Good Timing for Computational Models of Narrative Discourse*

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Abstract

The temporal order in which story events are presented in discourse can greatly impact how readers experience narrative; however, it remains unclear how narrative systems can leverage temporal order to affect comprehension and experience. We define structural properties of discourse which provide a basis for computational narratologists to reason about good timing, such as when readers learn about event relationships.

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1 Introduction

Narratologists frequently recognize that the temporal order in which story events are presented can greatly impact how readers comprehend narrative [6, 3, 1]. For example, readers usually notice when events are not presented in a possible storyworld chronology (e.g. flashbacks). Moreover, psychologists show that rearranging the order of events, while still presenting events in a possible storyworld chronology, affects how readers interpret narrative [13, 15, 14, 7]. Storytelling decisions about when readers should learn about event relationships have not received the same level of attention by narratologists compared to devices like flashback or flashforward. Computational narratologists interested in accounting for storytelling decisions about timing may benefit from encoding the relationship between temporal order of events in discourse presentation and comprehension in readers.

Our position is motivated by psychology research which demonstrates that rearranging events, while still presenting them in a possible storyworld chronology, affects how readers understand discourse. Consider an important event that has multiple relevant outcomes in a story. The order that readers learn about the outcomes can affect whether each outcome is interpreted as a direct result versus a side effect of the important event [13, 8]. Similarly, consider a situation where multiple antecedent events must occur for an outcome to occur. When readers think counterfactually about the outcome, research shows that readers are biased by temporal order when attributing causal responsibility to antecedent events and do not consider all antecedents equally [15, 9, 14, 7]. We believe these kinds of situations are

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opportunities for storytellers to use good timing in nonlinear stories, but further evaluation is needed to predict more precisely how temporal order affects narrative experience.

Previous approaches for modeling narrative discourse presentation have not encoded in a general way how presentation ordering can affect inferences made by readers during comprehension. Computational models of reader comprehension used in narrative systems [10, 4, 11] simulate human reasoning to make decisions about narrative discourse presentation. These reader models are limited because they lack a simple underlying characterization of the ways that timing affects the reader's experience of the story. We believe that reader models can more accurately model narrative experiences like suspense and surprise by encoding the way reader comprehension is biased by temporal order.

In the work presented, we formally define structural properties of discourse which provide a basis for computational narratologists to reason about good timing in narrative discourse. This model clearly distinguishes the causal structure of story which drives comprehension [16, 5, 12] from the temporal properties of discourse. We believe that a formal approach that delineates causal structure from temporal discourse structure would greatly benefit experiment design investigating the role of timing on comprehension. If the effects of timing on comprehension were better understood, narrative analysis and generation systems could then account for good timing in an actionable way to interpret and produce interesting narrative experiences.

2 Story Structure

A conjunction of function-free ground literals is used to represent the state of the world, describing what is true and false in the story world. The initial state of the world contains the propositions that are initially true. Other states are established as the result of an event.

▶ **Definition 1** (Event). An *event* is a tuple $\langle P, E, V \rangle$ where P is a set of preconditions (literals that must be true before the event can be executed), E is a set of effects, literals made true by the event's execution, and V is a label which distinguishes the event.

▶ **Definition 2** (Causal Link). A *causal link* between two events s and t, denoted $s \xrightarrow{p} t$ indicates that s is an event which has effect p that enables a precondition p of event t. Event s is the *antecedent*, t is the *consequent*, and s and t are *causal partners*.

▶ **Definition 3** (Ordering Constraint). An *ordering constraint* of two events s and t denoted $s \prec t$ indicates that event s is *necessarily ordered* before event t.

Constraints are transitive: if $s \prec k$ and $k \prec t$, then $s \prec t$.

▶ **Definition 4** (Story Plan). A *story plan* Φ is a tuple $\langle S, O, L \rangle$ where S is a set of events, O is a set of ordering constraints over events in S, and L is a set of causal links over events in S.

A story plan is complete if and only if every precondition of every event is satisfied (by other events or by the initial state) and it is not possible that an event can occur between causal partners that reverses the effect of the antecedent enabling the consequent.

Figure 1 shows an example story plan which models a simplified sequence of events in the film *Indiana Jones and the Raiders of the Lost Ark*. Initially, Indiana Jones (IJ) and a Nazi (N) are fighting over a headpiece medallion (medal) which is embedded with the location of the Ark. During the fight, the medal is set on fire and becomes burning hot. The Nazi picks up the medal and his hand is burned, resulting in two outcomes. The first outcome is that

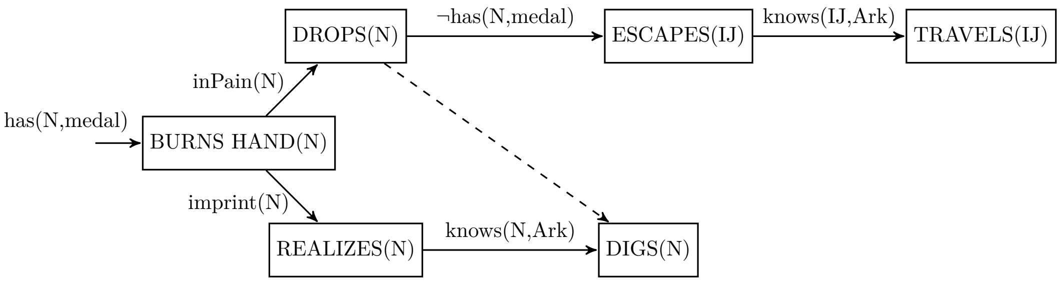

Figure 1 An example highly-simplified story plan of the Indiana Jones story. Ordering constraints are denoted by directed edges, with labeled edges indicating causal links.

the Nazi is in pain, causing him to drop the medal which enables Indiana Jones to escape with it and then travel to the Ark location. The second outcome is that the Nazi has the location from the medal imprinted into his hand. When he realizes this, he uses the location to choose a digging site.

3 Presentation Structure

The presentation of a story is a story plan where events are mapped to a total ordering in a sequential discourse structure.

▶ **Definition 5** (Presentation). A *presentation* Ψ is a tuple $\langle \Phi, T \rangle$ where $\Phi = \langle S, O, L \rangle$ is a story plan and T is a bijection function $T : S \rightarrow [1, ..., n]$ with $n = |S|$ mapping events in S to a total ordering in $\mathbb{N}$.

A presentation $\langle \Phi, T \rangle$ is complete if and only if the story plan Φ is complete and if $\forall u, v \in S,\ u \prec v \in O \implies T(u) < T(v)$.

▶ **Definition 6** (Temporal Adjacency). An event u is *temporally adjacent* to a causal partner v in a presentation Ψ if and only if $|T(u) - T(v)| = 1$.

▶ **Definition 7** (Intervening Discourse Event). An event v is an *intervening discourse event (IDE)* for causal link $s \xrightarrow{p} t$ in a presentation $\Psi = \langle \Phi, T \rangle$ where $\Phi = \langle S, O, L \rangle$ if and only if $v, s, t \in S$, $s \xrightarrow{p} t \in L$, and $T(s) < T(v) < T(t)$.

▶ **Definition 8** (Temporal Separation). An event u is *temporally separated* by separation size k from a causal partner v in a presentation $\Psi = \langle \langle S, O, L \rangle, T \rangle$ if and only if the number of IDEs for $u \xrightarrow{p} v$ is greater than k where $u, v \in S$ and $u \xrightarrow{p} v \in L$.

For simplicity, we do not encode differences between intervening discourse events such as the dimension of the situation [18, 2, 12], and therefore consider all events as equally weighted transitions of the world state.

In Figure 2, we show two presentations of the story plan from Figure 1. In Presentation A, a sequence resembling the order in the film, the events of Indiana Jones escaping with the medal (event 3) and traveling (event 4) are IDEs for causal link BURNS HAND $\xrightarrow{imprint}$ REALIZES. When these causal partners (events 1 and 5) are temporally separated, the consequent (event 5) may not be anticipated and perhaps will surprise the reader. However, in Presentation B, the same events BURNS HAND and REALIZES are temporally adjacent (events 1 and 2). This changes how the reader interprets the subsequent events, perhaps now anticipating that Indiana Jones will run into the Nazis at the Ark location.

The Indiana Jones Story
Init. The medallion is imprinted with the location of the Ark. The medallion is burning hot.
Presentation A. 1. The Nazi grabs the hot medallion and his hand is severely burned. 2. In pain, the Nazi drops the medallion. 3. Indiana Jones takes the medallion and escapes. 4. Indiana Jones travels to the destination indicated on the medallion. 5. The Nazi realizes the location from the medallion is imprinted onto his hand. 6. The Nazis dig for the Ark
Presentation B. 1. The Nazi grabs the hot medallion and his hand is severely burned. 2. The Nazi realizes the location is imprinted onto his hand. 3. In pain, the Nazi drops the medallion. 4. Indiana Jones takes the medallion and escapes. 5. Indiana Jones travels to the destination indicated on the medallion 6. The Nazi dig for the Ark.

Figure 2 Two presentations of the Indiana Jones story plan depicted in Figure 1.

The two presentations may elicit different narrative experiences because the temporal sequence affects the order that readers learn which events are *important*. A definition of causal importance, modeled as the number of incoming and outgoing causal connections of an event in a story plan, has proven effective at modeling human judgment [16, 17, 5, 4, 12]. Whenever a reader encounters a new event that has an antecedent in the story, the importance of that antecedent, from the reader's perspective, increases by virtue of the revealed causal connection. In the Indiana Jones Story, event 1 (BURNS) is the most important event in the story because it has two outgoing connections. In Presentation A, the reader does not learn of the event's importance until event 5, whereas in Presentation B, the event's importance is learned by event 3 which changes the context for interpreting the remaining events. In general, the timeline of when readers learn that events are more or less important may be a dimension of temporal discourse structure critical for characterizing narrative interpretation.

4 Summary

In the work presented, we provided a preliminary model with formally defined properties of story and discourse to act as a framework for reasoning about timing in narrative. One immediate application of our framework is that we can design experiments that tease out the effect of temporal order on comprehension and directly encode this with a computational model. This would enable generative systems to leverage timing in an actionable way for producing novel and more interesting experiences. Our framework currently captures only basic elements of story content and discourse timing to illustrate the relationship between causal structure and discourse presentation. The framework will be extended to identify relationships between discourse timing and other formally defined story content.

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