their summaries is computed as 20%. Its mean rank, 7.7, can be interpreted that the subjects rated its importance between 7^{th} and 8^{th} among 14 events where 1^{th} rank means the most important event.

The events in the summary that skeleton builder generated were #11, #14, #6, #2, and #12. As shown in Table 4.2, their corresponding probabilities of being included in the subject's summaries were 64%, 100%, 52%, 96%, 8%, and their corresponding ranks were 4.4, 2.2, 7.2, 2.1, 8.8 respectively. The standard deviation of ranking for each event had a range from 0.9 to 3.7. This was consistent with my first and second hypotheses stating that 1) the events selected by the skeleton builder largely overlapped with the events chosen by the majority of the subjects and 2) the events selected by the skeleton builder would be rated high in importance in the story by the subjects.

Although one of the five events selected by the skeleton builder had relatively low probability of inclusion in the subjects' summaries, the subjects' evaluation about the skeleton builder generated summary was encouraging; 32% of them valuated that the skeleton builder generated summary better represented the story than their own selected ones, and 52% of them answered that the sentences chosen by the skeleton builder are as good as theirs; only 12% answered their stories are better than the skeleton builder's. This result is consistent with my third hypothesis stating that the summary generated by the skeleton builder would be assessed as good as the summary created by the subjects.

4.1.4 Discussion

The result from this pilot study supports my three hypotheses, and suggests that the summary generated by the skeleton builder is comparable to those generated by humans. And yet, the low probability of the fifth event also suggests the limitation of determining the importance of an event relying on its causal relationship to the goal of the story.

4.2 Pilot Study 2: Heuristic Function Evaluation

This section examines a pilot study that I carried out to evaluate the effectiveness of stories in terms of suspense produced by a partial implementation of Suspenser compared with human created stories. In this study, the implementation of the skeleton builder module and the heuristic functions were used to create a sample *sjuzhet* that was presented to the subjects. The reader model was not tested in this study.

The hypothesis for this study is to test if there was any association between the generator type (independent variable) and the suspense level of the stories (response variable). To test this hypothesis, the suspense levels for 1) Suspenser *vs.* Humans and 2) Suspenser in high-suspense vs. Suspenser in low-suspense settings were compared to determine whether a significant difference can be found between these groups.

4.2.1 Configuring the Experimental System

The values of the constant scaling factors used in the skeleton builder are shown in Table 4.1 in Section 4.1.1. In this study, the causal chain value of an event was assigned 2.0 when the event's act type was a *motivated act* that was in a causal relationship with a precondition of the goal state in the story plan; the value of an event of other act types was assigned 0.0. The function that reflects an event's distance effect, *DistEffect(a, p)* in Eqs. (1) and (4), returned 1 in this study.

Table 4.3: Experimental values for weighting constants

Constant	Description	Value
w_t	Threatening link	2.0
w_s	Supporting link	1.0

The values of the scaling factors for Heuristic Function 3, estimating the potential suspense of an effect, that were used in this study are shown in Table 4.3. I assigned a greater value for the threatening link coefficient to compensate for the supporting strength by the causal links of the plan. To identify a series of events that increases the suspense level, I selected actions with potential suspense greater than a threshold (i.e., -0.3 for this study). In a similar fashion, a set of actions that reduces the suspense level was chosen as actions with potential suspense lower than a threshold (i.e. -0.7). These thresholds were adjusted from a number of informal experiments.

4.2.2 Method

4.2.2.1 Participants and design

A total of 39 undergraduate students ranging in age from 18 to 29 years old participated in this study. They were all recruited from an introductory statistics class at North Carolina State University, and were given extra credit in exchange. There were 27 females and 12 males. They majored in various fields, including biology, mathematics, social work, political sciences, etc. A between-group design was employed.

4.2.2.2 Materials and apparatus

4.2.2.2.1 Input *Fabula*

To obtain input to Suspenser, I ran Crossbow to create a *fabula*, which involved five characters: the President, an anti-hero Dr. Evil, who plans to assassinate the President, a renowned environmentalist Mr. Greenpeace, and a poor father Tom, who is the father of a six-year old boy named Ben. Crossbow took as input the planning problem, which specified the initial state and goal of the story, and a plan library composed of 17 plan operators, and then returned a complete plan containing: actions for Dr. Evil to assassinate the President, and actions for Mr. Greenpeace to save the earth, and actions for Tom to get Ben a Christmas gift, and actions to keep the President alive. The resulting plan consisted of partially ordered set of 25 steps which were manually linearized, and the plan was realized as text as in Figure A.8 using a simple template-matching technique which mapped one plan step into a single sentence.

4.2.2.2.2 Four *Sjuzhets*

For my pilot study, I prepared four *sjuzhets*: two stories by Suspenser and two stories by humans. Since the current implementation of Suspenser used a shallow reader model, the pilot study was to test if the heuristic functions 2 and 3, predicting the potential suspense of an action and an effect, were effective in identifying story events that manipulate suspense level, with the cooperation of the skeleton. From the setting described in 4.2.1, the system produced two stories: one in high-suspense mode (as shown in Figure 4.2) and one in low-suspense mode.

Mr. Greenpeace made a speech about the importance of taking action immediately to save the world. The President announced that he would raise funds to support Mr. Greenpeace's environmental foundation and whoever donated more than million dollars would be invited to the White House for a fund-raising celebration party. Dr. Evil watched the TV and found out that a donation would get him invited to the White House. Dr. Evil donated a million dollars to the White House. The President invited Dr. Evil to the fund-raising celebrating event. Tom traded his ring for Dr. Evil's toy; as a result, Tom obtained the toy that Ben wanted and Dr. Evil obtained the ring. Ben found his Christmas present--the toy that Tom left. Dr. Evil went to a bank to withdraw money from his bank account. Dr. Evil bought a gun. Dr. Evil registered for a hypnosis class to learn how to hypnotize people by waving a shiny object before their eyes. Dr. Evil traveled to the White House. Dr. Evil used the ring of power to put all the Secret Service agents to sleep; as a result, there was no one guarding the president. Dr. Evil fired his gun at the President. *At the last moment, Mr. Greenpeace rescued the President by pushing him out of the way.*

Figure 4.2: A sample story generated by Suspenser in high-suspense mode: Italicized sentence is not shown to the participants.

To obtain human generated stories, I recruited one graduate student in English and one PhD student in computer science at North Carolina State University. They were presented with the input *fabula* story in Figure A.8 and were asked to select a series of sentences that would be used as the story, where the events were to be chosen to create a strong sense of suspense. Both authors were told not to select the last sentence of the *fabula*, since it revealed the story outcome. For this study I did not constrain the number of sentences that they selected. The texts constructed from their selections are shown in Figure A.9 in Section A.2.

4.2.2.3 Procedure

Each subject individually participated in the study by accessing a web site that contained a paragraph describing the background and the goal of each character in the story. They were then asked to read text of one of the four *sjuzhets* which is randomly selected. After reading the text, they were asked to rate their suspense levels arising from their reading of the story on a four-scale basis (i.e., no suspense, a little suspense, moderate suspense, and a lot of suspense). The survey that was used in this study can be found in Appendix A.2.

4.2.3 Result

For the analysis part for this project, I performed a chi-square test using SAS version 9.1.3 SP. Table 4.4 shows the number of responses for each story category. For convenience, H-Suspenser refers to Suspenser in high-suspense mode and L-Suspenser stands for Suspenser in low-suspense mode. In analyzing the data set, the chi-square test was used to discover the relationships of suspense levels between the stories generated by a) H-Suspenser vs. human, and the stories by b) H-Suspenser vs. L-Suspenser. The responses for the two stories produced by human authors were categorized into one group.

Table 4.4: Collected data for each story category.

Story generator	**Suspense Level**				Total
	No	A little	Moderate	A lot	
Human	4	4	4	1	13
H-Suspenser	2	7	5	0	14
L-Suspenser	5	4	3	0	12
Total	11	15	12	1	39

To apply the chi-square test on my small data set, I grouped the four suspense levels into two categories: *no suspense* and *some suspense* (including the three suspense levels of a little, moderate and a lot), which is shown in Table 4.5. Table 4.6 shows the chi-square analysis result. Although the result was not statistically significant (since p>0.05 for both comparisons) due to the small sampling size, the chi-square values show that the two data sets of H-Suspenser vs. human (value = 1.060 and p=0.303) had more similarity than the sets of H-Suspenser vs. L-Suspenser (value = 2.462 and p=0.117).

Table 4.5: Contingency Table

Story generator	No Suspense	Some Suspense
Human	4	9
H-Suspenser	2	12
L-Suspenser	5	7

Table 4.6: Chi-square values for comparisons

Story generator	Degree of Freedom	Chi-square value	P
Human vs. H-Suspenser	1	1.060	0.303
H-Suspenser vs. L-Suspenser	1	2.462	0.117

In Table 4.7 a binomial distribution was used on the responses to create a 95% confidence interval. Note that H-Suspenser had the highest proportion of suspense. Also note that the confidence interval for H-Suspenser incorporates values higher than 0.5 (50%) which implies that the story generated by H-Suspenser has an effect on the suspense level. For a 5% margin of error, 186 subjects would be needed.

Table 4.7: Proportion with some suspense (a little, moderate, a lot) and 95% confidence interval based on a Binomial distribution of the response

Story generator	Proportion with some suspense	95% confidence interval
Human	0.69	(0.39, 0.91)
H-Suspenser	0.86	(0.57, 0.98)
L-Suspenesr	0.58	(0.28, 0.95)

4.2.4 Discussion

Although a statistically significant difference was not found, analysis of the data suggests that my heuristic functions and the skeleton builder were effective in identifying events of a story that manipulate the affect of suspense from human readers.

4.3 Pilot Study 3: Suspenser

This section examines a pilot study that I carried out to evaluate the effectiveness of stories in terms of suspense produced by a partial implementation of Suspenser compared with human created stories. In this study, the implementation of the skeleton builder module and the heuristic functions were used to create sample *sjuzhet* that were presented to the subjects. As before, the reader model was not tested in this study.

The hypothesis for my study was to test if there was any association between the generator type (independent variable) and the suspense level of the stories (response variable). To test this hypothesis, the suspense levels among the stories produced by a) Suspenser in high-suspense mode, b) Suspenser in low-suspense mode, and c) a human author were compared to determine whether a significant difference can be found.

4.3.1 Configuring the Experimental System

The values of the constant scaling factors used in the skeleton builder are shown in Table 4.1 in Section 4.1.1. In this study, the causal chain value of an event was assigned 2.0 when the event's act type was *motivated act* that was in a causal relationship with a precondition of the goal state in the story plan; the value of an event of other act types was assigned 0.0. The function that reflects an event's distance effect, *DistEffect(a, p)* in Eq. (1) returned 1 and *DistEffect(a, p)* in Eq. (4) returned the distance from an action to the goal (i.e., the minimum number of causal links that relate an action to the goal in a plan) in this study.

The values of the scaling factors for Heuristic Function 3, estimating the potential suspense of an effect, that were used in this study are shown in Table 4.8. I assigned a greater value for the threatening link coefficient than that of the supporting link coefficient to compensate for the supporting strength by the causal links of the plan.

To identify a series of events that increases the suspense level, I applied the algorithms shown in Figure 3.20 and in Figure 3.21 with the absence of the reader model. In this study, the number of repetitive application of the algorithm was set as the half of the number of events in the final *sjuzhet* to avoid taking too much from the initial skeleton. Since the reader model was not used in this study, the coherency of the skeleton and the suspense level from a given *sjuzhet* were not checked.

Table 4.8: Experimental values for weighting constants

Constant	Description	Value
w_t	Threatening link	7.0
w_s	Supporting link	2.0

4.3.2 Method

4.3.2.1 Participants and design

A total of 25 undergraduate students ranging in age from 20 to 29 years old participated in this study. There were 23 males and 2 females, all recruited from a Computer Science undergraduate course at the North Carolina State University. They were given extra credit in exchange of participating in this study, and were presented an alternative option. The study utilized a repeated measured between group design and the subjects were randomly assigned to one of nine subject groups. These groups were arranged according to a 3 × 3 Latin Square design (as in Table 4.9) to counter-balance the interference from different orderings of stories. From this design, a subject is shown one version of each of the three *fabulas*.

Table 4.9: Experimental Design

9 subject groups following the Latin Square Method

Subject Group	First story	Second story	Third story
S1	FAW	FBL	FCH
S2	FBL	FCH	FAW
S3	FAH	FBW	FCL
S4	FCW	FAL	FBH
S5	FAL	FBH	FCW
S6	FCH	FAW	FBL
S7	FBW	FCL	FAH
S8	FCL	FAH	FBW
S9	FBH	FCW	FAL

Story materials: three *fabulas* and nine *sjuzhets*

Story Generator	Fabula A	Fabula B	Fabula C
Human Writer's high suspense story	FAW	FBW	FCW
Suspenser's high suspense story	FAH	FBH	FCH
Suspenser's low suspense story	FAL	FBL	FCL

4.3.2.2 Materials and apparatus

4.3.2.2.1 Input *Fabulas*

To obtain an input to Suspenser, I ran Crossbow to plan three *fabulas*. The resulting plans consisted of partially ordered 18-20 steps which were manually linearized, and the plan was realized as text using a simple template-matching technique which mapped one plan step into a single sentence. Details of the input *fabulas* used for this study are shown in the appendix A.3.

4.3.2.2.2 *Sjuzhets* from the Input *Fabulas*

For the pilot study 3, I prepared a total of nine *sjuzhets*: three *sjuzhets*—two stories by Suspenser and one story by a human author—for each of the three *fabulas*. From the setting described in 4.3.1, the system produced two stories: one in high-suspense mode and one in low-suspense mode. To obtain human generated stories, I recruited one Master student majoring in English at North Carolina State University. She was presented with the instruction sheet shown in Figure A.14 followed by the three *fabulas* and their corresponding measurement point. She then was asked to select a series of sentences for each *fabula* to arouse high suspense from the reader at the specified point in the story. For this study I did not constrain the number of sentences that she selected. The complete texts constructed from the human author's and Suspenser selections are shown in Appendix A.3.

4.3.2.3 Procedure

Each subject individually participated in the study by accessing a web site. Each subject was presented with three stories and asked to rate his suspense levels at a particular point in the reading each of the stories. Each story was divided into two parts: one containing the text describing the story's background and the portion preceding the measurement point in the story, and one containing a paragraph describing the portion of the story after the measurement point. After reading the first part on a web page, the subject was asked to click the button "NEXT PAGE" to proceed to the next screen in which he was asked to answer his suspense level from reading the story on a seven-scale basis ranging from "no suspense" to "extremely suspenseful." On the completion of his responding to the question, a button click led him to the next page which displayed the second part of the story. The subject may leave the survey by closing the survey web page anytime they wanted. The survey interface that was used in this study can be found in Appendix A.3.

4.3.3 Result

The collected data contained 75 responses from 25 subjects, 25 responses for each *fabula*. However, due to an error in reproduction of the writer's selection, the responses for *sjuzhets* created from *Fabula B* were excluded from the analysis. As a result, 50 observations were used in this analysis. To detect a significant difference between story generators, I performed a one-way ANOVA to the collected data using SAS version 9.1.3 SP4.

As shown in Table 4.10, the data indicated that the story generator had no effect on the suspense level ($F(2, 47) = 0.01$, $p = 0.99$). The story generators showed uniform performance across the two stories.

Table 4.10: Data for Suspense

Means and standard deviations for suspense in each story generator

Suspenser in high-suspense (N=17)		Suspenser in low-suspense (N=17)		Human author (N=16)	
M	*SD*	*M*	*M*	*M*	*SD*
2.706	1.105	2.647	1.411	2.687	1.078

ANOVA summary table for Suspense

Source	DF	ANOVA SS	Mean Square	F Value	Pr > F
Generator	2	0.0307	0.015	0.01	0.990
Error (Generator)	47	68.849	1.465		
Corrected Total	49	68.880			

4.3.4 Discussion

As the ANOVA analysis indicates, the story generator type had no effect on the suspense that the reader felt from reading the sample stories. I conjecture that this unexpected result may be caused by several factors described below. First, the low mean ratings of the subjects' suspense levels across the two stories suggest that the participants felt little suspense from these stories. This phenomenon can be explained in three ways. The story materials themselves were not quite good enough to create any suspense from their readers. Hence, any combination (or even the best selection) of story events would have produced a very low suspense level, which in return created similar suspense levels across different story generators. Another interpretation lies in the way the story was presented to the participants. The first part of the stories formatted as a single paragraph which composed of approximately 10 sentences were presented to the subjects at once, which normally took them a very short time to read. Thus, the subjects had difficulty in being immersed into the story and preparing themselves to anticipate the next event. A third reason may lie in the high similarity between stories. The stories created from the high-suspense and low-suspense modes overlapped in over 50% of the total number of story sentences.

When the stories are assumed to be good enough to raise suspense, then uniform ratings across different generators may be caused by the generators themselves. The human writer may have performed relatively poorly on this job because her creativity was overconstrained and thus she couldn't show her best performance as a writer. The lack of differentiation between the system's high-suspense mode and low-suspense mode could be caused by the algorithms being used. The current algorithm for low-suspense mode takes the view that highly causally related events would weaken the suspense that reader's feels, and thus it intentionally chooses those events. However, it is my observation that these causally related events may compensate the suspense in other ways, since they also constitute the important events in the story. Third, the subjects, who were recruited from a game design class, could be biased. Their comments about the stories revealed that they were expecting attractive characters and sophisticated narrative techniques such as conversation rather than assertive sentences.

To make sure that these factors did not interfere with later experiments, I made some changes to the design of subsequent experiments. First, to see if there's difference in suspense between stories I used the writer's low-suspense mode story as the base narrative instead of using the story produced in the Suspenser's low-suspense mode. The writer's low-suspenseful story overlaps with the system generated story by only 25-30%. Second, rather than showing a set of story events in a paragraph at once, each sentence was presented on a screen and the subject was required to click a button to proceed to the next story event. Third, the subject's suspense was measured on a five-level scale instead of a seven-level scale. These modifications were applied in the final experiment which is described in the next section.

4.4 Main Experiment

This section describes the experiment that I performed to evaluate the effectiveness of stories that a complete implementation of Suspenser produces in terms of suspense. The hypothesis for my study was to test if there was any association between the story generator type (independent variable) and the suspense level of the stories (dependent variable). To test this hypothesis, the suspense levels among the stories produced by a) Suspenser in high-suspense mode, b) a human author intended to create high suspense, and c) a human author intended to create low suspense were compared to detect a significant difference among them.

4.4.1 Configuring the Experimental System

The values of the constant scaling factors used in the skeleton builder are shown in Table 4.1 in Section 4.1.1. In this study, the causal chain value of an event was assigned 2.0 when the event's act type was *motivated act* that is in a causal relationship with a precondition of the goal state in the story plan; the value of an event of other act types was assigned 0.0. The function that reflects an event's distance effect, *DistEffect(a, p)* in Eqs. (1) and (4) returned $d \times (d + 1)$ where d denotes the distance from an action to the goal (i.e., the minimum number of causal links that relate an action to the goal in a plan) in this study.

The values of the scaling factors for Heuristic Function 3, estimating the potential suspense of an effect, that were used in this study are shown in Table 4.8. To identify a series of events that increases the suspense level, I applied the algorithms shown in Figure 3.21. To avoid interference caused by different story lengths, the number of steps in a story, denoted N, was set to that of sentences that the human author selected intended for high suspense from readers. The value of the threshold T_h in the algorithm was assigned 0.07 from a number of informal experiments. The event selection in the low-suspense mode was not evaluated in this study.

The reader model contains three customizable parameters: the reader's knowledge, the reader's plan preference and his plan reasoning resource limit. In this study, the reader's knowledge was assumed identical to the system's plan libraries that were used to create the input *fabulas*. The reader model's plan ranking function preferred short plans with fewer flaws. Its reasoning resource limit was set to a search limit of 500 nodes.

4.4.2 Method

4.4.2.1 Participants and design

A total of 98 unpaid subjects voluntarily took part in the experiment, ranging in age from 20 to more than 50 years old (42 males, 57 females, and one no response): 72 recruited from NCSU communities including recently graduated under/graduate students across different departments and 26 from internet female technical communities (e.g., Systers.org). All subjects were native-speakers of English.

The study utilized a repeated measured between group design: subjects were randomly assigned to one of nine subject groups. These groups were arranged according to a 3 × 3 Latin Square design (as in Table 4.9) to counter-balance the interference from different orderings of stories. From this design, a subject was shown one version of each of the three *fabulas*.

4.4.2.2 Materials and apparatus

4.4.2.2.1 Input *Fabulas*

I used the same three *fabulas* that were created for the pilot study 3 described in Section 4.3.2.2. See the appendix A.3 for complete texts.

4.4.2.2.2 *Sjuzhets* from *Fabulas*

For the experiment, I prepared a total of nine *sjuzhets* as shown in Table 4.11: three *sjuzhets*—two stories by the human author and one story by Suspenser—for each of the three *fabulas*. The system produced one story in the high-suspense mode under the setting described in 4.4.1. To obtain human generated stories, I recruited one Master student majoring in English at North Carolina State University. She was presented with the instruction sheet shown in Figure A.14 followed by the three *fabulas* and their corresponding measurement point. She then was asked to select two series of sentences for each *fabula*: one to arouse high suspense and the other to arouse low suspense from the reader when his suspense level would be measured at a given point in the story. For this study I did not constrain the number of sentences that she selected. As a result, her two versions of a story differed in size within a margin of 2. The complete texts constructed from the human author's and Suspenser selections are shown in Appendix A.4.

Table 4.11: Story materials: three *fabulas* and nine *sjuzhets*

Story Generator	Fabula A	Fabula B	Fabula C
Human Writer's highly suspenseful story	FAW	FBW	FCW
Suspenser's highly suspenseful story	FAH	FBH	FCH
Human Writer's low suspenseful story	FAL	FBL	FCL

4.4.2.3 Procedure

Each subject individually participated in the study by accessing a web site. Each subject was presented with three stories along with their backgrounds and was asked to rate his suspense levels at one point in his reading each of the stories. Different from pilot study 3, the stories were presented to the subject sentence by sentence; one page contained only one sentence and a button click led the subject to the next page. After reading the portion preceding the measurement point sentence by sentence displayed on separate pages, the subject was asked to describe his suspense level on a five-point scale basis ranging from "no suspense" to "extremely suspenseful." After responding to the question, the subject was presented with the second part of the story sentence by sentence, followed by a page containing generic questions asking about story coherence and enjoyment on a five-scale basis ranging from "not at all" to "strongly agree." The survey interface that was used in this study can be found in Appendix A.4.

4.4.3 Result

The collected data contained 294 responses from 98 subjects. To detect a significant difference between three story generators, I performed a one-way ANOVA on the collected data using SAS version 9.1.3 SP4. In this analysis, two main effects were examined: the story generator type and the *fabula* type. Each type has three levels.

Table 4.12: Data for Suspense

Means and standard deviations for suspense in each story generator type (N=98)

Suspenser in the high-suspense mode		Human author for high suspense		Human author for low suspense	
M	*SD*	*M*	*SD*	*M*	*SD*
2.704	1.057	2.694	1.049	2.316	1.061

Means and standard deviations for suspense in each story type (N=98)

Fabula A		*Fabula* B		*Fabula* C	
M	*SD*	*M*	*SD*	*M*	*SD*
2.469	0.976	2.592	1.120	2.653	1.104

Means and standard deviations for suspense in each story and story generator

Story	Generator	N	M	SD
Fabula A	Suspenser	32	2.438	0.914
	Human-HS	33	2.667	0.890
	Human-LS	33	2.303	1.104
Fabula B	Suspenser	33	2.727	1.126
	Human-HS	32	2.656	1.096
	Human-LS	33	2.394	1.144
Fabula C	Suspenser	33	2.939	1.088
	Human-HS	33	2.758	1.173
	Human-LS	32	2.250	0.950

NOTE: Human-HS denotes the human author’s selection intended to create high suspense and Human-LS denotes the human author’s selection intended to create low suspense.

ANOVA summary table for Suspense

Source	**DF**	**SS**	**Mean Square**	**F Value**	**Pr > F**
Fabula	2	1.712	0.857	0.76	0.467
Generator	2	9.571	4.786	4.27	0.015
*Fabula**Generator	4	2.954	0.738	0.66	0.622
Error	285	319.760	1.122		

As shown in Table 4.12, the data indicated that the story generator type had an effect on the suspense level (F(2, 285) = 4.27, p value = 0.015). The result also shows that the *fabula* type had no effect on suspense. No interaction effect was found between the *fabula* type and the story generator type (F(4, 285) = 0.66, p value = 0.622). Despite the short sample stories, the subjects rated their experience of suspense is “moderate” (Mean = 2.571/5.0, SD = 1.059) on a five-point Likert scale. The system performance was superior to the other story generators in the categories of *fabula* B (Mean = 2.727, SD=1.126) and *fabula* C (Mean = 2.939, SD = 1.088).

A series of standard one-tailed t-tests were used to compare the performance of the three story generators. Table 4.13 gives the results of pair-wise comparison of means for suspense from stories produced by different generators. The results indicate that the stories produced by the system (Mean = 2.704) and the human author intended for high suspense (Mean = 2.694) were rated as more suspenseful than the version produced by the human author intended for low suspense (Mean = 2.316) with a 99% of confidence (Suspenser vs. Human-LS $t(194) = 2.56$, p value = 0.006; Human-HS vs. Human-LS $t(194)=2.50$, p value = 0.007).

Table 4.13: One-tailed t-test analysis showing pair-wise comparison of means for suspense. Comparisons significant at the 0.01 level are indicated by **.

Generator	Mean	Generator	Mean	t Value	Pr > | t |
Suspenser	2.704	Human-HS	2.694	0.07	0.473
Suspenser	2.704	Human-LS	2.316	2.56	0.006**
Human-HS	2.694	Human-LS	2.316	2.50	0.007**

4.4.4 Discussion

The data clearly show that the story generators had an influence on the amount of suspense that the subjects felt. In particular, the stories produced by Suspenser, the computational model of story generation for suspense, created stories comparable in suspense to those produced by human authors intended for high suspense effect (Suspenser Mean = 2.704; Human author intended for high suspense Mean = 2.694). The results also show that the difference between the suspense levels felt by the subjects from Suspenser’s story for high-suspense and the human author’s story for low-suspense was significant with a 99% of confidence.

To test if Suspenser selects appropriate content for the effect of suspense, the Suspenser-generated stories were compared with other types of stories in content and size; the size of a story was measured by counting the number of sentences up to the point where the subjects' suspense was measured. First, the comparisons of stories in size with respect to suspense level indicate that text size of the stories used in these studies had little effect on suspense. The six stories generated by Suspenser and by the author intended for the high-suspense treatments were identical in size (10 sentences for all the three types of *fabulas*). Suspenser-generated stories were superior to the author-generated stories intended for high suspense in two categories (*fabula* B and C) and inferior to them in one category (*fabula* A). The author-generated stories intended for low-suspense had different magnitudes (6 sentences for *fabula* A, and 9 sentences for *fabula* B and C). The shortest story (Human-LS for *fabula* A) produced a suspense level (Mean = 2.303) similar to the suspense levels produced by the other two stories (Human-LS *fabula* B Mean = 2.394, Human-LS *fabula* C Mean = 2.250). Second, the investigation of the contents of the six *sjuzhets* indicates that the set of stories for high suspense effect differed in content from the set for low suspense effect. The story created by the system overlaped that created by the human author intended for high suspense in 50%-80% of the total number of story sentences (*fabula* A 50%, *fabula* B 60%, *fabula* C 80%). In contrast, the stories created for high suspense overlaped the story created by the author intended for low suspense in 20%-30% (*fabula* A 20%, *fabula* B 20%, *fabula* C 30%). This means that the story event sets targeting high suspense and the set intended for low-suspense tend to be mutually exclusive. The story events that the author selected for low suspense were not related to the protagonist's goals. This observation suggests a direction to improve the algorithm for event selection in low-suspense mode. Instead of using the skeleton, future work may consider the use of satellites as the basic building block for creating stories in the low-suspense mode.

To test if the text quality affected the reader's story comprehension, the subjects were asked to rate the story coherency after reading each story. The collected data suggest that the text quality was good enough for the subjects to understand the stories. The participants evaluated the given stories as relatively coherent (Mean = 2.938/5.0, SD = 1.031). It is also noticeable that the system generated story (Mean = 3.208, SD = 1.025) was rated more coherent than the author produced stories (intended for high suspense Mean = 2.958, SD = 1.075; intended for low suspense Mean = 2.649, SD = 1.061).

While the results of this study show that Suspenser was effective in generating suspenseful stories, the design of the experiment does not allow us to point conclusively at single reason for its effectiveness. In producing the sample *fabulas* used for this study, the skeleton builder played a more important role than the suspense creator because of several conditions that restricted the candidates for the algorithm in Figure 3.20. First, attributing to the small number of steps that constituting each *fabula*, when an initial *fabula* was constructed, only a few steps remained available to be checked as supplemental steps that would increase the suspense level. Second, the plan representation used in this study did not allow a plan to have conflicting goals. A plan structure used in this research was considered a sound solution plan only when it contains no conflicts. In order to create conflicting situations—critical conditions for suspense—the characters' goals were manually specified to foster a compelling story. As a result, protagonist's and antagonist's plans were often related via causal relationships. For example, when the villain's goal was to kill a famous actress, I set his goal in the plan to be switching on a bomb installed in her car rather than actually killing her. In this way, the villain's goal was assumed to be achieved even when the bomb was disarmed, failing him to kill her. For the protagonist, her goal was set to be the bomb being disarmed. When the planner constructed a solution to her goal, it first found a plan operator that disarmed the bomb. Because the 'disarming the bomb' step required a condition that the bomb had been switched on, the villain's switching on action served to support the protagonist's plan rather than as a threat. As a result, a sound plan tended to contain only a very few threatening steps, which make it difficult for the suspense creator to find candidates that would serve as supplemental actions for suspense effect. A redesign of the experiment to use a more conflict-expressive plan representation is needed to better characterize the contribution of the suspense creator in the readers' level of suspense.

Chapter 5

Conclusions

The generation of stories by computers, with applications ranging from computer games to education and training, has been the focus of research by computational linguists and AI researchers for several decades. Although a number of approaches have shown promise in their ability to generate narrative, there has been little research on creating stories for an intended emotion.

This paper presents a computational model of suspense, exploring the concept that a reader's suspense level is affected by the number of solutions available to the problems faced by a narrative's protagonists (Brewer, 1996; Gerrig and Bernardo 1994; Comisky and Bryant 1982; Carroll, 1984; Carroll, 1996; de Wied, 1994; Zillmann, 1996). When given a complete story world, this model elaborates a story structure—content—that can manipulate reader suspense at a specific point in its telling.

In constructing the story structure, this approach gauges the suspense level that a reader would feel by modeling the reader's narrative comprehension using a planning technique. This approach takes as input a partial plan indicating the portion of a story that has been conveyed so far and computes the reader's anticipated suspense level based on the inverse of the number of solution plans that can be found to the protagonist's goals in the space of plans she can consider within her reasoning resources (i.e., reasoning algorithm, plan library, a resource bound representing her reasoning limit).

To generate a partial plan that maximizes the reader's suspense, the system takes a plan as input and selects a set of core events that have high causal connectivity and that also play an important role in the story as basic building blocks. The partial plan then is supplemented by harmful actions (e.g., those that conflcit with the protagonist's goals) that intensify the reader's suspense level.

The model has been implemented and formally evaluated. The data from the experiments have shown this system to be successful in selecting content that elicits high suspense. In particular, the data show that, in the context of my experiments, this model was as effective as a human author in generating suspenseful stories.

5.1 Future Work

Several aspects of the current model will be investigated and extended in future work. First, the suspense level measuring function can be refined. The current function does not consider the difficulty of achieving a plan; whereas, human readers also consider various aspects of a plan (e.g., size, the characters that it involves, readiness of executing its actions). In order to devise a function that simulates a human's cognitive process in gauging her suspense, a probabilistic planning technique could be employed. Second, the current approach does not attempt to model the reader's learning process during her exposure to a story. Learning can occur when a story plan contains an action instantiated from an operator that is missing in the reader's plan library. The current system assumes that the reader's knowledge is identical to the system's knowledge when the input fabula is created. This means that every event that composes a story is guaranteed to be understandable and inferable by its readers. This limits the use of narrative for educational purposes. As Bruner (1991) points out, narrative serves not only as an entertainment but also as an intellectual tool: people perceive and understand the world in part through stories. Thus, it will be quite intriguing to model deficiencies in their knowledge, especially from a pedagogical perspective.

My current approach takes as input a *fabula* which includes every incident that occurs in the story world. As a result, the model may require additional adjustment to be incorporated in an interactive setting in which actions involving the user-controlled characters are determined as the story unfolds. I plan to extend this model to interactive environments by expanding previous related work on narrative replanning techniques (Riedl, Saretto, and Young, 2003; Harris and Young, 2005).

Also in future work, a story generation architecture that allows the bidirectional interaction among the *fabula*, *sjuzhet*, and discourse layers could augment the system's suspense generating techniques. For example, the technique of postponing story resolution has been widely employed to invoke reader suspense in human-authored narratives. To this end, MINSTREL (Turner, 1994) inserts additional events relating the protagonist's struggles in between the story's climax and its resolution. With a bidirectional interaction model, Suspenser could notify the *fabula* creator of an updated *fabula*, incorporating auxiliary events that situate the protagonist in a seemingly dangerous position. Likewise, the *fabula* and the *sjuzhet* could be adjusted upon request from the discourse generator. For instance, in filming a scene, the discourse generator may find no spots to capture a specified shot of characters due to the physical setting that the current *fabula* provides. Bidirectional interaction would allow the *fabula* to be replaced with a new *fabula* to fix this problem.

5.2 Concluding Remarks

Story narratives should entertain their readers. To date, story generation systems have focused on creating logically sensible stories rather than engaging stories. They also have focused on means used to create original story worlds, but researchers have shown little interests in the problems involved in conveying a given story world to readers for a specific effect. Although human storytellers carefully select tellable events in stories considering the individual hearer's expected mental activity (and its limitations), only a few researchers have explored these aspects of storytelling. To my knowledge, this system is unique in aiming to generate suspenseful stories by modeling a storyteller who selects relevant story elements based on the reader's reasoning process. I believe that this work will benefit the AI community by motivating research on affective story generation for providing various emotional experiences for users.

References

Alwitt, L. F. (2002). Suspense and Advertising Responses. *Journal of Consumer Psychology*, 12 (1), 35-49.

Aylett, R. (1999). Narrative in Virtual Environments – Towards Emergent Narrative. In *Narrative Intelligence: Papers from the 1999 AAAI Fall Symposium*, North Falmouth, MA.

Appelt, D. (1985). Planning English Referring Expressions. (1985). *Artificial Intelligence*, vol. 26.

Bailey, P. (1999). Searching for Storiness: Story-generation from a Reader's Perspective. In M. Mateas & P. Sengers (Eds.) *Narrative Intelligence: Papers from the 1999 Fall Symposium*, pp. 157-163, Menlo Park, CA: American Association for Artificial Intelligence.

Bal, M. (1985). Narratology: Introduction to the Theory of Narrative. Toronto: University of Toronto Press.

Barthes, R. (1975). An Introduction to the Structural Analysis of Narrative. *New Literary History*, 6, 237-62.

Bates, J. (1992). Virtual Reality, Art, and Entertainment. *Presence: The Journal of Teleoperators and Virtual Environments*, 1(1), 133-138.

Brewer, W. F. (1996). The Nature of Narrative Suspense and the Problem of Rereading. In P. Vorderer, H. J. Wulff, & M. Friedrichsen (Eds.), *Suspense: Conceptualizations, theoretical analyses, and empirical explorations*, 107-127, Mahwah, NJ: Erlbaum.

Brewer, W. F. and Ohttsuka, K. (1988). Story Structure, Characterization, Just World Organization, and Reader Affect in American and Hungarian Short Stories. *Poetics, 17*, 395-415.

Brewer, W.F. and Lichtenstein, E. H. (1981). Event Schemas, Story Schemas and Story Grammars. In J. Long and A. Baddeley (Eds.) *Attention and Performance*, 9, 363-379.

Brewer, W.F. and Lichtenstein, E. H. (1982). Stories are to Entertain: A Structural-affect Theory of Stories. *Journal of Pragmatics*, 6, 473-483.

Bringsjord, S., and Ferrucci, D. (1999). AI and Literary Creativity: Inside the Mind of Brutus, A Storytelling Machine. Mahwah, NJ: Lawrence Erlbaum

Britton, B. (1983). What Makes Stories Interesting. Behavioral and Brain Sciences, 6: 596-597.

Bruner, J. (1991). The Narrative Construction of Reality. *Critical Inquiry* 18(1):1-21

Carroll, N. (1984). Toward a Theory of Film Suspense. *Persistence of Vision*, 1, 65-89.

Carroll, N. (1996). The Paradox of Suspense. In P. Vorderer, H. J. Wulff, & M. Friedrichsen (Eds.), *Suspense: Conceptualizations, theoretical analyses and empirical explorations*, 71-92, Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Callaway, C. B. and Lester, J. C. (2002). Narrative Prose Generation. *Artificial Intelligence*, 139, 213–252.

Cavazza, M., Charles, F., and Mead, S. J. (2002). Character-Based Interactive Storytelling. *IEEE Intelligent Systems*, *17*(4): 17-24.

Charles, F., Lozano, M., Mead, S.J., Bisquerra, A.F., and Cavazza, M. (2003). Planning Formalisms and Authoring in Interactive Storytelling. In *Proceedings of the 1st International Conference on Technologies for Interactive Digital Storytelling and Entertainment*, Darmstadt, Germany.

Chatman, S. (1978). Story and Discourse: Narrative Structure in Fiction and Film. Ithaca, New York: Cornell University Press.

Christian, D. and Young, M. (2004). Comparing Cognitive and Computational Models of Narrative Structure. In *Proceedings of the Nineteenth National Conference on Artificial Intelligence*, 385-390, San Jose, CA.

Dale, R and Reiter, E. (1995). Computational Interpretations of the Gricean Maxims in the Generation of Referring Expressions. *Cognitive Science*, 19(2), 233–263.

de Wied, M. (1994). The Role of Temporal Expectancies in the Production of Film Suspense. *Poetics*, 23, 107-123.

Díaz-Agudo, B., Gervás, P., and Peinado, F. (2004). A case based reasoning approach to story plot generation. In P. A. González-Calero and P. Funk (Eds), Advances in Case-Based Reasoning. In *Proceedings of the 7th European Conference on Case Based Reasoning*, volume 3155 of Lecture Notes in Artificial Intelligence, pages 142–156, Madrid, Spain, 2004. Springer Verlag.

Duckworth, G. E. (1933). Foreshadowing and Suspense in the Epics of Homer, Apollonius, and Vergil. Princeton.

Elhadad, M. and Robin, J. (1996). An overview of SURGE: A Reusable Comprehensive Syntactic Realization Component. *Technical Report Technical Report 96-03, Dept of Mathematics and Computer Science*, Ben Gurion University, Beer Sheva, Israel.

Emmott, C. (1997). Narrative Comprehension: Text, Knowledge and Inference Making. *Narrative Comprehension: A Discourse Perspective*, pp. 3-19. Oxford University Press.

Foss, C. L., and Bower, G. H. (1986). Understanding Actions in Relation to Goals. In N. E. Sharkey (Ed.), *Advances in Cognitive Science* , Vol. I, 94-124, Chichester: Ellis Horwood, Ltd.

Friedrichsen, M. (1996). Problems of Measuring Suspense. In P. Vorderer, H. J. Wulff, & M. Friedrichsen (Eds.), *Suspense: Conceptualizations, theoretical analyses, and empirical explorations*, 329-346, Hillsdale, NJ: Lawrence Erlbaum Associates.

Freytag, G. (1863). The Technique of the Drama: An Exposition of Dramatic Composition and Art. (Johnston Reprint Corp. 1968).

Genette, G. (1988). Narrative Discourse. Ithaca, NY: Cornell University Press.

Gerrig, R. J. (1996). The Resiliency of Suspense. In P. Vorderer, H. J. Wulff, & M. Friedrichsen (Eds.), *Suspense: Conceptualizations, theoretical analyses, and empirical explorations*, 93-105, Hillsdale, NJ: Lawrence Erlbaum Associates.

Gerrig, R., and Bernardo, D. (1994) Readers as problem-solvers in the experience of suspense. *Poetics 1994;22*, 459-472.

Graesser, A.C., Lang, K.L., & Roberts, R.M. (1991). Question answering in the context of stories. *Journal of Experimental Psychology: General*, 120(3), 254-277.

Graesser, A.C., and Wiemer-Hastings, K. (1999). Situation models and concepts in story comprehension. In Goldman, S.R., Graesser, A.C., and van den Broek, P. (Eds). *Narrative comprehension, causality, and coherence.* 77-92. Mahwah, NJ: Erlbaum.

Graesser, A. C, Olde, B., and Klettke, B. (2002). How does the mind construct and represent stories? In Green, Melanie C., Strange, Jeffrey J., and Brock, Timothy C. (Eds). *Narrative Impact: Social and cognitive foundations*. 229-262, Lawrence Erlbaum Associates, Inc.

Gratch, J. (2000). Modeling the Interplay Between Emotion and Decision Making. In *Proceedings of the 9th Conference on Computer Generated Forces and Behavioral Representation*.

Gratch, J. and Marsella, S. (2004a). Modeling Emotions in the Mission Rehearsal Exercise. In *Proceedings of the 10th Conference on Computer Generated Forces and Behavioral Representation*.

Gratch, J., and Marsella, S. (2004b). A Domain-independent Framework for Modeling Emotion. *Journal of Cognitive Systems Research*.

Greimas, A. J. (1983). Structural Semantics: An Attempt at a Method. 197-213. First publ. as Sémantique structurale: Recherche de méthode (1966).

Guidry, J. A. (2004). The Experience of … Suspense: Understanding the Construct, its Antecedents, and its Consequences in Consumption and Acquisition Contexts. *Ph.D. Dissertation, Department of Marketing, Texas A&M University*.

Harris, J. and Young, M. (2005). Proactive Mediation in Plan-Based Narrative Environments. In *Proceedings of the Fifth International Conference on Intelligent Virtual Agents*, 292-304, Kos, Greece.

Hill, R. W., Gratch, J., Marsella, S., Rickel, J., Swartout, W., and Traum, D. Virtual. (2003). Humans in the Mission Rehearsal Exercise System, *Kunstliche Intelligenz* (Special Issue on Embodied Conversational Agents).

Hoeken, H. & Vliet, M.V. (2000). Suspense, Curiosity, and Surprise: How Discourse Structure Influences the Affective and Cognitive Processing of a Story. *Poetics* 27(4), 277-286.

Kambhampati, S., Knoblock, C. A., and Qiang, Y. (1995). Planning as refinement search: a unified framework for evaluating design tradeoffs in partial-order planning. *Artificial Intelligence*, 76:167-238.

Kelso, M. T., Weyhrauch, P., and Bates, J. (1993). Dramatic Presence. *Presence: The Journal of Teleoperators and Virtual Environments*, 2(1), 1-15.

Lazarus, R. S. (1991). Emotion and Adaptation. Oxford Press.

Lebowitz, M. (1984). Creating Characters in a Story-telling Universe. *Poetics*, 13, 171-194.

Lebowitz, M. (1985). Story-telling as Planning and Learning. *Poetics*, 14, 483-502.

Lönneker, B. (2005). Narratological Knowledge for Natural Language Generation. In G. Wilcock, K. Jokinen, C. Mellish, and E. Reiter (Eds.), In *Proceedings of the 10th European Workshop on Natural Language Generation (ENLG 2005), Aberdeen, Scotland, August 8-10,* 91-100.

Magerko, B. and Laird, J. (2004). Mediating the Tension between Plot and Interaction. In *Papers from the 2004 AAAI Workshop Series: Challenges in Game Artificial Intelligence*, 108-112, San Jose, CA.

Mann, W. C. and Thompson, S. A. (1988). Rhetorical Structure Theory. Toward a Functional Theory of Text Organisation. *Text*, 8(3):243–281.

Mateas, M. and Sengers, P. (1999). Narrative Intelligence: An Introduction to the NI Symposium. In M. Mateas and P. Sengers (Eds.), *Working notes of the Narrative Intelligence Symposium* , AAAI Fall Symposium Series. Menlo Park: Calif.: AAAI Press.

Mateas, M. and Stern, A. (2003) Façade: An Experiment in Building a Fully-Realized Interactive Drama. In *Game Developer's Conference: Game Design Track*, San Jose, California, March.

Mattenklott, A. (1996). On the Methodology of Empirical Research on Suspense. P. Vorderer, H. J. Wulff, & M. Friedrichsen (Eds.), *Suspense: Conceptualizations, theoretical analyses and empirical explorations*, 283-299, Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Meehan, J.R. (1976). The Metanovel: Writing Stories by Computer. Ph.D. Dissertation, Yale University.

Montfort, N. (2006). Natural Language Generation and Narrative Variation in Interactive Fiction. In *Proceedings of the Twenty-First AAAI 2006 Computational Aesthetic Workshop*, Boston, MA.

Mott, B. W., Callaway, C., Zettlemoyer, L., Lee, S., and Lester, J. (1999). Towards Narrative-Centered Learning Environments. *Working Notes* of the 1999 AAAI Fall Symposium on Narrative Intelligence, 78-82, Cape Cod, MA.

Mott, B. W. (2006). Decision-Theoretic Narrative Planning for Guided Exploratory Learning Environments. *Ph.D. Dissertation, Department of Computer Science, North Carolina State University*.

Nelson, M. and Mateas M. (2005). Search-Based Drama Management in the Interactive Fiction Anchorhead. In *Proceedings of the First Intl. Conference on Artificial Intelligence and Interactive Digital Entertainment (AIIDE-05)*.

Nieding, G., Ohler, P., and Thuβbas, C. (1996). The Cognitive Development of Temporal Structures: How Do Children Make Inferences With Temporal Ellipses in Films? In P. Vorderer, H. J. Wulff, & M. Friedrichsen (Eds.), *Suspense: Conceptualizations, theoretical analyses and empirical explorations*, 301-328, Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Ortony, A., Clore, G., and Collins, A. (1988). The Cognitive Structure of Emotions. New York: Cambridge University Press.

Platts, J., Blandford, A., & Huyck, C. (2002). Awaiting the Sensation Of a Short, Sharp Shock: Twist-Centred Story Generation by Transformation. In *Proceedings of the AISB'02 Symposium on AI and Creativity in Arts and Science*, 89-97.

Prieto-Pablos, J. A. (1998). The Paradox of Suspense. *Poetics*, 26, 99-113.

Prince, G. (1987). A Dictionary of Narratology. Lincoln, NE: University of Nebraska Press.

Propp, V. (1968). Morphologi' of the Folktale. Austin, TX: University of Texas Press.

Rattermanna, M. J., Spectorb, L., Grafmanc, J., Levind, H., Harwarde, H. (2001). Partial and Total-order Planning: Evidence from Normal and Prefrontally Damaged Populations. *Cognitive Science*, vol. 25, 941–975.

Riedl, M. O. (2004). Narrative Planning: Balancing Plot and Character. *Ph.D. Dissertation, Department of Computer Science, North Carolina State University*.

Riedl, M. O., and R. Michael Young. (2004). A Planning Approach to Story Generation for History Education. *Proceedings of the 3rd International Conference on Narrative and Interactive Learning Environments*, Edinburgh.

Riedl, M. O. and Young, R. M. (2004). An Intent-driven Planner for Multi-agent Story Generation. In *Proceedings of the 3rd International Joint Conference on Autonomous Agents and Multi Agent Systems.*

Rimmon-Kenan, S. (2002). Narrative Fiction: Contemporary Poetics. New York: Metheun, Routledge.

Ryokai K., Vaucelle C, and Cassell J. (2003). Virtual Peers as Partners in Storytelling and Literacy Learning. *Journal of Computer Assisted Learning*, vol. 19, no. 2, 195-208(14)

Sgouros, N. M. (1999) Dynamic Generation, Management and Resolution of Interactive Plots. *Artificial Intelligence* 107(1), 29-62.

Swartout, W., Hill, R., Gratch, J., Johnson, L., Kyriakakis, C., Labore, C., Lindheim, R., Marsella, S., Miraglia, D., Moore, B., Morie, J., Rickel, J., Thiébaux, M., Tuch, L., Whitney, R., and Douglas, J. (2001). Towards the Holodeck: Integrating Graphics, Sound, Character and Story. In *Proceedings of the Fifth International Conference on Autonomous Agents*, 409-416. Montreal, Canada.

Szilas, N. (2001). A New Approach to Interactive Drama: From Intelligent Characters to an Intelligent Virtual Narrator. In the *Proceedings of the AAAI Spring Symposium on AI and Interactive Entertainment*, 72-76.

Tan, E. and Diteweg, G. (1996). Suspense, Predictive Ineference, and Emotion in Film Viewing. In P. Vorderer, H. J. Wulff, and M. Friedrichsen (Eds.), *Suspense: Conceptualizations, Theoretical Analyses, and Empirical Explorations*, 149-188, Mahwah, NJ: Lawrence Erlbaum Associates.

Toolan, M. (2001). Narrative: A Critical Linguistic Introduction. New York: Routledge.

Trabasso, T. and Sperry, L. L. (1985). Causal Relatedness and Importance of Story Events. *Journal of Memory and Language*, vol. 24, 595-611.

Truffaut, F. (1967). Hitchcock. New York: Simon and Schuster.

Turner, S. (1994). The Creative Process: A Computer Model of Storytelling and Creativity. Hillsdale, NJ: Lawrence Erlbaum Associates.

van der Hoek, W. and Lomuscio, A. (2004). A Logic for Ignorance. In *Declarative Agent Languages and Technologies (DALT)*, Leite, Omicini, Sterling and Torroni (Eds), LNAI 2990, 97 - 108.

Vorderer, P. (1996). Toward a Psychological Theory of Suspense. In P. Vorderer, H. J. Wulff, and M. Friedrichsen (Eds.), *Suspense: Conceptualizations, Theoretical Analyses, and Empirical Explorations*, 233-254, Mahwah, NJ: Lawrence Erlbaum Associates.

Weyhrauch, P. (1997). Guiding Interactive Ficiton Ph.D. Dissertation, Carnegie Mellon University, Pittsburgh, PA.

Wuss, P. (1996). Narrative Tension in Antonioni. In P. Vorderer, H. J. Wulff, and M. Friedrichsen (Eds.), *Suspense: Conceptualizations, Theoretical Analyses, and Empirical Explorations*, Mahwah, NJ: Lawrence Erlbaum Associates.

Yanal, R. J. (1996). The Paradox of Suspense. *British Journal of Aesthetics*, 36(2), 146-158.

Young, R. M.; Pollack, M. E.; and Moore, J. D. (1994). Decomposition and Causality in Partial Order Planning. In Proceedings *of the Second International Conference on AI and Planning Systems*, 188-193.

Young, R. M. and Moore, J. D. (1994) DPOCL: A Principled Approach to Discourse Planning. In the *Proceedings of the Seventh International Workshop on Text Generation*, Kennebunkport, ME.

Young, R. M. (1999). Using Grice's Maxim of Quantity to Select the Content of Plan Descriptions, *Artificial Intelligence*, No. 115, 215-256.

Zillmann, D. (1991). The Logic of Suspense and Mystery. In Jennings Bryant & D. Zillmann (Eds.), *Responding to the screen: Reception and reaction processes*, 281-303, Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Zillmann, D. (1996). The Psychology of Suspense in Dramatic Exposition. In P. Vorderer, H. J. Wulff, & M. Friedrichsen (Eds.), *Suspense: Conceptualizations, theoretical analyses and empirical explorations*, 199-232, Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Appendices

Appendix A

Evaluation Materials

This appendix describes the evaluation materials used for the three pilot studies and one large-scale empirical experiment that I conducted to evaluate the efficacy of Suspenser. Section A.1 shows the materials used for pilot study 1 that were designed to test if the skeleton builder effectively extracts important events in a story compared with human subjects. The material for pilot study 1 was presented on a pen-and-paper questionnaire. Section A.2 shows the materials used for pilot study 2 designed to evaluate the effectiveness of the skeleton builder and heuristic functions used in the suspense creator component. Section A.3 shows the materials used for pilot study 3, which was designed for testing the same efficacy as pilot study 2 and the interface for the experimental study. Section A.4 shows the materials used for the main experimental study designed to measure the efficacy of Suspenser in generating suspenseful stories compared with a human author. Finally, pilot study 2, pilot study 3, and the experimental study employed a web-based survey to present the materials.

A.1 Evaluation Materials for Pilot Study 1

Pre-Experiment Questionnaire

Please complete the following list of questions. You may choose to NOT answer any of the following questions by selecting "No response".

1. Gender: Female Male No response

2. Age Group: 18-19 20-24 25-29 30-34 35-39 40-49 50+ No response

3. Race (select one or more):
American Indian or Alaska Native
Asian
African American
Hispanic or Latino
Native Hawaiian or Other Pacific Islander
White
No response

4. Major (please write down your major and minor if any):

5. Year in School: Freshman Sophomore Junior Senior Masters PhD Other No Response

6. Language:
English as a native language
English as an official language in your country
English as a foreign language

7. Marriage Status: Single Married Other No response

8. Children: No children 1 child 2 children 3+ children No response

Figure A.1: Pre-Experiment Questionnaire

Story Summarization

The purpose of this survey is to measure the quality of a system which summarizes a story. Please read the following stories and complete the questions as they are presented. **Please do not look ahead or flip back the pages.**

Story Background:

A rich villain named Dr. Evil is planning to rule the world. To be the ruler of the world, he needs the President to be eliminated. However, the White House is a secure place where only invited people can enter. While Dr. Evil is plotting to rule the world, the President has of goal of inviting wealthy people to the White House to raise money for education. In a nearby suburb of Washington, a father named Tom, who has a six-year old son Ben, is too poor to buy Ben a Christmas present. Tom has a ring that was given to him by his wife. Unknown to Tom, the ring is magical, providing its wearer with absolute power over others. Tom's goal is to get a toy for Ben's Christmas present; Tom knows that Dr. Evil has a toy that he's willing to trade for Tom's ring.

Story:

1. Tom traveled to Dr. Evil's castle (to trade his ring for Dr. Evil's toy).
2. Tom traded his ring for Dr. Evil's toy. As a result, Tom obtained the toy that Ben wants to have and Dr. Evil obtained the ring of absolute power.
3. Tom traveled back to his house, and went up to the Christmas tree.
4. Tom put the toy under the Christmas tree.
5. Ben walked from his room to the Christmas tree.
6. Ben found his Christmas present—the toy that Tom left.
7. Dr. Evil went to the Wachovia bank to withdraw money from his bank account.
8. Dr. Evil withdrew enough cash from his account to buy a gun.
9. Dr. Evil traveled to a gun store.
10. Dr. Evil bought a gun.
11. The President invited Dr. Evil to the fund-raising event at the White House.
12. Dr. Evil traveled to the White House.
13. Dr. Evil used the ring of absolute power to put all the Secret Service agents to sleep; as a result, there was no one around the president.
14. Dr. Evil shot the president with his gun and became the ruler of the world.

1. If you were to tell the above story to your friends in five sentences, which sentences would you pick to include in the story? Please write down the numbers for the sentences to include in the summary.

2. Why did you choose those particular sentences? Please provide the reasons if any. You can choose not answer by skipping this question.

Figure A.2: First Page of Survey

3. Please rank each of the following sentences from 1, which is the most important event, to 14, which is the least important event, on the left-most column of the table below. You may choose to NOT answer any of the following questions by skipping this question.

Rank	Sentences
	1. Tom traveled to Dr. Evil's castle (to trade his ring for Dr. Evil's toy). 2. Tom traded his ring for Dr. Evil's toy. As a result, Tom obtained the toy that Ben wants to have and Dr. Evil obtained the ring of absolute power. 3. Tom traveled back to his house, and went up to the Christmas tree. 4. Tom put the toy under the Christmas tree. 5. Ben walked from his room to the Christmas tree. 6. Ben found his Christmas present – the toy that Tom left. 7. Dr. Evil went to the Wachovia bank to withdraw money from his bank account. 8. Dr. Evil withdrew enough cash from his account to buy a gun. 9. Dr. Evil traveled to a gun store. 10. Dr. Evil bought a gun. 11. The President invited Dr. Evil to the fund-raising event at the White House. 12. Dr. Evil traveled to the White House. 13. Dr. Evil used the ring of absolute power to put all the Secret Service agents to sleep; as a result, there was no one around the president. 14. Dr. Evil shot the president with his gun and became the ruler of the world.

4. Rate the following goal from the story in terms of its significance to the story's main point:

The President's goal of raising money for education

1) Not significant
2) Marginally significant
3) Somewhat significant
4) Very significant
5) Extremely significant

5. Rate the following goal from the story in terms of its significance to the story's main point:

Tom's goal of pleasing Ben with a Christmas present.

1) Not significant
2) Marginally significant
3) Somewhat significant
4) Very significant
5) Extremely significant

Figure A.3: Second Page of Survey

6. Rate the following goal from the story in terms of its significance to the story's main point:

Dr. Evil's goal of being the ruler of the world.

1) Not significant
2) Marginally significant
3) Somewhat significant
4) Very significant
5) Extremely significant

Question 7 relates just to the following paragraph:

Tom traded his ring for Dr. Evil's toy. As a result, Tom obtained the toy that Ben wants to have and Dr. Evil obtained the ring of absolute power. Ben found his Christmas present—the toy that Tom left. The President invited Dr. Evil to the fund-raising event at the White House. Dr. Evil traveled to the White House. Dr. Evil shot the president with his gun and became the ruler of the world.

7. How well do you think the paragraph above represents the story?

1) better than those that I selected.
2) equally well as those that I selected.
3) less well than those that I selected.
4) no response.

Figure A.4: Third Page of Survey

Post-Experiment Questionnaire

Please complete the following list of questions. You may choose to NOT answer any of the following questions by skipping those questions.

1. Please write any suggestions about the story.

2. Please write any suggestions about the experimental method.

Figure A.5: Post-Experiment Questionnaire

A.2 Evaluation Materials for Pilot Study 2

The purpose of this survey is to measure the suspense level from a given story. Please carefully read the following story and complete the questions as they are presented. This story will not be shown again. And click the button "Next page" when you complete reading.

Story Background

In 2020 mankind faces severe environmental problems. The process of desertification spreads to North America, and shrinking glaciers have raised sea level significantly. An environmentalist named Mr. Greenpeace, head of the biggest environmental foundation in the world, is aware of these urgent problems, and plans to persuade the U.S. President to take prompt actions to prevent disaster. Meanwhile, a rich villain named Dr. Evil is planning to assassinate the President. His plans are complicated by the security in place at the White House, where only people with invitations can enter. In a nearby suburb of Washington, a man named Tom, who is the father of a six-year old boy named Ben, is hoping to give his son a Christmas present. Unfortunately, Tom is too poor to buy Ben a Christmas present. Tom has a shiny silver ring that was given to him by his wife. Unknown to Tom, the ring is magical; when worn, the ring can send out a magical pulse that will knock out anyone within a ten foot radius. Tom's goal is to get a toy for Ben's Christmas present; Tom knows that Dr. Evil has a toy that he's willing to trade for Tom's ring.

Story

Mr. Greenpeace made a speech about the importance of taking action immediately to save the world. The President gave the promised government financial support to Mr. Greenpeace's foundation. Tom traded his ring for Dr. Evil's toy. As a result, Tom obtained the toy that Ben wanted and Dr. Evil obtained the ring. Tom put the toy under the Christmas tree. Ben found his Christmas present--the toy that Tom left. Dr. Evil went to a bank to withdraw money from his bank account. Dr. Evil bought a gun. Dr. Evil registered for a hypnosis class to learn how to hypnotize people by waving a shiny object before their eyes. Dr. Evil traveled to the White House. Dr. Evil used the ring of power to put all the Secret Service agents to sleep; as a result, there was no one guarding the president. Dr. Evil fired his gun at the President.

Next Page

Figure A.6: Story Sheet for the Questionnaire in the Study

1. How much suspense did you feel from this story?

- A lot
- Moderate
- A little
- Not at all

Next Page

2. Do you think President will survive?

- Yes
- No

Next Page

3. How much did you enjoy the story?

- A lot
- Moderate
- A little
- Not at all

Next Page

Figure A.7: Questions in the Survey

Input *Fabula*

[1] Mr. Greenpeace traveled from the Amazon to the US Capitol. [2] Mr. Greenpeace made a speech about the importance of taking action immediately to save the world. [3] The President announced that he would raise funds to support Mr. Greenpeace's environmental foundation and whoever donated more than million dollars would be invited to the White House for a fund-raising celebration party. [4] Dr. Evil watched the TV and found out that a donation would get him invited to the White House. [5] Dr. Evil donated a million dollars to the White House. [6] The President traveled to the White House. [7] The President invited Dr. Evil to the fund-raising celebrating event. [8] The President gave the promised government financial support to Mr. Greenpeace's foundation. [9] Tom traveled to Dr. Evil's castle. [10] Tom traded his ring for Dr. Evil's toy; as a result, Tom obtained the toy that Ben wanted and Dr. Evil obtained the ring. [11] Tom traveled back to his house, and went up to the Christmas tree. [12] Tom put the toy under the Christmas tree. [13] Ben walked from his room to the Christmas tree. [14] Ben found his Christmas present—the toy that Tom left. [15] Dr. Evil went to a bank to withdraw money from his bank account. [16] Dr. Evil withdrew enough cash from his account to buy a gun and to register a hypnosis class. [17] Dr. Evil traveled to a gun store. [18] Dr. Evil bought a gun. [19] Dr. Evil registered for a hypnosis class to learn how to hypnotize people by waving a shiny object before their eyes. [20] Dr. Evil took a hypnosis class; as a result, he knew how to hypnotize people by waving a shiny object before their eyes. [21] Dr. Evil traveled to the White House. [22] Dr. Evil used the ring of power to put all the Secret Service agents to sleep; as a result, there was no one guarding the president. [23] Mr. Greenpeace traveled to the White House. [24] Dr. Evil fired his gun at the President. [25] At the last moment, Mr. Greenpeace rescued the President by pushing him out of the way.

Figure A.8: Input *Fabula*

Story by a Professional Writer

Dr. Evil donated a million dollars to the White House. Tom traveled to Dr. Evil's castle (to trade his ring for Dr. Evil's toy). Tom traded his ring for Dr. Evil's toy. As a result, Tom obtained the toy that Ben wanted and Dr. Evil obtained the ring. Tom traveled back to his house, and went up to the Christmas tree. Ben walked from his room to the Christmas tree. Ben found his Christmas present--the toy that Tom left. Dr. Evil traveled to a gun store. Dr. Evil bought a gun. Dr. Evil took a hypnosis class; as a result, he knew how to hypnotize people by waving a shiny object before their eyes. Dr. Evil traveled to the White House. Dr. Evil used the ring of power to put all the Secret Service agents to sleep; as a result, there was no one guarding the president. Dr. Evil fired his gun at the President.

Story by someone is not a professional writer

The President announced that he would raise funds to support Mr. Greenpeace's environmental foundation and whoever donated more than million dollars would be invited to the White House for a fund-raising celebration party. Dr. Evil watched the TV and found out that a donation would get him invited to the White House. The President invited Dr. Evil to the fund-raising celebrating event. Tom traveled to Dr. Evil's castle (to trade his ring for Dr. Evil's toy). Tom traded his ring for Dr. Evil's toy. As a result, Tom obtained the toy that Ben wanted and Dr. Evil obtained the magical ring. Tom put the toy under the Christmas tree. Ben walked from his room to the Christmas tree. Dr. Evil traveled to a gun store. Dr. Evil bought a gun. Dr. Evil took a hypnosis class; as a result, he knew how to hypnotize people by waving a shiny object before their eyes. Dr. Evil traveled to the White House. Dr. Evil used the ring of power to put all the Secret Service agents to sleep; as a result, there was no one guarding the president. Mr. Greenpeace traveled to the White House. Dr. Evil fired his gun at the President.

Figure A.9: Stories Produced by Humans

High Suspense Story by computer

Mr. Greenpeace made a speech about the importance of taking action immediately to save the world. The President announced that he would raise funds to support Mr. Greenpeace's environmental foundation and whoever donated more than million dollars would be invited to the White House for a fund-raising celebration party. Dr. Evil watched the TV coverage of the President's announcement and learned that a donation would get him invited to the White House. Dr. Evil donated a million dollars to the White House. The President invited Dr. Evil to the fund-raising celebrating event. The President gave the promised government financial support to Mr. Greenpeace's foundation. Tom traded his ring for Dr. Evil's toy. As a result, Tom obtained the toy that Ben wanted and Dr. Evil obtained the ring. Ben found his Christmas present--the toy that Tom left. Dr. Evil went to a bank to withdraw money from his bank account. Dr. Evil bought a gun. Dr. Evil registered for a hypnosis class to learn how to hypnotize people by waving a shiny object before their eyes. Dr. Evil traveled to the White House. Dr. Evil used the ring of power to put all the Secret Service agents to sleep; as a result, there was no one guarding the president. Dr. Evil fired his gun at the President.

Low Suspense Story by computer

Mr. Greenpeace made a speech about the importance of taking action immediately to save the world. The President gave the promised government financial support to Mr. Greenpeace's foundation. Tom traded his ring for Dr. Evil's toy. As a result, Tom obtained the toy that Ben wanted and Dr. Evil obtained the ring. Tom put the toy under the Christmas tree. Ben found his Christmas present--the toy that Tom left. Dr. Evil went to a bank to withdraw money from his bank account. Dr. Evil bought a gun. Dr. Evil registered for a hypnosis class to learn how to hypnotize people by waving a shiny object before their eyes. Dr. Evil traveled to the White House. Dr. Evil used the ring of power to put all the Secret Service agents to sleep; as a result, there was no one guarding the president. Dr. Evil fired his gun at the President.

Figure A.10: Stories Produced by Suspenser

A.3 Evaluation Materials for Pilot Study 3

Background

The lunatic supervillian known as Jack has been developing biological weapons of devastating proportions. To accomplish the final stages of weapon development, he kidnapped the famous scientist, Dr. Cohen, and brought him to his private fortress on Skeleton Island. Jack expected that the FBI would soon send Smith, their top agent, to rescue Dr. Cohen. To keep the troublesome Smith out of his hair, Jack ordered his own agent, Erica, to monitor Smith and capture him if he is assigned to Dr. Cohen's rescue operation.

Story

1. Erica installs a wiretap in Smith's home while he is away.
2. Erica eavesdrops on the phone conversation in which Smith is given the order to rescue Dr. Cohen.
3. Erica meets with Smith.
4. Erica tells Smith that her father was kidnapped by Jack and taken to Skeleton Island, and she asks Smith to save her father.
5. Erica gives Smith the blueprints of Jack's fortress, with her father's cell marked.
6. Erica provides Smith with a boat for transportation to Skeleton Island.
7. Before going to the island, Smith hides a diamond in his shoe.
8. Smith goes to the port containing Erica's boat.
9. Smith rides the boat to Skeleton Island.
10. Smith sneaks into the cell marked on the map containing Erica's father.
11. Jack and his guard capture Smith as he enters the cell.
12. The guard disarms Smith.
13. The guard locks Smith into the cell.

14. Smith bribes the guard with the diamond in his shoe.
15. The guard unlocks the door.
16. Smith leaves the cell.
17. Smith sneaks to the lab where Dr. Cohen is captured.
18. Smith fights the guards in the lab.
19. Smith takes Dr. Cohen from the lab.
20. Smith and Dr. Cohen ride the boat to shore.

Figure A.11: *Fabula* A. The point where the reader's suspense level was measured between the sentence 13 and the sentence 14.

Background

In 2020 mankind faces severe environmental problems. The process of desertification spreads to North America, and shrinking glaciers have raised sea level significantly. An environmentalist named Mr. Greenpeace, head of the biggest environmental foundation in the world, is aware of these urgent problems, and plans to persuade the U.S. President to take prompt actions to prevent disaster. Meanwhile, a rich villain named Dr. Evil is planning to assassinate the President. His plans are complicated by the security in place at the White House, where only people with invitations can enter. In a nearby suburb of Washington, a man named Tom, who is the father of a six-year old boy named Ben, is hoping to give his son a Christmas present. Unfortunately, Tom is too poor to buy Ben a Christmas present. Tom has a shiny silver ring that was given to him by his wife. Unknown to Tom, the ring is magical; when worn, the ring can send out a magical pulse that will knock out anyone within a ten foot radius. Tom's goal is to get a toy for Ben's Christmas present; Tom knows that Dr. Evil has a toy that he's willing to trade for Tom's ring.

Story

1. Mr. Greenpeace traveled from the Amazon to the Capitol.
2. Mr. Greenpeace gave a speech about the importance of taking action immediately to save the world.
3. The President announced that he would raise funds to support Mr. Greenpeace’s environmental foundation and whoever donated more than million dollars would be invited to the White House for a fund-raising celebration party.
4. Dr. Evil watched the TV and found out that a donation would get him invited to the White House.
5. Dr. Evil donated a million dollars to the White House.
6. The President invited Dr. Evil to the fund-raising celebrating event.
7. The President gave the promised government financial support to Mr. Greenpeace's foundation.
8. Tom traded his ring for Dr. Evil’s toy; as a result, Tom obtained the toy that Ben wanted and Dr. Evil obtained the ring.
9. Tom put the toy under the Christmas tree.
10. The next day on Christmas, Ben found his Christmas present—the toy that Tom left.
11. Dr. Evil withdrew enough cash from his account to buy a gun and to register a hypnosis class.
12. Dr. Evil bought a gun.
13. Dr. Evil registered for a hypnosis class to learn how to hypnotize people by waving a shiny object before their eyes.
14. Dr. Evil took a hypnosis class; as a result, he knew how to hypnotize people by waving a shiny object before their eyes.
15. Dr. Evil used the ring of power to put all the Secret Service agents to sleep; as a result, there was no one guarding the president.
16. Mr. Greenpeace traveled to the White House.
17. Dr. Evil fired his gun at the President.
18. At the last moment, Mr. Greenpeace rescued the President by pushing him out of the way.

Figure A.12: *Fabula* B. The point where the reader’s suspense level was measured between the sentence 17 and the sentence 18.

Background

Sykes is the owner of the Hollywood Theater, which was once prosperous but has now become dilapidated and is in need of major renovations. Sykes has accrued a sizable gambling debt, and with his theater in shambles, he has no means with which to pay it back. He is constantly threatened by his crooked debtors. Janet is a famous actress with dreams of winning an Oscar, an acting award. She is jealous of the actress Agatha, who is her contender for the Oscar this year and also is well-known for her active involvement in charity. Janet knows a number of scoundrels including a guy named Kent, a bomb dealer. Agatha is in love with Bill, who serves as a lieutenant in the Los Angeles Police Department's Serious Crime squad. Janet knows that Agatha is planning to go to the Charity Bazaar for the Poor to be held in Hollywood Theater. To ensure that she will win the award, Janet plans to kill Agatha during the charity event.

Story

1. Janet convinces Sykes to participate in her plan to kill Agatha by convincing him that if he participates, he will be able pay off his gambling debts.
2. Janet and Sykes plan to burn down Sykes' theater to get the insurance money and kill Agatha during the charity bazaar.
3. Sykes borrows some money from the bank by mortgaging his theater.
4. Sykes buys insurance to cover his loss in case of a fire.
5. Janet gives Kent's contact information to Sykes and informs him of Kent's expertise with firebombs.
6. Kent takes a bomb to the Hollywood Theater and meets with Sykes.
7. Sykes purchases the firebomb.
8. Sykes installs the firebomb.
9. The lieutenant, Bill, issues a warrant permitting the arrest of Kent for his illegal weapons dealing.
10. Bill arrests Kent.
11. Bill coaxes Kent to give information in exchange for releasing him.
12. Kent informs Bill that Sykes is planning to firebomb his own theater during the charity event.
13. Bill releases Kent for his cooperation.
14. Agatha goes to the theater for the charity event.
15. Sykes sets the timer of the firebomb to explode during the charity event.
16. Sykes switches on the firebomb.
17. Bill searches for the firebomb in the theater.

18. Bill defuses the firebomb.
19. Agatha participates in the charity event.

Figure A.13: *Fabula* C. The point where the reader's suspense level was measured between the sentence 18 and the sentence 19.

The purpose of my experiment is to measure the performance of my computational program in creating suspense from readers compared with that of a human author.

For each story, I marked a point *T*. A reader's suspense level will be measured when she read events preceding *T*. After the measurement, she will proceed to read the rest of the story and at the end of the story she shall respond to her suspense level again. But the second measurement will not be used as significant data to my experiment. It will be used only when additional explanation is needed.

First, please select some events from each of the following stories that arouse the highest suspense from the reader at the time of *T*. In your selection, you may circle the index number of each sentence. Please be aware that the story constructed from your selected events should be read coherent from the reader's perspective. You can't reorder the events.

Second, please repeat the same task to arouse the lowest suspense from the reader at the time of *T*.

Figure A.14: Instruction Sheet for the Human Author

Fabula A Background

The lunatic supervillian known as Jack has been developing biological weapons of devastating proportions. To accomplish the final stages of weapon development, he kidnapped the famous scientist, Dr. Cohen, and brought him to his private fortress on Skeleton Island. Jack expected that the FBI would soon send Smith, their top agent, to rescue Dr. Cohen. To keep the troublesome Smith out of his hair, Jack ordered his own agent, Erica, to monitor Smith and capture him if he is assigned to Dr. Cohen's rescue operation.

FAW

Erica eavesdrops on the phone conversation in which Smith is given the order to rescue Dr. Cohen. Erica tells Smith that her father was kidnapped by Jack and taken to Skeleton Island, and she asks Smith to save her father. Erica gives Smith the blueprints of Jack's fortress, with her father's cell marked. Smith goes to the port containing Erica's boat. Smith rides the boat to Skeleton Island. Smith sneaks into the cell marked on the map containing Erica's father. Jack and his guard capture Smith as he enters the cell. The guard locks Smith into the cell.

FAH

Erica tells Smith that her father was kidnapped by Jack and taken to Skeleton Island, and she asks Smith to save her father. Erica gives Smith the blueprints of Jack's fortress, with her father's cell marked. Smith rides the boat to Skeleton Island. Smith sneaks into the cell marked on the map containing Erica's father. Jack and his guard capture Smith as he enters the cell. The guard disarms Smith. The guard locks Smith into the cell.

FAL

Erica eavesdrops on the phone conversation in which Smith is given the order to rescue Dr. Cohen. Erica tells Smith that her father was kidnapped by Jack and taken to Skeleton Island, and she asks Smith to save her father. Before going to the island, Smith hides a diamond in his shoe. Smith rides the boat to Skeleton Island. Smith sneaks into the cell marked on the map containing Erica's father. Jack and his guard capture Smith as he enters the cell. Smith bribes the guard with the diamond in his shoe.

Figure A.15: *Sjuzhets* Produced from *Fabula* A for the portion before suspense mesaured

Fabula B Background

In 2020 mankind faces severe environmental problems. The process of desertification spreads to North America, and shrinking glaciers have raised sea level significantly. An environmentalist named Mr. Greenpeace, head of the biggest environmental foundation in the world, is aware of these urgent problems, and plans to persuade the U.S. President to take prompt actions to prevent disaster. Meanwhile, a rich villain named Dr. Evil is planning to assassinate the President. His plans are complicated by the security in place at the White House, where only people with invitations can enter. In a nearby suburb of Washington, a man named Tom, who is the father of a six-year old boy named Ben, is hoping to give his son a Christmas present. Unfortunately, Tom is too poor to buy Ben a Christmas present. Tom has a shiny silver ring that was given to him by his wife. Unknown to Tom, the ring is magical; when worn, the ring can send out a magical pulse that will knock out anyone within a ten foot radius. Tom's goal is to get a toy for Ben's Christmas present; Tom knows that Dr. Evil has a toy that he's willing to trade for Tom's ring.

FBW

Dr. Evil watched the TV and found out that a donation would get him invited to the White House. The President invited Dr. Evil to the fund-raising celebrating event. Tom traded his ring for Dr. Evil's toy; as a result, Tom obtained the toy that Ben wanted and Dr. Evil obtained the ring. Dr. Evil withdrew enough cash from his account to buy a gun and to register a hypnosis class. Dr. Evil bought a gun. Dr. Evil registered for a hypnosis class to learn how to hypnotize people by waving a shiny object before their eyes. Dr. Evil took a hypnosis class; as a result, he knew how to hypnotize people by waving a shiny object before their eyes. Dr. Evil used the ring of power to put all the Secret Service agents to sleep; as a result, there was no one guarding the president. Mr. Greenpeace traveled to the White House.

FBH

Mr. Greenpeace traveled from the Amazon to the Capitol. Mr. Greenpeace gave a speech about the importance of taking action immediately to save the world. The President invited Dr. Evil to the fund-raising celebrating event. Tom traded his ring for Dr. Evil's toy; as a result, Tom obtained the toy that Ben wanted and Dr. Evil obtained the ring. Tom put the toy under the Christmas tree. The next day on Christmas, Ben found his Christmas present--the toy that Tom left. Dr. Evil withdrew enough cash from his account to buy a gun and to register a hypnosis class. Dr. Evil bought a gun. Dr. Evil fired his gun at the President.

FBL

Mr. Greenpeace gave a speech about the importance of taking action immediately to save the world. The President invited Dr. Evil to the fund-raising celebrating event. Tom traded his ring for Dr. Evil's toy; as a result, Tom obtained the toy that Ben wanted and Dr. Evil obtained the ring. Dr. Evil withdrew enough cash from his account to buy a gun and to register a hypnosis class. Dr. Evil registered for a hypnosis class to learn how to hypnotize people by waving a shiny object before their eyes. Dr. Evil took a hypnosis class; as a result, he knew how to hypnotize people by waving a shiny object before their eyes. Dr. Evil used the ring of power to put all the Secret Service agents to sleep; as a result, there was no one guarding the president. Mr. Greenpeace traveled to the White House. Dr. Evil fired his gun at the President.

Figure A.16: *Sjuzhets* Produced from *Fabula* B for the portion before suspense measured

Fabula C Background

Sykes is the owner of the Hollywood Theater, which was once prosperous but has now become dilapidated and is in need of major renovations. Sykes has accrued a sizable gambling debt, and with his theater in shambles, he has no means with which to pay it back. He is constantly threatened by his crooked debtors. Janet is a famous actress with dreams of winning an Oscar, an acting award. She is jealous of the actress Agatha, who is her contender for the Oscar this year and also is well-known for her active involvement in charity. Janet knows a number of scoundrels including a guy named Kent, a bomb dealer. Agatha is in love with Bill, who serves as a lieutenant in the Los Angeles Police Department's Serious Crime squad. Janet knows that Agatha is planning to go to the Charity Bazaar for the Poor to be held in Hollywood Theater. To ensure that she will win the award, Janet plans to kill Agatha during the charity event.

FCW

Janet and Sykes plan to burn down Sykes' theater to get the insurance money and kill Agatha during the charity bazaar. Janet gives Kent's contact information to Sykes and informs him of Kent's expertise with firebombs. Kent takes a bomb to the Hollywood Theater and meets with Sykes. Sykes purchases the firebomb. Sykes installs the firebomb. Kent informs Bill that Sykes is planning to firebomb his own theater during the charity event. Agatha goes to the theater for the charity event. Sykes sets the timer of the firebomb to explode during the charity event. Sykes switches on the firebomb. Bill searches for the firebomb in the theater.

FCH

Janet and Sykes plan to burn down Sykes' theater to get the insurance money and kill Agatha during the charity bazaar. Janet gives Kent's contact information to Sykes and informs him of Kent's expertise with firebombs. Sykes purchases the firebomb. Bill arrests Kent. Kent informs Bill that Sykes is planning to firebomb his own theater during the charity event. Bill releases Kent for his cooperation. Agatha goes to the theater for the charity event. Sykes switches on the firebomb. Bill searches for the firebomb in the theater.

FCL

Janet convinces Sykes to participate in her plan to kill Agatha by convincing him that if he participates, he will be able pay off his gambling debts. Kent takes a bomb to the Hollywood Theater and meets with Sykes. Sykes purchases the firebomb. Bill arrests Kent. Bill coaxes Kent to give information in exchange for releasing him. Agatha goes to the theater for the charity event. Sykes sets the timer of the firebomb to explode during the charity event. Sykes switches on the firebomb. Bill searches for the firebomb in the theater.

Figure A.17: *Sjuzhets* Produced from *Fabula* C for the portion before suspense mesaured

Figure A.18: First Page of Web Survey Interface

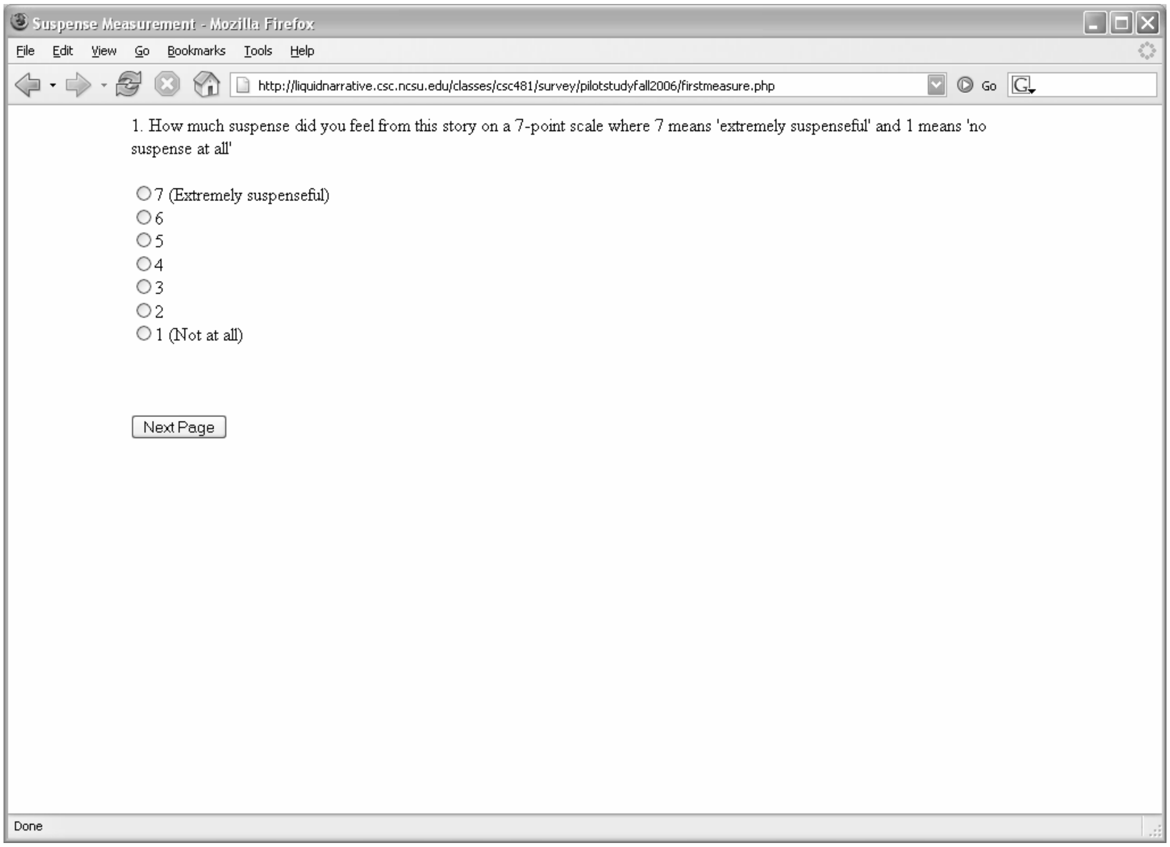


Figure A.19: Second Page of Web Survey Interface Which Measures the Suspense Level that the Reader Feel

Figure A.20: Third Page of Web Survey Interface Showing the Story after the Suspense Level Measurement point

A.4 Evaluation Materials for the Experiment

The lunatic supervillian known as Jack has been developing biological weapons of devastating proportions. To accomplish the final stages of weapon development, he kidnapped the famous scientist, Dr. Cohen, and brought him to his private fortress on Skeleton Island. Jack expected that the FBI would soon send Smith, their top agent, to rescue Dr. Cohen. To keep the troublesome Smith out of his hair, Jack ordered his own agent, Erica, to monitor Smith and capture him if he is assigned to Dr. Cohen's rescue operation.

FAW

Erica eavesdrops on the phone conversation in which Smith is given the order to rescue Dr. Cohen. Erica tells Smith that her father was kidnapped by Jack and taken to Skeleton Island, and she asks Smith to save her father. Erica gives Smith the blueprints of Jack's fortress, with her father's cell marked. Smith goes to the port containing Erica's boat. Smith rides the boat to Skeleton Island. Smith sneaks into the cell marked on the map containing Erica's father. Jack and his guard capture Smith as he enters the cell. The guard locks Smith into the cell. *Smith sneaks to the lab where Dr. Cohen is captured. Smith fights the guards in the lab.*

FAH

Erica tells Smith that her father was kidnapped by Jack and taken to Skeleton Island, and she asks Smith to save her father. Erica provides Smith with a boat for transportation to Skeleton Island. Before going to the island, Smith hides a diamond in his shoe. Smith rides the boat to Skeleton Island. Smith sneaks into the cell marked on the map containing Erica's father. Jack and his guard capture Smith as he enters the cell. The guard disarms Smith. The guard locks Smith into the cell. *Smith bribes the guard with the diamond in his shoe. The guard unlocks the door. Smith leaves the cell. Smith sneaks to the lab where Dr. Cohen is captured. Smith fights the guards in the lab. Smith takes Dr. Cohen from the lab.*

FAL

Erica installs a wiretap in Smith's home while he is away. Erica meets with Smith. Erica gives Smith the blueprints of Jack's fortress, with her father's cell marked. Before going to the island, Smith hides a diamond in his shoe. Smith goes to the port containing Erica's boat. The guard disarms Smith. *Smith bribes the guard with the diamond in his shoe. The guard unlocks the door. Smith leaves the cell. Smith takes Dr. Cohen from the lab. Smith and Dr. Cohen ride the boat to shore.*

Figure A.21: *Sjuzhets* Produced from *Fabula* A: Italicized sentences are the portion after suspense was measured.

In 2020 mankind faces severe environmental problems. The process of desertification has spread to North America, and shrinking glaciers have raised the sea level significantly. An environmentalist named Mr. Greenpeace, head of the biggest environmental foundation in the world, is aware of these urgent problems, and plans to persuade the U.S. President to take prompt action to prevent disaster. Meanwhile, a rich villain named Dr. Evil is planning to assassinate the President. His plans are complicated by the security in place at the White House, where only people with invitations can enter. In a nearby suburb of Washington, a man named Tom, who is the father of a six-year old boy named Ben, is hoping to give his son a Christmas present. Unfortunately, Tom is too poor to buy Ben a Christmas present. Tom has a shiny silver ring that was given to him by his wife. Unknown to Tom, the ring is magical; when worn, the ring can send out a magical pulse that will knock out anyone within a ten foot radius. Tom's goal is to get a toy for Ben's Christmas present; Tom knows that Dr. Evil has a toy that he's willing to trade for Tom's ring.

FBW

Dr. Evil watched the TV and found out that a donation would get him invited to the White House. The President invited Dr. Evil to the fund-raising celebrating event. Tom traded his ring for Dr. Evil's toy; as a result, Tom obtained the toy that Ben wanted and Dr. Evil obtained the ring. Dr. Evil withdrew enough cash from his account to buy a gun and to register for a hypnosis class. Dr. Evil bought a gun. Dr. Evil registered for a hypnosis class to learn how to hypnotize people by waving a shiny object before their eyes. Dr. Evil took a hypnosis class; as a result, he knew how to hypnotize people by waving a shiny object before their eyes. Dr. Evil used the ring of power to put all the Secret Service agents to sleep; as a result, there was no one guarding the president. Mr. Greenpeace traveled to the White House. Dr. Evil fired his gun at the President.

FBH

Mr. Greenpeace gave a speech about the importance of taking action immediately to save the world. Dr. Evil donated a million dollars to the White House. The President invited Dr. Evil to the fund-raising celebrating event. The President gave the promised government financial support to Mr. Greenpeace's foundation. Tom traded his ring for Dr. Evil's toy; as a result, Tom obtained the toy that Ben wanted and Dr. Evil obtained the ring. Dr. Evil withdrew enough cash from his account to buy a gun and to register for a hypnosis class. Dr. Evil bought a gun. Dr. Evil used the ring of power to put all the Secret Service agents to sleep; as a result, there was no one guarding the president. Mr. Greenpeace traveled to the White House. Dr. Evil fired his gun at the President. *At the last moment, Mr. Greenpeace rescued the President by pushing him out of the way.*

FBL

Mr. Greenpeace traveled from the Amazon to the Capitol. Mr. Greenpeace gave a speech about the importance of taking action immediately to save the world. The President announced that he would raise funds to support Mr. Greenpeace's environmental foundation and whoever donated more than a million dollars would be invited to the White House for a fund-raising celebration party. Dr. Evil watched the TV and found out that a donation would get him invited to the White House. Dr. Evil donated a million dollars to the White House. The President gave the promised government financial support to Mr. Greenpeace's foundation. Tom put the toy under the Christmas tree. The next day on Christmas, Ben found his Christmas present--the toy that Tom left. Dr. Evil withdrew enough cash from his account to buy a gun and to register for a hypnosis class. *At the last moment, Mr. Greenpeace rescued the President by pushing him out of the way.*

Figure A.22: *Sjuzhets* Produced from *Fabula* B: Italicized sentences are the portion after suspense was measured.

Sykes is the owner of the Hollywood Theater, which was once prosperous but has now become dilapidated and is in need of major renovations. Sykes has accrued a sizable gambling debt, and with his theater in shambles, he has no means with which to pay it back. He is constantly threatened by his crooked debtors. Janet is a famous actress with dreams of winning an Oscar, an acting award. She is jealous of the actress Agatha, who is her contender for the Oscar this year and also is well-known for her active involvement in charity. Janet knows a number of scoundrels including a guy named Kent, a bomb dealer, and the theater owner Sykes. Agatha is in love with Bill, who serves as a lieutenant in the Los Angeles Police Department's Serious Crime squad. Janet knows that Agatha is planning to go to the Charity Bazaar for the Poor to be held in Hollywood Theater. To ensure that she will win the Oscar, Janet plans to kill Agatha during the charity event.

FCW

Janet and Sykes plan to burn down Sykes' theater to get the insurance money and kill Agatha during the charity bazaar. Janet gives Kent's contact information to Sykes and informs him of Kent's expertise with firebombs. Kent takes a bomb to the Hollywood Theater and meets with Sykes. Sykes purchases the firebomb. Sykes installs the firebomb.Kent informs Bill that Sykes is planning to firebomb his own theater during the charity event. Agatha goes to the theater for the charity event. Sykes sets the timer of the firebomb to explode during the charity event. Sykes switches on the firebomb. Bill searches for the firebomb in the theater. *Bill defuses the firebomb.*

FCH

Kent takes a bomb to the Hollywood Theater and meets with Sykes. Sykes purchases the firebomb. Sykes installs the firebomb. Bill arrests Kent. Kent informs Bill that Sykes is planning to firebomb his own theater during the charity event. Bill releases Kent for his cooperation. Agatha goes to the theater for the charity event. Sykes sets the timer of the firebomb to explode during the charity event. Sykes switches on the firebomb. Bill searches for the firebomb in the theater. *Bill defuses the firebomb. Agatha participates in the charity event.*

FCL

Janet convinces Sykes to participate in her plan to kill Agatha by convincing him that if he participates, he will be able pay off his gambling debts. Sykes borrows some money from the bank by mortgaging his theater. Sykes buys insurance to cover his loss in case of a fire. Janet gives Kent's contact information to Sykes and informs him of Kent's expertise with firebombs. Kent takes a bomb to the Hollywood Theater and meets with Sykes. Sykes purchases the firebomb. The lieutenant, Bill, issues a warrant permitting the arrest of Kent for his illegal weapons dealing. Bill coaxes Kent to give information in exchange for releasing him. Bill releases Kent for his cooperation. *Agatha participates in the charity event.*

Figure A.23: *Sjuzhets* Produced from *Fabula* C: Italicized sentences are the portion after suspense was measured.

Pre-Experiment Questionnaire

Please complete the following list of questions.

You may choose to NOT answer any of the following questions by selecting No response.

1. Name in full:

2. Gender:
   - Female
   - Male
   - No response

3. Age Group:
   - 18-19
   - 20-24
   - 25-29
   - 30-34
   - 35-39
   - 40-49
   - 50+
   - No response

4. Race:
   - American Indian or Alaska Native
   - Asian
   - African American
   - Hispanic or Latino
   - Native Hawaiian or Other Pacific Islander
   - White
   - No response

5. Major:

Figure A.24a: Pre-Experiment Questionnaire

6. Year in School:

- Freshman
- Sophomore
- Junior
- Senior
- Master
- PhD
- Other
- I'm not a student
- No Response

7. Language:

- English as a native language
- English as an official language in your country
- English as a foreign language
- No response

8. How often do you watch a movie, either at home or at a movie theater?

- More than once a week
- More than once a month
- Seldom
- No response

Next Page

Figure A.25b: Pre-Experiment Questionnaire

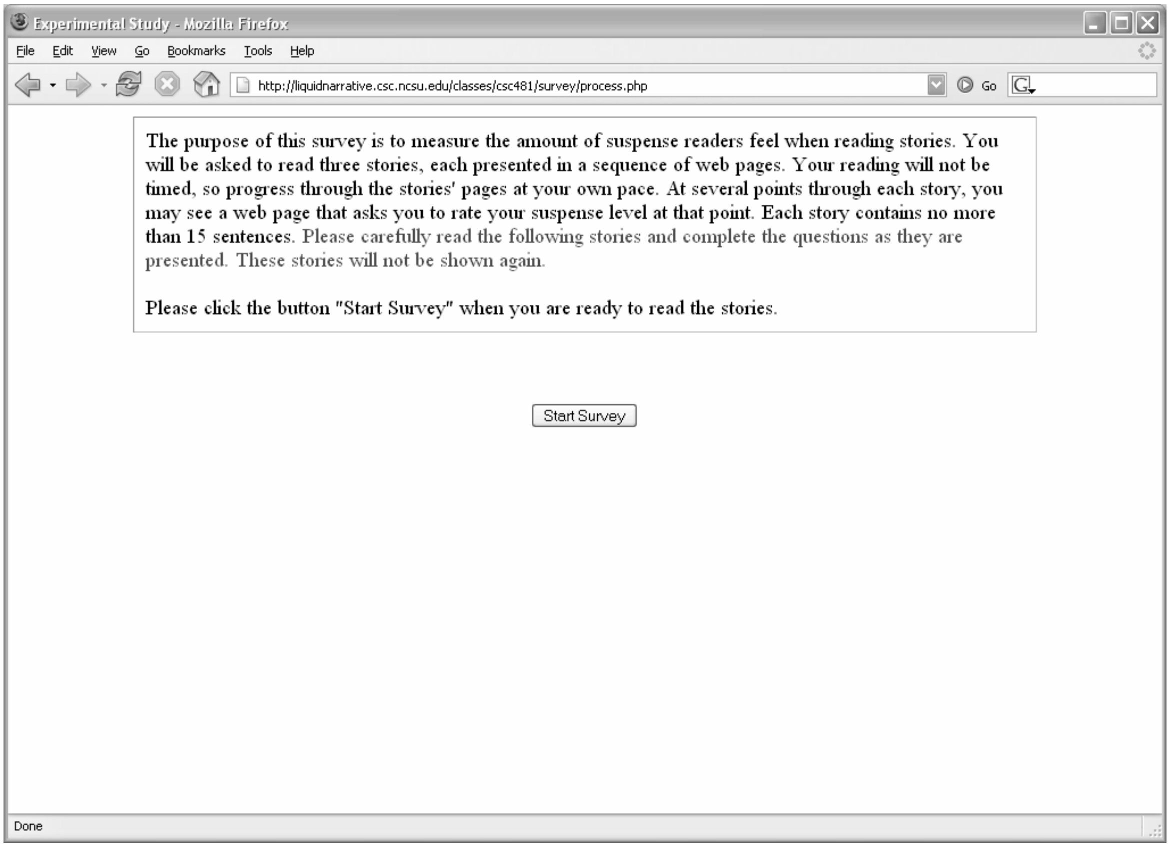


Figure A.26: First Page of Survey

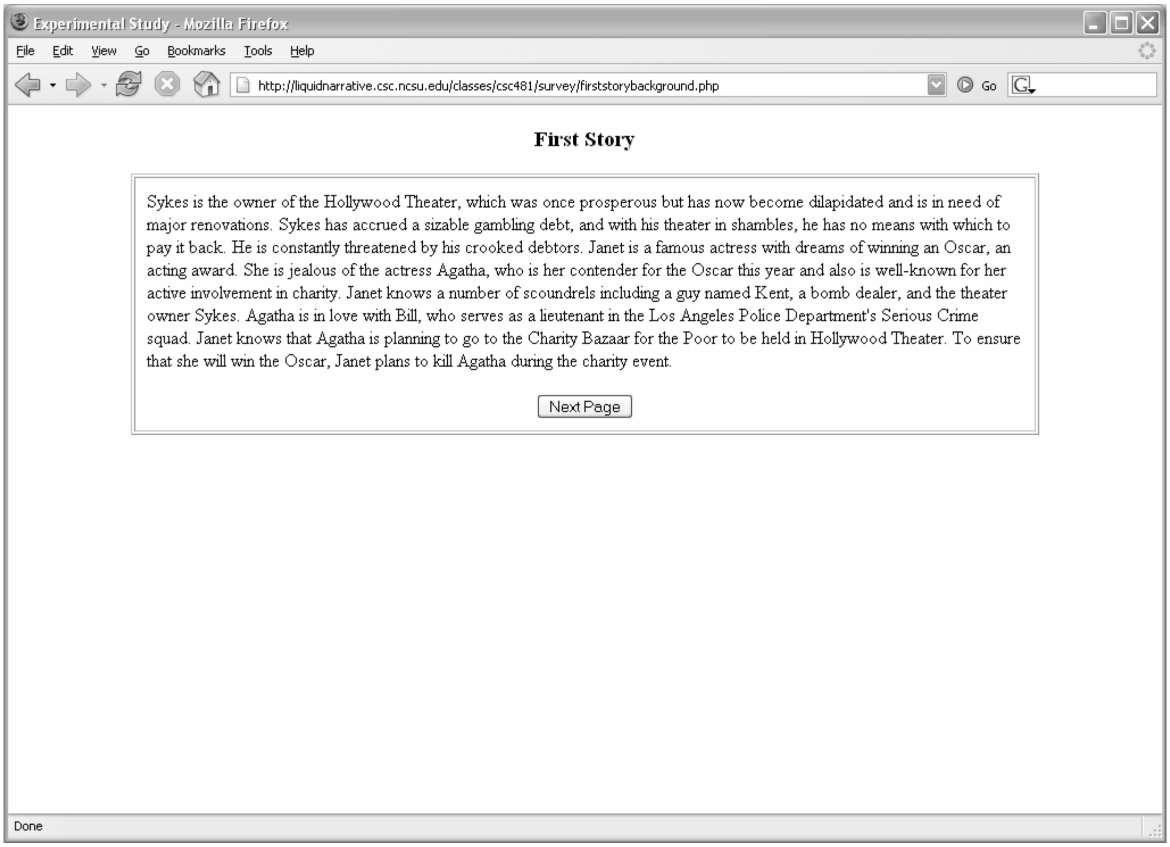


Figure A.27: First Story Background

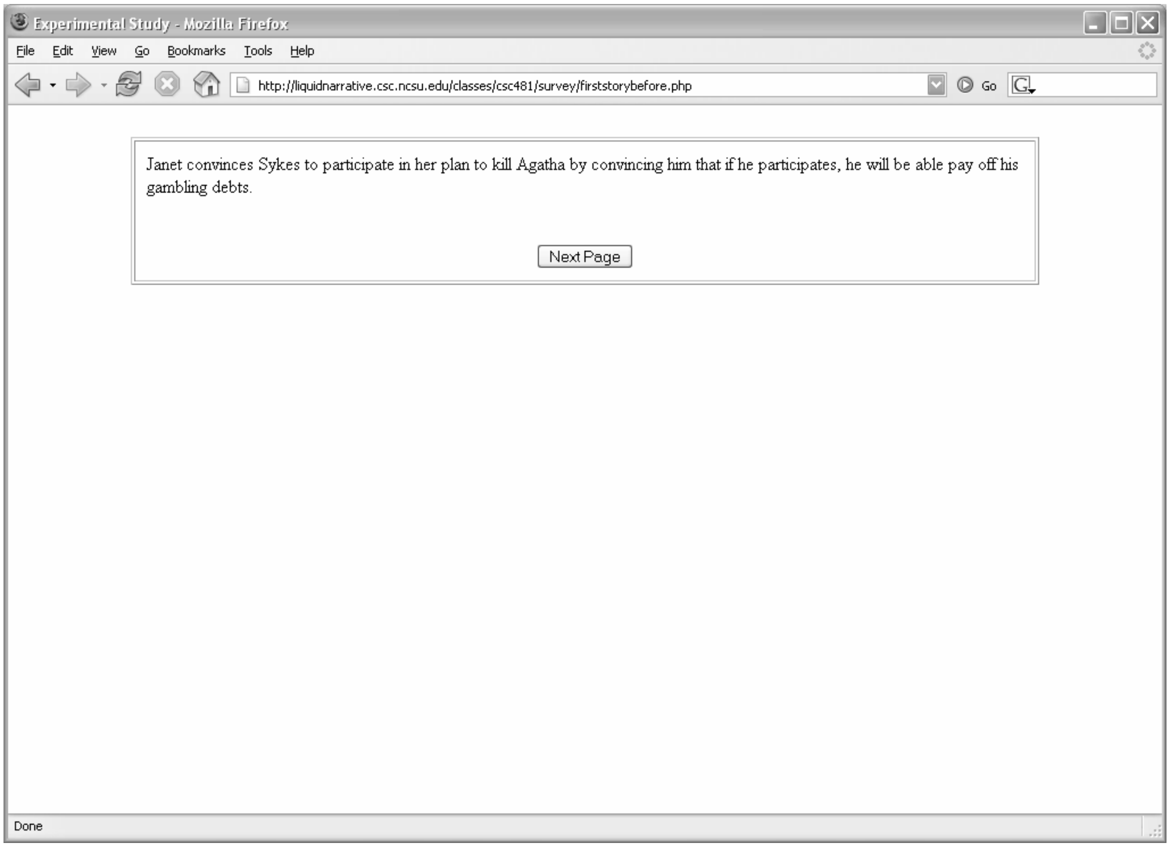


Figure A.28: Story Shown sentence by sentence

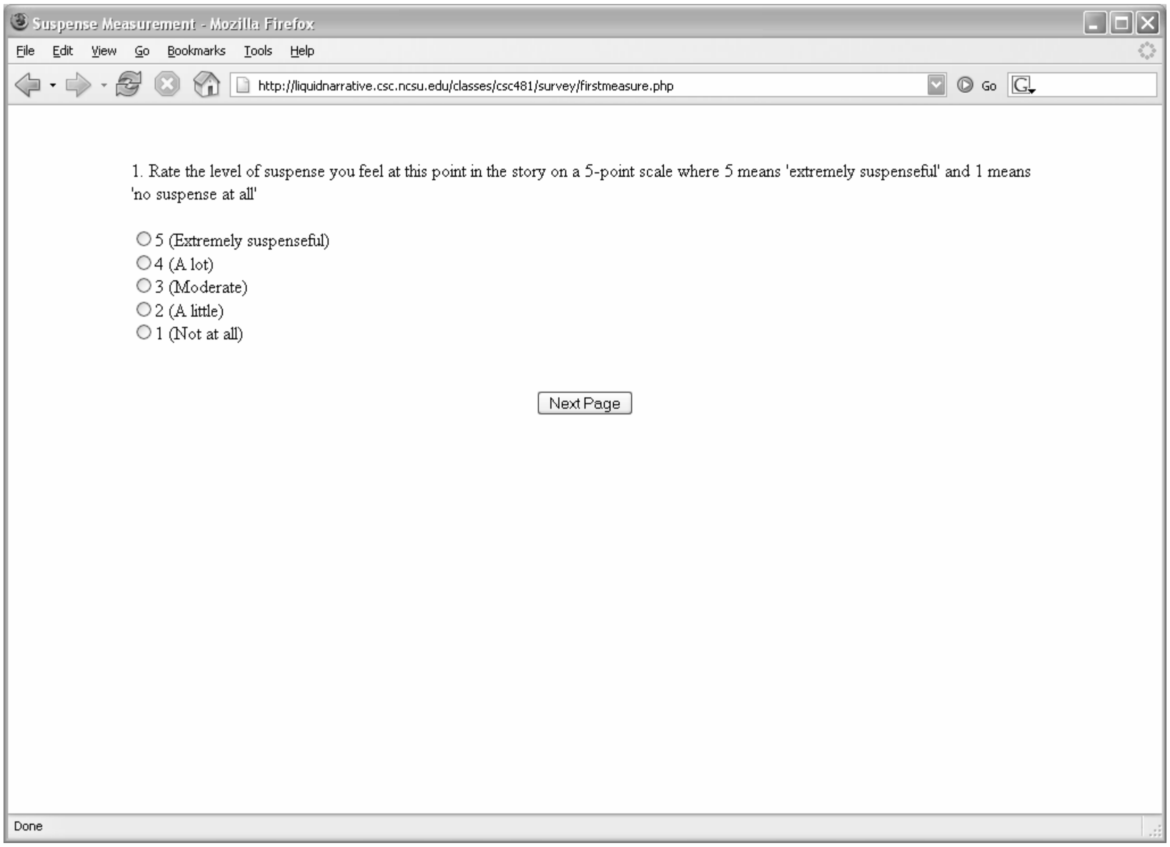


Figure A.29: Page for Measuring Suspense

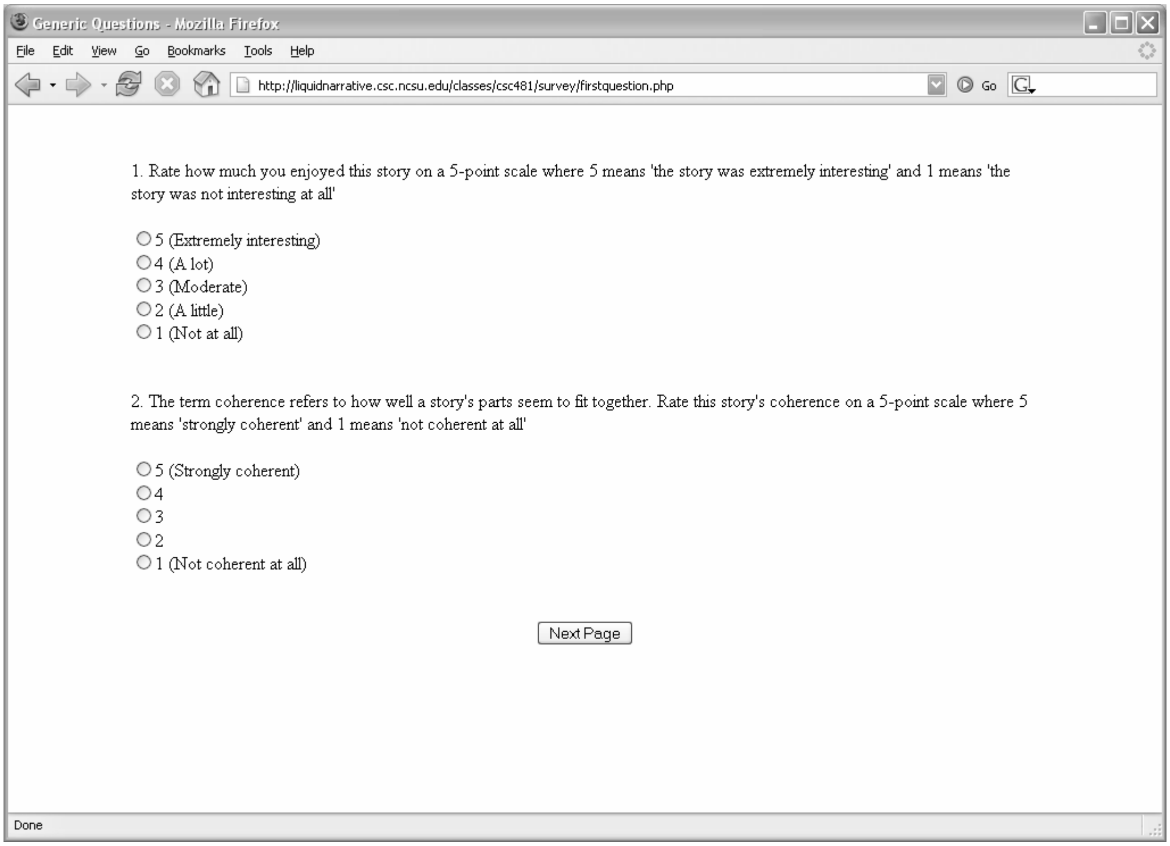


Figure A.30: Page for Generic Questions

Post-Experiment Questionnaire

Please complete the following list of questions. You may choose to NOT answer any of the following questions by skipping those questions. But please make sure to click 'Done' button when you leave this page.

1. Please provide a brief description of what is suspenseful to you. How would you describe stories that are suspenseful compared to stories that are not?

2. Please write any suggestions about the story.

3. Please write any suggestions about the how you think the experiment could be improved.

Done

Figure A.31: Post-Experiment Questionnaire