What killed the cat? Towards a logical formalization of curiosity (and suspense and surprise) in narratives

Florence Dupin de Saint-Cyr Anne-Gwenn Bosser Benjamin Callac Eric Maisel

31st International Symposium on Temporal Representation and Reasoning (TIME)
Montpellier, Oct. 28-30, 2024

Dramatic tension

[1]

- In a story, there's a very important thingy called dramatic tension.
- That means you don't let go of the action. You don't stop in the middle of your story to think.

[1] Heliotrope, tome 3 - "Le prix de mes larmes", Joann Sfar and Benjamin Chaud, 27 Septembre 2024, Dupuis, ISBN 9791034760404

Outline

1. Dramatic tension
2. Framework for analysing dramatic tension
3. Properties and graduality

Dramatic tension

Dramatic tension = 3 affects

According to [Baroni, 2007] 3 main ingredients:

- Curiosity: a crucial knowledge is omitted in the past or in the present
- Suspense: an impacting event can happen in the future
- Surprise: rupture from previous expectations

Other emotional mechanisms can also have an impact:

- Compassion/identification with a character of the story
- Familiarity with the universe of the story

Issues

- Dramatic tension affects $\Rightarrow$ narrative engagement [Baroni, 2007]
- Narrative engagement $\Rightarrow$ persuasion [Green and Brock, 2000]

$$\text{convince (rational)} \neq \text{persuade (emmotional)}$$

- Discourse analysis: Identifying the emotions of dramatic tension
  - Make explicit persuasion mechanisms and communication objectives
  - Encourage critical thinking
- Discourse generation (under constraints)

Narratology: the three levels

$$\text{Telling a story} = \begin{cases} 1. & \text{picking events/properties of the story} \\ 2. & \text{choosing when and how to tell them} \\ 3. & \text{with a communicative goal in mind} \end{cases}$$

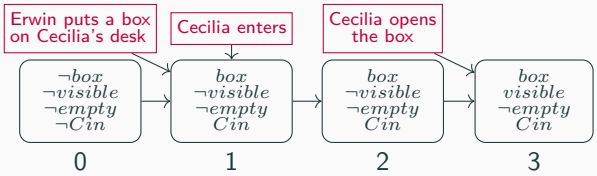
Discourse "*Cecilia enters her office. She sees a closed box lying on her desk that was not there when she last left the room.*"

Narratology: the three levels

Telling a story $=$
1. picking events/properties of the story
2. choosing when and how to tell them
3. with a communicative goal in mind

Discourse "*Cecilia enters her office. She sees a closed box lying on her desk that was not there when she last left the room.*"

Story



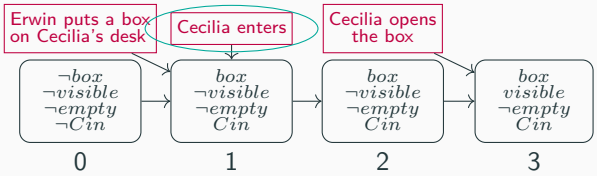
Narratology: the three levels

Telling a story = $\begin{cases} 1. & \text{picking events/properties of the story} \\ 2. & \text{choosing when and how to tell them} \\ 3. & \text{with a communicative goal in mind} \end{cases}$

Discourse "*Cecilia enters her office. She sees a closed box lying on her desk that was not there when she last left the room.*"

Narrative [Cecilia enters$_1$; box$_1$; $\neg$visible$_1$; $\neg$box$_0$]

Story



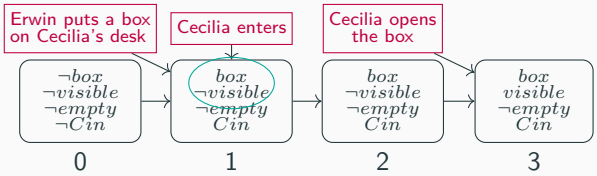
Narratology: the three levels

Telling a story = $\begin{cases} 1. & \text{picking events/properties of the story} \\ 2. & \text{choosing when and how to tell them} \\ 3. & \text{with a communicative goal in mind} \end{cases}$

Discourse "*Cecilia enters her office. She sees a closed box lying on her desk that was not there when she last left the room.*"

Narrative [Cecilia enters$_1$; box$_1$; $\neg$visible$_1$; $\neg$box$_0$]

Story



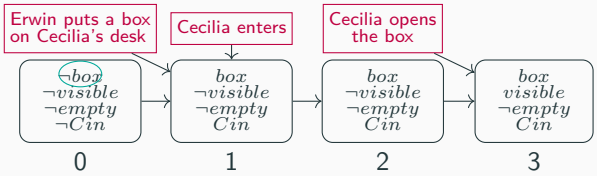
Narratology: the three levels

Telling a story = 1. picking events/properties of the story
2. choosing when and how to tell them
3. with a communicative goal in mind

Discourse "*Cecilia enters her office. She sees a closed box lying on her desk that was not there when she last left the room.*"

Narrative [Cecilia enters$_1$; box$_1$; $\neg$visible$_1$; $\neg$box$_0$]

Story



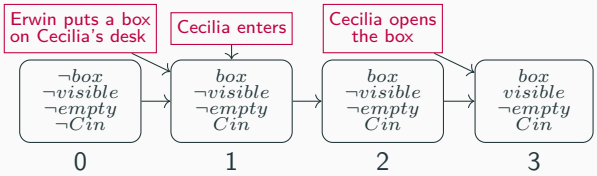
Narratology: the three levels

Telling a story = $\begin{cases} 1. & \text{picking events/properties of the story} \\ 2. & \text{choosing when and how to tell them} \\ 3. & \text{with a communicative goal in mind} \end{cases}$

Discourse "*Cecilia enters her office. She sees a closed box lying on her desk that was not there when she last left the room.*"

Narrative [Cecilia enters$_1$; box$_1$; $\neg$visible$_1$; $\neg$box$_0$]

Story



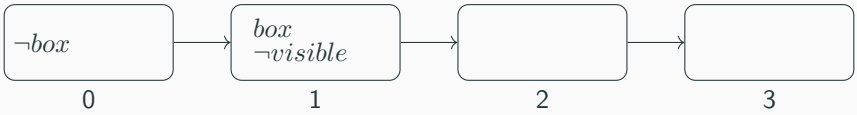
State of the art

- Suspense:
  - [Baroni, 2007] "primary" suspense = uncertainty about what happens next in the story
  - [Cheong and Young, 2015] with Suspenser = $\begin{cases} \text{planning the various narrative elements} \\ + \text{ maximize the suspense estimation} \end{cases}$
- Surprise:
  - [Shackle, 1961] surprise degree = impossibility degree of the event
  - [Dupin de Saint-Cyr and Prade, 2023] surprise in jokes: belief revision and defaults
- Curiosity ?

The box story

"Cecilia enters her office. She sees a closed box lying on her desk that was not there when she last left the room."

Assumption: this short story can create curiosity, suspense and surprise.



The box story: representation

- 3 agents only: Albert, Erwin and Cecilia
- Reasoning from the point of view of Cecilia

Actions	Fluents
• A : Albert, • E : Erwin } puts a closed box on Cecilia's desk • C : Cecilia opens the box	• box: there is a box on Cecilia's desk • $empty$: the box is empty • $visible$: Cecilia sees something in the box

- Close world assumption: no change unless one of the three actions is done

Framework for analysing dramatic tension

Epistemic state

- Dramatic tension affects depends on the beliefs and reasoning of the agent
- Restriction: we consider only the story level
- Epistemic state $S = (F, S_{\mathcal{L}}, S_{\Delta})$
- Example: Cecilia's epistemic state

Facts	Strict Rules	Defeasible Rules
$\neg box_0$	$(\neg box_t \wedge box_{t+1}) \rightarrow (A_t \vee E_t)$	$\neg visible_t \wedge C_t \wedge empty_t \rightsquigarrow \neg visible_{t+1}$
box_1	$(\neg visible_t \wedge visible_{t+1}) \rightarrow C_t$	$\neg visible_t \wedge C_t \rightsquigarrow visible_{t+1}$
$\neg visible_1$		$\neg box_t \wedge (A_t \vee E_t) \rightsquigarrow box_{t+1}$
		$\neg box_t \rightsquigarrow \neg box_{t+1}$
		$box_t \rightsquigarrow box_{t+1}$
		$\neg visible_t \rightsquigarrow \neg visible_{t+1}$
		$\vdots$

Awareness and epistemic state

Definition (awareness)

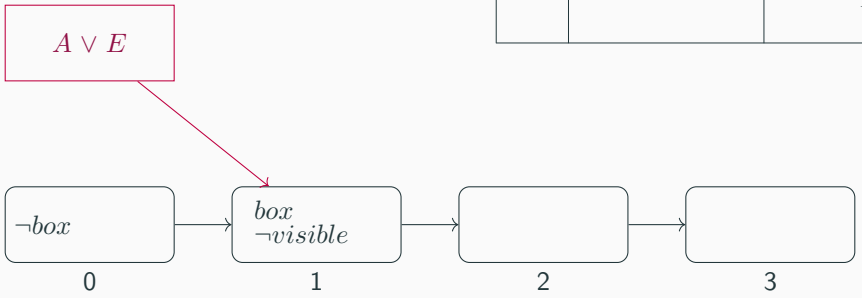
An agent, represented by its epistemic state $S = (F, S_{\mathcal{L}}, S_{\Delta})$,
is aware of variable $v \in \mathcal{V}$ if

- *v appears inside a fact formula of F or*
- *v appears inside a rule of $S_L \cup S_{\Delta}$ containing a variable the agent is already aware of.*

The box story (continued)

Facts	Stric Rules	Defeasible Rules	
$\neg box_0$	$(\neg box_t \wedge box_{t+1}) \rightarrow (A_t \vee E_t)$	$\neg visible_t \wedge C_t \wedge empty_t$	$\rightsquigarrow \neg visible_{t+1}$
box_1	$(\neg visible_t \wedge visible_{t+1}) \rightarrow C_t$	$\neg visible_t \wedge C_t$	$\rightsquigarrow visible_{t+1}$
$\neg visible_1$		$\neg box_t \wedge (A_t \vee E_t)$	$\rightsquigarrow box_{t+1}$
		$\neg box_t$	$\rightsquigarrow \neg box_{t+1}$
		box_t	$\rightsquigarrow box_{t+1}$
		$\neg visible_t$	$\rightsquigarrow \neg visible_{t+1}$
		$\vdots$	

Cecilia's epistemic state



- Cecilia's is aware of box and $visible$ hence given her beliefs she is aware of A, E, C, $empty$
- Cecilia can infer $A_0 \vee E_0$ from her beliefs

Curiosity

Definition (curiosity)

An agent with state S is curious about $\varphi \in \mathcal{L}$ at $t \in T$ if,

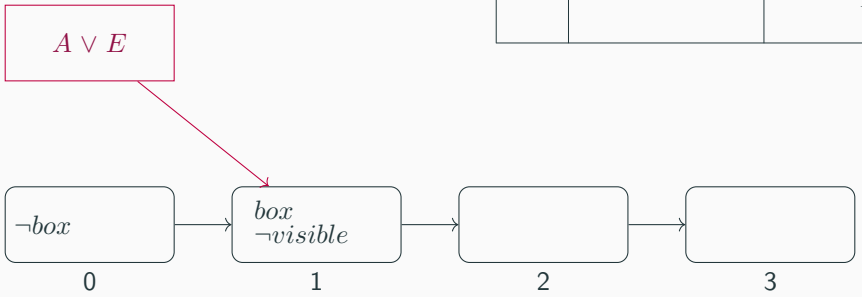
1. *according to $S_{\to t}$ (S until t) she is aware of (all variables of) φ and*
2. *at time t, she is unable to infer the value of φ:*
   - $\not\vdash_{S_{\to t}} \varphi$ *and*
   - $\not\vdash_{S_{\to t}} \neg\varphi$

$\vdash_S$ being the lexicographic non-monotonic inference operator based on the epistemic state S

Curiosity (example)

Facts	Strict Rules	Defeasible Rules	
$\neg box_0$	$(\neg box_t \wedge box_{t+1}) \rightarrow (A_t \vee E_t)$	$\neg visible_t \wedge C_t \wedge empty_t$	$\rightsquigarrow \neg visible_{t+1}$
box_1	$(\neg visible_t \wedge visible_{t+1}) \rightarrow C_t$	$\neg visible_t \wedge C_t$	$\rightsquigarrow visible_{t+1}$
$\neg visible_1$		$\neg box_t \wedge (A_t \vee E_t)$	$\rightsquigarrow box_{t+1}$
		$\neg box_t$	$\rightsquigarrow \neg box_{t+1}$
		box_t	$\rightsquigarrow box_{t+1}$
		$\neg visible_t$	$\rightsquigarrow \neg visible_{t+1}$
		$\vdots$	

Cecilia's epistemic state



- Cecilia is curious about who put the box there (A or $\neg A$?)
- Cecilia is curious about the content of the box ($empty$ or $\neg empty$?)

Suspense

Definition (suspense)

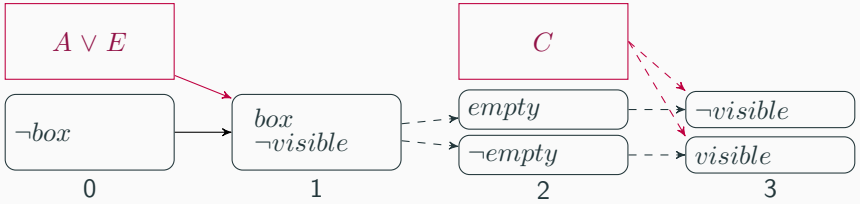
An agent in state $S = (F, S_{\mathcal{L}}, S_{\Delta})$ feels suspense about $\varphi \in \mathcal{L}$ at time point t if

- *according to S, the agent is curious about φ at time t and*
- *the agent is aware of a formula ψ consistent with S until t and*
- *ψ enables the agent to infer either φ or $\neg\varphi$ in $t' > t$*
  i.e., $\mid\!\sim_{S'} \varphi_{t'}$ or $\mid\!\sim_{S'} \neg\varphi_{t'}$ holds, with $S' = (F \cup \{\psi\}, S_{\mathcal{L}}, S_{\Delta})$.

Suspense (example)

Facts	Strict Rules	Defeasible Rules	
$\neg box_0$	$(\neg box_t \wedge box_{t+1}) \rightarrow (A_t \vee E_t)$	$\neg visible_t \wedge C_t \wedge empty_t$	$\rightsquigarrow \neg visible_{t+1}$
box_1	$(\neg visible_t \wedge visible_{t+1}) \rightarrow C_t$	$\neg visible_t \wedge C_t$	$\rightsquigarrow visible_{t+1}$
$\neg visible_1$		$\neg box_t \wedge (A_t \vee E_t)$	$\rightsquigarrow box_{t+1}$
C_2		$\neg box_t$	$\rightsquigarrow \neg box_{t+1}$
$visible_3$		box_t	$\rightsquigarrow box_{t+1}$
		$\neg visible_t$	$\rightsquigarrow \neg visible_{t+1}$
			$\vdots$

Cecilia's epistemic state



Cecilia feels suspense at time 1 about whether she will know if the box is empty or not

Surprise

Definition (surprise)

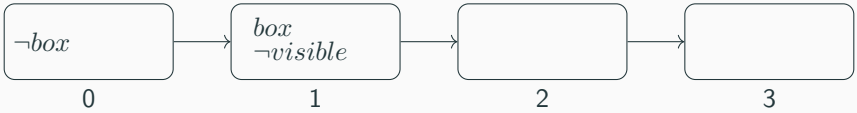
An agent represented by $S = (F, S_{\mathcal{L}}, S_{\Delta})$ is surprised at time t about a formula $\varphi \in \mathcal{L}$ if

1. $\varphi \in F_{\to t}$ *and* $S_{\to t}$ *is consistent (φ occurred and it was not impossible) but*
2. $S' = (F_{\to t-1}, S_{\mathcal{L}\to t}, S_{\Delta\to t})$ *is such that:* $\not\sim_{S'} \neg\varphi$ *(from $t-1$, $\neg\varphi$ was expected)*

Surprise (example)

Facts	Stric Rules	Defeasible Rules	
$\neg box_0$	$(\neg box_t \wedge box_{t+1}) \rightarrow (A_t \vee E_t)$	$\neg visible_t \wedge C_t \wedge empty_t$	$\rightsquigarrow \neg visible_{t+1}$
box_1	$(\neg visible_t \wedge visible_{t+1}) \rightarrow C_t$	$\neg visible_t \wedge C_t$	$\rightsquigarrow visible_{t+1}$
$\neg visible_1$		$\neg box_t \wedge (A_t \vee E_t)$	$\rightsquigarrow box_{t+1}$
		$\neg box_t$	$\rightsquigarrow \neg box_{t+1}$
		box_t	$\rightsquigarrow box_{t+1}$
		$\neg visible_t$	$\rightsquigarrow \neg visible_{t+1}$
		$\vdots$	

Cecilia's epistemic state



Cecilia is surprised at time 1

Properties and graduality

Properties derived from the definitions

Propositions 1 & 2

No fact known
Only one most plausible interpretation
$\Rightarrow$ No curiosity nor suspense

Proposition 3

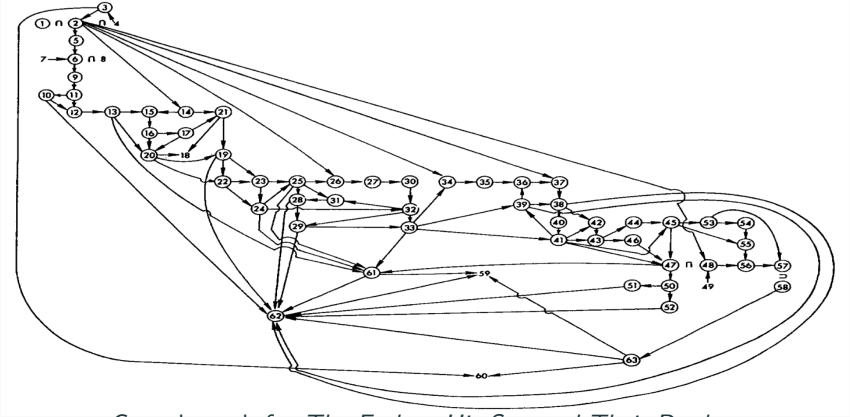
Surprise about φ at t $\Rightarrow$ No curiosity about φ neither at $t-1$ nor at t

Proposition 4

Deciding whether

- an agent is aware of a variable/formula is linear
- an agent is curious, feels suspense or surprise about a formula is P^{NP}-complete

Towards defining measures: importance of events



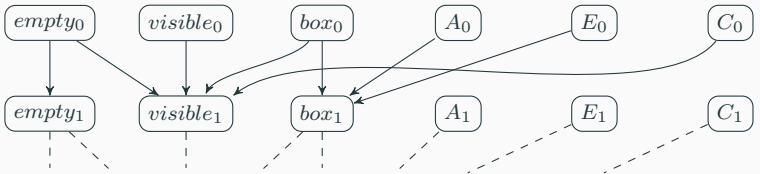
Causal graph for *The Father, His Son and Their Donkey*

The perceived importance of events in a story is related to the degree of the associated vertex in the causal graph [Trabasso and Sperry, 1985].

Towards defining measures: curiosity degree

Facts	Strict Rules	Defeasible Rules	
$\neg box_0$	$(\neg box_t \wedge box_{t+1}) \rightarrow (A_t \vee E_t)$	$\neg visible_t \wedge C_t \wedge empty_t$	$\rightsquigarrow \neg visible_{t+1}$
box_1	$(\neg visible_t \wedge visible_{t+1}) \rightarrow C_t$	$\neg visible_t \wedge C_t$	$\rightsquigarrow visible_{t+1}$
$\neg visible_1$		$\neg box_t \wedge (A_t \vee E_t)$	$\rightsquigarrow box_{t+1}$
		$\neg box_t$	$\rightsquigarrow \neg box_{t+1}$
		box_t	$\rightsquigarrow box_{t+1}$
		$\neg visible_t$	$\rightsquigarrow \neg visible_{t+1}$
		$\vdots$	

Cecilia's epistemic state



Causal graph induced by the epistemic state

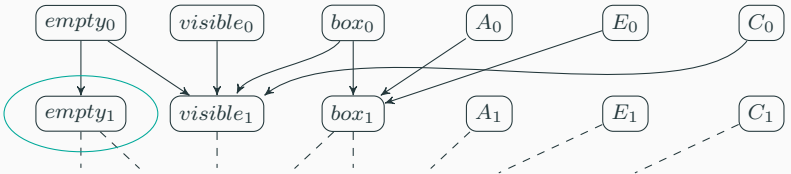
Definition (Curiosity intensity)

Curiosity degree(formula) = sum of its variable degrees in the causal graph

Towards defining measures: curiosity degree

Facts	Strict Rules	Defeasible Rules	
$\neg box_0$	$(\neg box_t \wedge box_{t+1}) \rightarrow (A_t \vee E_t)$	$\neg visible_t \wedge C_t \wedge empty_t$	$\rightsquigarrow \neg visible_{t+1}$
box_1	$(\neg visible_t \wedge visible_{t+1}) \rightarrow C_t$	$\neg visible_t \wedge C_t$	$\rightsquigarrow visible_{t+1}$
$\neg visible_1$		$\neg box_t \wedge (A_t \vee E_t)$	$\rightsquigarrow box_{t+1}$
		$\neg box_t$	$\rightsquigarrow \neg box_{t+1}$
		box_t	$\rightsquigarrow box_{t+1}$
		$\neg visible_t$	$\rightsquigarrow \neg visible_{t+1}$
		$\vdots$	

Cecilia's epistemic state



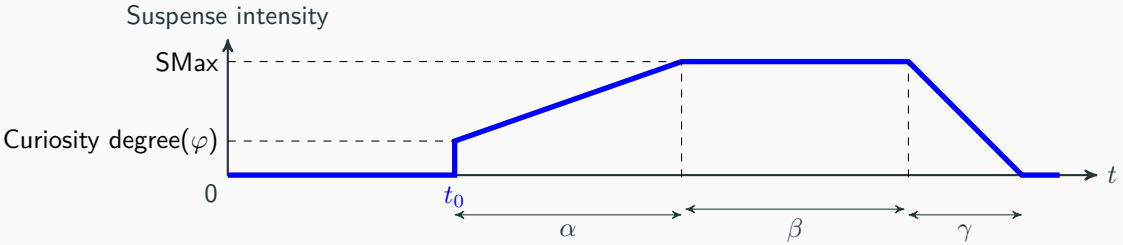
Causal graph induced by the epistemic state

Definition (Curiosity intensity)

Curiosity degree(formula) = sum of its variable degrees in the causal graph

Example: Curiosity degree($empty_1$) =3

Towards defining measures: Suspense intensity



Definition

Given an epistemic state $S = (F, S_{\mathcal{L}}, S_{\Delta})$ *and a suspense profile* $p = (\alpha, \beta, \gamma, \mathrm{SMax})$

Without revival nor resolution, suspense degree(φ) follows the pattern

where t_0 *= earliest time where the agent was curious about* φ.

Surprise intensity

[Shackle, 1961] = degree of impossibility of φ

Definition (surprise intensity)

Given an epistemic state $S = (F, S_{\mathcal{L}}, S_{\Delta} = \Delta_1 \dots \Delta_n)$ *with a surprise about* φ

$$\textit{Surprise degree}(\varphi) = n - i$$

where i *is the most specific strata with a rule violated by* φ

Conclusion

Conclusion

- Preliminary study
- Framework for formalizing the emotions at the heart of dramatic tension
- Unified framework for the 3 emotions: curiosity, suspense and surprise + their relationships
- Framework built on non-monotonic reasoning (NMR)
  - Compact language for simulating default reasoning of an agent under incomplete information
  - NMR (lexicographic inference) induces a cost in complexity: problems in P^{NP}
  - Measures of intensity for the three affects

Future work

- Discourse analysis
  - Implement this model in different frameworks:
    PDDL [Ghallab et al., 1998] Ceptre [Martens, 2015] TouIST [Slimane et al., 2015]
  - Find benchmarks of stories annotated with emotions
  - Integrate the three levels (discourse, narrative sequence, story)
  - Extend to other emotions in OCC theory
    [Ortony et al., 1988, Lorini and Schwarzentruber, 2011, Adam et al., 2009]
  - Build causal graphs associated to stories (narrative closure)
  - ▶ DEMA^{2}IN project: deconstructing affective and argumentative persuasion mechanisms in digital influence campaigns
- Discourse generation
  - Adaptation to the user
  - Interactive storytelling: maintain both causal and affective coherence

References

Adam, C., Herzig, A., and Longin, D. (2009).
A logical formalization of the OCC theory of emotions.
Synthese, 168(2):201–248.

Baroni, R. (2007).
La tension narrative: suspense, curiosité et surprise.
Poétique. Éd. du Seuil, Paris.

Cheong, Y.-G. and Young, R. M. (2015).
Suspenser: A Story Generation System for Suspense.
IEEE Transactions on Computational Intelligence and AI in Games, 7(1):39–52.

Dupin de Saint-Cyr, F. and Prade, H. (2023).
Belief revision and incongruity: Is it a joke?
Journal of Applied Non-Classical Logics, 33(3-4):467–494.

Ghallab, M., Howe, A., Knoblock, C., McDermott, D., Ram, A., Veloso, M., Weld, D., and Wilkins, D. (1998).
PDDL – the planning domain definition language.
AIPS-98 Planning Competition Committee CVC TR-98-003/DCS TR-1165, Yale Center for Computational Vision and Control.

Green, M. and Brock, T. (2000).
The Role of Transportation in the Persuasiveness of Public Narrative.
Journal of personality and social psychology, 79:701–21.

Lorini, E. and Schwarzentruber, F. (2011).
A logic for reasoning about counterfactual emotions.
Artificial Intelligence, 175(3):814–847.

Martens, C. (2015).
Ceptre: A language for modeling generative interactive systems.
In *Proceedings of the AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment*, volume 11, pages 51–57.

Ortony, A., Clore, G. L., and Collins, A. (2022 (original work published 1988)).
The cognitive structure of emotions.
Cambridge university press.

Shackle, G. L. S. (1961).
Decision, Order and Time in Human Affairs.
(2nd edition), Cambridge University Press, UK.

Slimane, K. S. B., Comte, A., Gasquet, O., Heba, A., Lezaud, O., Maris, F., and Valais, M. (2015).
Twist your logic with ToulST.
CoRR, abs/1507.03663.

Trabasso, T. and Sperry, L. L. (1985).
Causal relatedness and importance of story events.
Journal of Memory and Language, 24(5):595–611.