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Towards Narrative-Based Knowledge Representation in Cognitive Systems

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Abstract

The hypothesis according to which narrative is not only a prominent form of human communication but also a fundamental way to represent knowledge and to structure the mind has been limitedly but increasingly discussed for the last 40 years. However, in the realm of Artificial Intelligence, it did not lead to an elaborate model of knowledge representation, beyond scripts and cases. In this paper, we attempt to go further by identifying three differentiating features of narratives that may inspire novel forms of knowledge representation: transformation, conflict and unactualized events. In particular, these three features open the way for knowledge representation formalisms that take greater account of the co-existence of intertwined conflicting representations, with various validities and validity domains, beyond a purely factual representation of the world.

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1 The narrative hypothesis in cognition

Cognitive science and narrative theory have developed separately, with limited dialogue between the 1950s and the 1990s, as illustrated by the absence of the entry "narrative" in the *MIT Encyclopedia of the Cognitive Sciences* [10]. These two large domains have both emerged from the need to combine various points of views from distinct disciplines with the goal of studying cognition and narrative respectively. Whereas cognitive science has covered psychology, neuroscience, epistemology, computer science and linguistics, narratology has covered literature studies, anthropology, sociology and linguistics.

However, from the 1990s the two "interdisciplines" have initiated a dialogue, in which two symmetrical directions of influence can be observed [10, 27]: How cognitive science could provide relevant models of narrative, in terms of reader's modeling (cf. cognitive narratology); and how narrative could provide relevant models of cognition, in terms of interpreting the world and reasoning about it. The focus of this article will be put on the latter, that is, the processing of information in narrative terms.

There has been extensive research on text comprehension, focusing on how a text, often a narrative text, is processed and represented as a mental structure. Such models include hierarchical decomposition via grammars [17, 36], a configuration of plot units —small patterns of affective states— [16], causal network [37], and many others. This body of research has focused exclusively on structures that represent a narrative discourse provided as a text.

In contrast, J. Bruner has significantly broadened the scope of narrative in his influential article: "The narrative construction of reality" [6]. In this paper, Bruner argues that in order to make sense of human interaction, our mind needs to be narratively structured:


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"we organize our experience and our memory of human happenings mainly in the form of narrative". For Bruner, narrative is not discussed as a prominent universal form of human communication but as a form of knowledge representation for a large class of situations in the world, not just storytelling situations per se. In this vein, D. Herman states in his search for a "Story Logic" within the human mind: "narrative constitutes a logic in its own right, providing human beings with one of their primary resources for organizing and comprehending experience" [11]. However, in the rest of the discussion, Herman tends to step back to the understanding of narrative discourse, as does his subsequent book entitled "Story Logic" [11]. R. Schank adopts a wider scope when stating that "stories about one's experiences, and the experiences of others, are the fundamental constituents of human memory, knowledge, and social communication" [29], in the sense that any experience would be coded as stories, not as facts. We concern with such a larger view stating that narrative is a logic for structuring the experience in general, not just story-like inputs. In other words, from our point of view, it is worth studying whether a non-narrative text or a non-narrative experience is still processed in a narrative way. If a cognitive system such as the human mind tends to construct a narrative from any real-life experience, then the story structures evoked above in the domain of narrative text comprehension would be candidate for a general knowledge representation approach in cognition. Finally, while Bruner appears to focus on the "messy domain of human interaction", we propose to discard such a restriction and claim that narrative is a way to understand a still larger class of phenomena. In particular, by the effect of personification, many objects and events can be attributed two fundamental properties of narrative: character and intention [26]. Importantly, a narrative-based representation is not static but possibly ongoing long after the exposure of stimuli, in an attempt to reconstruct one or more representations that fit the experience.

In the rest of the paper, we call the hypothesis that narrative should be used to interpret a large class of real-world happenings **the narrative hypothesis**. This hypothesis is speculative and has been criticized by M.-L. Ryan [27]. However, we are not convinced by her demonstration, because it postulates that narrative is the result of various abilities such as experiencing emotions, having a sense of chronological ordering, being able to infer causal relations. However, the narrative hypothesis states that these abilities do not come first but *with* narrative, as it will be detailed below. Based on the narrative hypothesis, we form two research questions:

1. Has the narrative hypothesis been used in the field of Artificial Intelligence (AI)?
2. If not, or not much, how and for what purpose should we use it?

Through these questions we tend to explore that if AI manages to draw valuable computational techniques from the narrative hypothesis then this hypothesis will acquire some validity and make narrative studies a genuine contributor to cognitive science.

2 AI for Narrative, Narrative for AI

In the field of AI, we are interested in the domain of Knowledge Representation (KR). Our question in this context is: Is there a KR technology that is based on the narrative hypothesis? R. Davis his colleagues [8] consider five different roles for any knowledge representation: 1) as a surrogate, 2) as a set of ontological commitments, 3) as a tool of reasoning, 4) as a medium for efficient computation and 5) as a medium of human expression. Therefore, our question is: Is there a KR that has, as a fundamental way to view the world, the narrative hypothesis (ontological commitment)?

A large variety of KR approaches have been proposed in cognitive science: rules, frames,

scripts [28], semantic nets, cases, conceptual graphs [31], etc.. Two of them have been found to share similarities with the narrative hypothesis: scripts and cases. As KR, scripts and cases contrast with logic-based approaches in the sense that they no longer consider reasoning solely as logic deduction process, but also as storage of stereotypical situations that embed a known solution. For *scripts*, this situation includes "a predetermined stereotyped sequence of actions" [28], which resembles a story. Schank and Abelson propose that our memory is constituted of many of these scripts. They guide our understanding of both narrative text and real-world events, by being first recognized as appropriate and then used (after possible adaptation) in the current situation. For *cases*, what is stored is not necessary a story-like structure as for scripts, but a problem-solution couple that corresponds to a case that has been successfully solved previously. Contrary to scripts, cases have been widely used in the field of AI to solve a large range of problems. However, scripts and cases cover minimally the notion of narrative. As Schank and Abelson state, "a script is, in effect, a very boring little story" [28]. Scripts share with narrative the idea of temporal succession and character, but the former lack many other features such as intention (stored outside the script), emotion, conflict, evaluation, and closure. In that sense, they do not constitute the narrative construction of reality called by Bruner [6]. Besides, there has been a significant increase in computational models of narrative research in the field of Interactive Storytelling since the late 1990's. With the goal of generating narratives (in various media including 3D worlds) or driving narrratively the experience in an interactive narrative such as an adventure video game, this field has produced a wide range of narrative models based on various narrative principles: Aristotelian/Freytagian tension curve [18], characters' intentions [2, 7], characters' emotions [2], audience's emotional response [32, 41], dilemma [3, 34], conflict [33, 40], causality [22, 24], etc. Although these models of narrative were not conceived as models of cognition, we raise the question whether some of them, once adapted, could play such a role.

In the rest of the paper, we will explore this possibility by first defining more precisely the requirements for a narrative-based KR and then by proposing some routes for such a model.

3 From knowledge to stories... or reverse!

Before studying the requirements for a narrative-based KR, it is necessary to precise our viewpoint regarding the positioning of narrative in terms of level of processing. From a cognitive perspective, the ability to process narratives has often been considered as a high level feature of cognition. For example, in early structuralist narratology, narrative goes "beyond the sentence" and constitutes a "large sentence" [4], which implicitly means that one needs to be able to make and understand sentences (covered by the field of linguistics) before being able to make and understand narratives. In a totally different narratological tradition, Labov and Waletzky [14], studying oral narratives, define narrative as "one method for recapitulating past experience by matching a verbal sequence of clauses to the sequence of events which actually occurred". This definition presupposes that the events must initially happen and be stored before being later processed narratively, which is in contrast with the above-mentioned narrative hypothesis stating that narrative is the way the events are encoded. Finally, the question raised by the present conference "Can narrative be subsumed by current models of higher-level cognition, or does it require new approaches?" has positioned narrative as a higher-level cognitive phenomenon. We challenge this position in suggesting that, as a hypothesis, narrative should be a basic and primitive way to process and store information. While one tends to see narrative as made of characters, goals, values, etc.,

we suggest that the latter elements may be build as an outcome of a more fundamental and narrative-based representation. As Schank and Abelson put it in a somewhat extreme statement: "We propose that there is no factual knowledge as such in memory" [29]. This primacy of narrative is consistent with B. Victorri's views on the relation between linguistics and narrative [38]. He claims that language would be the result of narrative, making it possible for human beings to survive by recalling a past experience, which is contrary to the linguistics' point of view — narrative is considered to be a by-product of language and language is used to give true/false statements about the world. It is naturally out of the scope of this research to discuss such a hypothesis, but it illustrates that the "natural" ordering of things —first we represent objects and their relation and second we make a story out of it— may be an illusion.

From a computational point of view, AI comes from logic and symbolic reasoning. This has been intensively challenged by connectionism who raised the question on how these symbols appeared in the human mind with an emphasis on learning by the adjustment of continuously-valued units [30]. In our case, the logico-symbolic is criticized in a less radical way: we suppose that there exists an intermediate narrative representation between a simple episodic memory and higher-level symbols. In other words, instead of storing "the glass is on the table" that can be represented by various KR approaches, we would store a narrative representation stemming from the experience of putting a glass on a table and observing with surprise that it did not fall. Compared to Schank and Abelson position however, we are not claiming that "The mind can be seen as a collection of stories, collections of experiences one has already had" [29] because this intermediate narrative KR may be (and certainly is) an abstraction of these stories. This narrative representation may be closer to recent work on counterfactual reasoning [20]. In addition, it would be interconnected with other forms of representation, forming a hybrid representation/system, a known research domain in AI.

Back to interactive storytelling research, the absence of such an intermediate KR may explain why "Early on, artificial intelligence researchers showed that enormously complex linguistic and cognitive operations are required to generate or comprehend even the most minimal stories." [11, p. 1]. AI researchers may simply have used the wrong tools to generate stories in attempting to reconstitute them from symbolic factual descriptions of the world's entities, while they may have been advantageously described via on a more suited KR.

4 Narrative Features for KR

4.1 Approach

While we have identified the lack of a KR corresponding to the narrative hypothesis, the question of the utility of such a KR must be raised. In terms of the above-mentioned five roles identified by Davis and colleagues [8], two roles are missing: as a tool of reasoning and as a medium for efficient computation. That is, one needs to identify, from a computational point of view, which advantages would bring a narrative representation of the world. In the following parts, instead of proposing a fully specified KR approach, we investigate which narrative-specific feature of narrative could be used for building a narrative-based KR. J. Bruner argues that memory is structured narratively and enumerates ten features of narrative that he judges as particularly relevant to examine "how [narrative] operates as an instrument of mind in the construction of reality" [6]. D. Hermann, in his quest for "narrative as an instrument of mind" identifies "five ways stories scaffold intelligent behaviors" [12]: chunking experience, imputing causal relations, problem raising/solving, sequencing actions, distributing intelligence. Our approach is slightly different because we want to push

the narrative hypothesis further by targeting a specific and useful form of KR. Therefore we need to identify more precise narrative features. For instance, chunking experience and imputing causal relation are not specific to narrative. Similarly, sequencing of actions is not sufficient to characterize narrative, if we admit, with J.-M. Adam that a cooking recipe is not a story [1]. We are focusing in the following on three essential narrative features in hoping that they are the differentiating bedrocks for a future narrative-based KR.

4.2 Narrative transformation and Knowledge Acquisition

One of the fundamental characteristics of narrative is the transformation that underlies any story. Transformation is part of several definitions of narrative [1, 26]. This transformation concerns the heroes of the story and more importantly it concerns the audience as well. From the pragmatics' viewpoint, narrative is a form of discourse that carries a message from the author to the audience [1]. Experiencing a narrative is a form of knowledge acquisition, which is based on various strategies that include storage of story events in the episodic memory, transmission of factual information regarding the world (the fictional world is never totally disconnected from the real world), transmission of a moral viewpoint through the story's value system [13]. Therefore, a cognitive system using a narrative-based KR does not store knowledge solely as a static representation but as the transformation that leads to that knowledge. This is a fundamental change compared to traditional KR that aims at representing the world in a static and unambiguous manner. Conversely, relating a given knowledge to a past and possibly erroneous knowledge is in line with the constructivist epistemology. The constructivist epistemology states that if older knowledge may be false compared to newer knowledge, it is still valid and useful in restricted domains of validity —the classical example in the history of science being the Newtonian mechanics, invalidated by the theory of relativity, but still useful in everyday calculation. A narrative-based KR would be able to relate different pieces of knowledge, by linking newly acquired knowledge and previous knowledge that it is supposed to supersede. From an AI perspective, such a KR would allow not only to keep and use knowledge that is generally wrong but applicable within its domain of validity, but also to identify the domains of validity and invalidity via the stories attached to the successively acquired knowledge. This is related to the notion of context.

4.3 Dramatic conflict and cognitive conflict

Around the term "conflict", there is a striking similarity, at least in terminology, between narrative (drama in particular) and learning. In dramaturgy, conflict is recognized as a key mechanism of drama[1], a principle largely used within the screenwriting community, via the motto "All drama is conflict" [9, p. 24]. It is a term with a broad meaning, that may include antagonism between characters, physical (or external) obstacles, and internal dilemma [15, 19]. In constructivist learning theory, cognitive conflict plays a key role in bringing a learning subject to change his/her internal representation in order to accommodate new information from the world [21]. Cognitive conflict is an incompatibility between the subject's representations and new facts. The subject may reject the new fact because of the conflict or search for a new representation that would integrate the fact. Based on an analogy between these two conflicts, how could a narrative view on KR provide a suited

[1] This principle is sometimes wrongly attributed to Aristotle, but it rather seems to emerge in the XIXth century.

model for knowledge acquisition? There is no straightforward answer since the notion of conflict in narrative can be interpreted in various ways when it comes to implement it in a computational model [32, 39]. We will offer an initial level of answer with consideration of the following stereotypical proto-story: In a certain situation, character C wants to reach a goal G by attempting an action A that, according to his current knowledge, must lead to G. However, without any external intervention, action A leads to another situation and G is not reached. C is puzzled and looks for an explanation that he find later in the story. This story embeds an obstacle, a typical dramatic element that is a sort of dramatic conflict, maybe not the most interesting, and generates an emotional response: the surprise of the character as well as his disappointment, both leading to an emotional response of the audience, via the mechanism of empathy [35]. While this story falls below the sophistication of many simple stories, it is still more narrative than scripts as described above, since it embeds conflict and emotion. Furthermore, this story tells how certain knowledge has proven wrong and how it could be replaced by a new knowledge. A narrative-based KR could store the fundamental conflict of the above story within the acquired knowledge. Then, not only, as we discussed above, would the knowledge be supplemented with the previous knowledge it supersedes, but also would it embed the elements that characterize a conflicting situation between knowledge and the emotional valence attached to that situation. What is embedded is not the story itself (the sequence), but an abstraction that codes the core conflictual elements in the story. Such abstractions have been proposed in interactive storytelling research [3, 32, 5].

4.4 The disnarrated, the unactualized and the hypothetical reasoning

Because narrative is often defined as telling events that have certain characteristics, a dimension of narrative is often neglected: events that do not occur in the fabula or events that are not narrated, G. Prince called the latter the disnarrated [23]. It covers many types of events: ellipses, events that by their nature are difficult to tell [23], hypothetical events in possible worlds [25], counterfactual events, etc. In the above-mentioned epistemological point of view, some unactualized events correspond to what could have occurred if a given knowledge were true, while it did not occur because this knowledge was not true in this context. This is illustrated for example in the following excerpt: "The slightest breeze that ruffles the surface of the water makes you bow your heads, while I, the mighty Oak, stand upright and firm before the howling tempest."[2]. The following of the story proves this affirmation wrong. The disnarrated events and the unactualized events correspond in fact to an essential feature of the hypothetico-deductive scientific methodology: elaborating of an experimental setting where two results could occur with one validating the hypothesis and thus promoting a new knowledge and the other invalidating the hypothesis and leading to a status-quo. In the above proto-story, the unreached goal G is disnarrated or narrated in a conditional mode —the consequences of its reaching do not occur— but it is still part of the story. Therefore, this suggests that a narrative-based KR would naturally and natively include the disnarrated and unactualized events. For example, the knowledge formulated as a fact by "The earth is round" can be narratively represented by "A person travels straightforward to reach the end of the earth, but he does not reach this end. He finally reaches his starting point". Another example, the fact "birds fly with their wing" may be narratively represented by a story with a farmer clipping the wings of his chicken (although this example is misleading, since chicken cannot really fly). This is not a common way to

[2] From the Aesop's fable "The Oak and the Reeds".

represent knowledge in AI, but in addition to be more psychologically plausible, it may prove useful in knowledge-based systems to provide explanation of the outputs.

5 Conclusion, future work

Following the studies of J. Bruner, R. Schank and D. Hermann, we have explored how narrative could be viewed as a fundamental way to represent knowledge. Our goal is to go further in designing and implementing a computational model of narrative, not for processing narratives (generation or analysis) but to represent knowledge in a much broader scope. While this ambitious goal has not been reached yet, our intention with this contribution was first to identify it and present it to the research community, as a new direction in AI within the broad umbrella of Cognitive Science. In the spirit of the latter, two main directions of research could be followed. The first direction consists in validating a narrative-based KR model via psychological experimentation. This involves inventing an experimental protocol showing that non-narrative information is stored in a narrative manner, rather than as declarative knowledge. By "in a narrative manner", one needs to understand more than "sequentially" or "procedurally": typical narrative elements such as conflict, suspense, evaluation need to be there. The second direction consists in designing and implementing a computational model of KR that is different and, for some purposes, more powerful than existing KR approaches. We have not yet identified what task such a KR model should help to accomplish, which constitutes a future challenge of this research. In terms of computational model, it may be an extension of Case-Based Reasoning, where "correct" cases and "incorrect" cases would co-exist in a conflictual manner; Or it may be an advanced explanation system for a knowledge base; Or it may be a hybrid system, combining a rule-based system with a narrative-based system, each with its own inference mechanism. The complexity and richness of narrative may open many fresh directions in AI, revigorating the dialog between computational intelligence and human intelligence, in the tradition of Cognitive Science.

References

1 Jean-Michel Adam. *Le texte Narratif*. Nathan, Paris, 1994.

2 Ruth Aylett, Sandy Louchart, Joao Dias, Ana Paiva, Marco Vala, Sarah Woods, and Lynne Hall. Unscripted narrative for affectively driven characters. *IEEE Journal of Graphics and Animation*, 26(May/June):42 – 52, 2006.

3 Heather Barber and Daniel Kudenko. Dynamic generation of dilemma-based interactive narratives. In *Proc. Third Conf. on Artificial Intelligence and Interactive Digital Entertainment – AIIDE*, pages 2–7, Menlo Park, CA, 2007. AAAI Press.

4 Roland Barthes. Introduction à l'analyse structurale des récits. *Communications*, 8(1):1–27, 1966.

5 Cristina Battaglino, Rossana Damiano, and Vincenzo Lombardo. Moral Values in Narrative Characters: An Experiment in the Generation of Moral Emotions. In David Oyarzun, Federico Peinado, R. Michael Young, Ane Elizalde, and Gonzalo Méndez, editors, *ICIDS*, pages 212–215, Heidelberg, 2014. Springer.

6 Jerome Bruner. The narrative construction of reality. *Critical Inquiry*, 18:1–21, 1991.

7 Marc Cavazza, Fred Charles, and Steven J. Mead. Characters in Search of an author: AI-based Virtual Storytelling. In Olivier Balet, Gérard Subsol, and Patrice Torguet, editors, *International Conference on Virtual Storytelling (ICVS 2001). LNCS 2197*, Lecture Notes in Computer Science, pages 145–154. Springer, Heidelberg, September 2001.

8 Randall Davis, Howard Shrobe, and Peter Szolovits. What is a Knowledge Representation? *AI Magazine*, 14(1):17–33, 1993.

9 Syd Field. *Screenplay – The Foundations of Screenwriting*. Dell Publishing, New York, 1984.

10 David Herman. Narratology as a cognitive science. *Image [&] Narrative, online Magasine of the Visual Narrative*, (1), 2000.

11 David Herman. *Story Logic: Problems and Possibilities of Narrative*. University of Nebraska Press, Lincoln, 2002.

12 David Herman. *Storytelling and the Sciences of Mind*. MIT press, 2013.

13 Vincent Jouve. *Poétique des valeurs*. PUF, coll. "Ecriture", Paris, 2001.

14 William Labov and Joshua Waletzky. Narrative analysis: Oral versions of personal experience. *Essays on Verbal and Visual Arts*, pages 12–44, 1967.

15 Yves Lavandier. *La dramaturgie*. Le clown et l'enfant, Cergy, France, 1997.

16 Wendy Lehnert. Plot units and narrative summarization. *Cognitive Science*, 5(4):293–331, December 1981.

17 Jean M. Mandler and Nancy S. Johnson. Remembrance of things parsed: Story structure and recall. *Cognitive Psychology*, 9(1):111–151, 1977.

18 Michael Mateas and Andrew Stern. Integrating Plot, Character and Natural Language Processing in the Interactive Drama Façade. In Stefan Göbel, Norbert Braun, Ulrike Spierling, Johanna Dechau, and Holger Diener, editors, *Proceedings of the Technologies for Interactive Digital Storytelling and Entertainment (TIDSE) Conference*, AAAI Fall Symposium Series, pages 139–151, Darmstadt, 2003. Fraunhofer IRB.

19 Robert McKee. *Story: Substance, Structure, Style, and the Principles of Screenwriting*. Harper Collins, New York, 1997.

20 Srini Narayanan. Mind Changes: A simulation semantic model of counterfactuals. 2012. URL: `http://www1.icsi.berkeley.edu/~snarayan/counterfactuals.pdf`.

21 Jean Piaget. *L'équilibration des structures cognitives: probème central du développement*, volume 33. Presses universitaires de France, 1975.

22 Julie Porteous, Marc Cavazza, and Fred Charles. Applying planning to interactive storytelling: Narrative control using state constraints. *ACM Transactions on Intelligent Systems and Technology*, 1(2):10:1—-10:21, 2010.

23 Gerald Prince. The Disnarrated. *Style*, 22(1):1–8, 1988.

24 Mark Riedl, C J Saretto, and R Michael Young. Managing Interaction Between Users and Agents in a Multi-agent Storytelling Environment. In *Proceedings of the Second International Joint Conference on Autonomous Agents and Multiagent Systems*, AAMAS '03, pages 741–748, New York, NY, USA, 2003. ACM.

25 Marie-laure Ryan. *Possible Worlds, Artificial Intelligence, and Narrative Theory*. Indiana University Press, Bloomington, IN, 1991.

26 Marie-Laure Ryan. Introduction. In Marie-Laure Ryan, editor, *Narrative Across Media*. University of Nebraska Press, Lincoln and London, 2004.

27 Marie-laure Ryan. Narratology and Cognitive Science: a Problematic Relation. *Style*, 44(4):469–495, 2010.

28 Roger C Schank and Robert P Abelson. Scripts, Plans, and Knowledge. In *Proceedings of the 4th International Joint Conference on Artificial Intelligence - Volume 1*, IJCAI'75, pages 151–157, San Francisco, CA, USA, 1975. Morgan Kaufmann Publishers Inc.

29 Roger C Schank and Robert P Abelson. Knowledge and memory: The real story. *Knowledge and memory: The real story. Advances in social cognition*, 8:1–85, 1995.

30 Paul Smolensky. Connectionist AI, symbolic AI, and the brain. *Artificial Intelligence Review*, 1(2):95–109, 1987.

31 John F Sowa. Conceptual Graphs for a Data Base Interface. *IBM Journal of Research and Development*, 20(4), 1976.

32 Nicolas Szilas. A Computational Model of an Intelligent Narrator for Interactive Narratives. *Applied Artificial Intelligence*, 21(8):753–801, 2007.

33 Nicolas Szilas, Jason Barles, and Manolya Kavakli. An implementation of real-time 3D interactive drama. *Computers in Entertainment*, 5(1):5, January 2007.

34 Nicolas Szilas and Urs Richle. Towards a Computational Model of Dramatic Tension. In Mark A Finlayson, Bernhard Fisseni, Benedikt Löwe, and Jan Christoph Meister, editors, *2013 Workshop on Computational Models of Narrative*, volume 32 of *OpenAccess Series in Informatics (OASIcs)*, pages 257–276, Dagstuhl, Germany, 2013. Schloss Dagstuhl–Leibniz-Zentrum fuer Informatik. URL: `http://drops.dagstuhl.de/opus/volltexte/2013/4164`.

35 Ed Tan. *Emotion and the structure of narrative film. Film as an emotion machine*. Erlbaum, Mahwah, NJ, 1996.

36 Perry W Thorndyke. Cognitive structures in comprehension and memory of narrative discourse. *Cognitive Psychology*, 9(1):77–110, 1977.

37 Tom Trabasso, Paul Van Den Broek, and So Young Suh. Logical necessity and transitivity of causal relations in stories. *Discourse Processes*, 12(1):1–25, 1989.

38 Bernard Victorri. La place de la fonction narrative dans l'{é}mergence du langage et la structure des langues. *Théorie, Littérature, Enseignement*, (17):23–38, 1999. URL: `https://halshs.archives-ouvertes.fr/halshs-00009329`.

39 Stephen G Ware and R Michael Young. CPOCL: A Narrative Planner Supporting Conflict. In *Proceedings of the Seventh AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment*, number Young, pages 97–102, Palo Alto, CA, 2011. AAAI Press.

40 Stephen G Ware, R Michael Young, Brent E Harrison, and David L Roberts. Four Quantitative Metrics Describing Narrative Conflict. In David Oyarzun, Federico Peinado, R Michael Young, Ane Elizalde, and Gonzalo Méndez, editors, *Fifth International Conference on Interactive Digital Storytelling (ICIDS). LNCS, 7648*, LNCS, pages 18–29, Heidelberg, 2012. Springer.

41 Peter Weyhrauch. *Guiding Interactive Drama*. PhD thesis, Carnegie Mellon University, 1997.