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Supporting Children in Mastering Temporal Relations of Stories:
The TERENCE Learning Approach

Tania Di Mascio, Dipartimento di Ingegneria e Scienze dell'Informazione e Matematica, Università degli Studi dell'Aquila, L'Aquila, Italy

Rosella Gennari, Faculty of Computer Science, Free University of Bozen, Bolzano, Italy

Alessandra Melonio, Faculty of Computer Science, Free University of Bozen, Bolzano, Italy

Laura Tarantino, Dipartimento di Ingegneria e Scienze dell'Informazione e Matematica, Università degli Studi dell'Aquila, L'Aquila, Italy

ABSTRACT

Though temporal reasoning is a key factor for text comprehension, existing proposals for visualizing temporal information and temporal connectives proves to be inadequate for children, not only for their levels of abstraction and detail, but also because they rely on pre-existing mental models of time and temporal connectives, while in the case of children the system has to induce the development of a mental model not existing yet. Filling this gap was the main goal of the FP7 European project TERENCE, which developed an adaptive learning system shaped around the concepts of *repeated interaction experience* and of *graded text simplification* and consistent with consolidated pedagogical approaches built on *question-based games*. In particular, in this paper the authors present the main features of its learner-oriented read-and-play visual interaction environment that, according to the dual-coding theory, follows a two-tiers approach pairing verbal and visual information.

KEYWORDS

Adaptive Learning System, Temporal Reasoning Visualization, User Interface

INTRODUCTION

As observed by Scott (1997), the acquisition of common sense time concepts is among the most essential cognitive skills that children must master to integrate well in the society. Moreover, temporal reasoning is recognized as a key factor for achieving a good text comprehension, as discussed, among others, in the study of (Duran et al., 2007), which underlines the relevance of temporal features of texts as viable cues for facilitating the coherent interpretation of text.

Text Comprehension

Reasoning coherently with time concepts is a skill acquired indirectly through narration and evolving with age and experience. In general, after the age of 5 normally developing children become able to make deductions with temporal relations and to reason on sequences of events with *before* and *after* (McColgan & McCormack, 2008). This ability develops further from the age of 7 to that of 9, when children seem to be able to master the *while* temporal connective (Ge & Xuehong, 2002), and

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then up until the age of 11, when the concrete operational stage ends; consequently, 7 to 11 years old children are classified as *novice (text) comprehenders*. However, a significant share of novice comprehenders show problems in making global deductions on texts, turning out to be *poor (text) comprehenders* (e.g., among children without hearing impairments, poor comprehenders comprise up to 10% of 7 – 11 years old children in UK schools (Yuill & Oakhill, 1991)).

Poor comprehenders, despite proficiency in word decoding as well as other low-level cognitive skills, demonstrate text comprehension difficulties related to inference-making skills (especially in temporal reasoning). More specifically, several studies experimentally prove that poor comprehenders fail to master the following high-level text processing skills: (skill 1) coherent use of cohesive markers such as connectives (e.g., *because*, *before*, and *after*) that signal temporal relations in text; (skill 2) inference-making from different or distant parts of a text, integrating them coherently (Cain, Oakhill, & Elbro, 2003); (skill 3) detection of inconsistencies in texts (Oakhill, Hartt & Samols, 2005). As discussed by Cain (2009), there is clear evidence that integration and inference making reasoning skills are very likely to be causally implicated in the development of good text comprehension.

It has to be observed that the comprehension process is generally stimulated by educational interventions carried out by primary school educators, who aim at retracing temporal relations among main events of a story (Valeriani, 1986) and in general at reasoning about them. In stories, comprehension depends on the correlation of narrated events, which can be introduced in different parts of the stories in order to construct a coherent representation of the story's meaning (Cain, 2009). Appropriately interspersed connectives about temporal information in stories then facilitate the construction of conceptual relations between events in a novice comprehender's representation of a text's meaning (Cain & Nash, 2011).

The Role of Visual Representations of Temporal Relations

Valuable help for text comprehension may come also from pictorial representations of temporal information, according to the dual-coding theory postulating that both verbal association and visual imagery are to be used to represent information and to master learned material (Paivio, 1991). It is in fact hypothesized that visual and verbal information are processed differently and separately along distinct channels in the human mind, and that the distinct mental codes so produced are used to organize and store incoming information and then to recall it: when asked to recall a stimulus, a person can retrieve either the word or the image individually, or both simultaneously (Sternberg, 2003). So, coding temporal information both verbally and pictorially increases the probability of mastering it compared to when it is coded in one way only.

It is worth noting that time visualization raises representation and perception issues related to its intuitive comprehension and that the adequacy of a visual representation of time therefore strongly depends on its final users and their tasks (Aigner et al., 2007). Defining suitable visual representations for temporal structures of stories needs the integration of theoretical and methodological work both from traditional areas devoted to temporal representation (logic, reasoning, and databases) and from information visualization research field (we refer to (Aigner et al., 2007; Catarci & Fernandes Silva, 2000; Chittaro & Combi 2001) for surveys on temporal visual representations). Unfortunately, existing proposals for visual representations of temporal relationships among events and intervals – mostly based on seminal Allen's work on temporal logic (Allen, 1983) – are oriented to computational linguists or information engineers rather than to learners and their educators, because of their levels of *abstraction* and *detail* (Di Mascio & Tarantino, in press): (1) almost all proposals are based on too abstract elements, and even metaphors based on real objects, such as paint strips, turns out to be not realistic enough, while recent studies prove that children appreciate realistic illustrations (Cecilia et

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