Learning temporal connectives by playing:
the TERENCE experience with children

Tania Di Mascio¹, Laura Tarantino¹, Pierpaolo Vittorini², Maria Rosita Cecilia²

¹ DISIM Università degli Studi dell’Aquila, Via Vetoio 1
67100 L’Aquila, Italy

² MeSVA, Università degli Studi dell’Aquila, Piazzale S. Salvatore, Ed. Delta 6
67100 L’Aquila, Italy

{tania.dimascio,laura.tarantino,pierpaolo.vittorini}@univaq.it; mariarosita.cecilia@graduate.univaq.it

Extended abstract

Introduction Reading is a complex cognitive activity that transforms print to speech and print to meaning through a negotiation of meaning between the text and its reader, as an activity of problem solving [23]. According to [13], reading is a multidimensional process, including decoding and comprehension; although correlated, these skills depend on different cognitive and linguistic skills [20] and thus researchers classify poor readers in poor decoders and poor comprehenders, with distinct cognitive and linguistic profiles [12]. While poor decoders, often defined as dyslexics, have difficulties with fluent reading, yet manage to comprehend what read reasonably well [25], poor comprehenders read words and sentences accurately, fluently and at age-appropriate levels, but have serious difficulty understanding what they have read [19]. Stories have been recognized as first class tools of poor comprehenders oriented psycho-pedagogical stimulation plans [24]: text comprehension may be improved by educational interventions aimed at reasoning about stories designed so to include appropriately interspersed temporal connectives through which children construct relations about story’s events (e.g., [5]).

In this extended abstract we summarize the experience we gained in such a context within the framework of the TERENCE project (www.terenceproject.eu), by sketching main results about the roles of smart games in the construction of the child mental model for temporal reasoning and the evaluation of the system (which is necessarily referred to the psycho-pedagogical value of the system given its Technology Enhanced Learning (TEL) nature). Ideally, one should turn evaluation evidences into specific guidelines for design. However, when talking about children the translation from experimental data to guidelines raises difficulties that designers do not experience when designing for adults, for a number of reasons [14, pp. 361-362]: first of all, since children are a moving target, rapidly learning and changing their cognitive, sensory and motor skills, longitudinal studies should be necessary; furthermore, guidelines may shortly become obsolete since children in one decade tend to have more experiences with ICT devices than children from the previous decade. It is anyhow crucial that designers report on their findings, to contribute to the maturation of the field (as advocated, e.g., by [14]). In particular, we report some reflections about the differences that a designer has to take in mind when designing for children and for adults, for what concerns (1) the visual elements used to support temporal reasoning and (2) the gamified approach to the interaction.

The TERENCE learning approach. TERENCE was an FP7 multidisciplinary project that developed the first Adaptive Learning System for supporting 7-11 years old poor text comprehenders and their educators. Based on consolidated results about games as a means for fostering deep learning (e.g., [18]), and having in mind Kapp’s view of gamification in learning context (game-based mechanics, esthetics and game thinking to engage people, motivate action, promote learning, and solve problems) [26], the TERENCE learning approach is grounded on the ideas of “learning through gaming”, “learning via iterations”, and “rewarding structures” [10]. For encouraging reading, it is important that readers play and enjoy repeated learning experiences; the sessions (two/three per week) are collectively run in a dedicated classroom under the vigilance of a teachers, while each learner has his/her own individual experience with the system. The stimulation plan, designed by the psycho-pedagogical expert of TERENCE, is grounded on two basic principles, guiding the system adaptivity: (P1) learners have to be presented with material at an appropriate level of difficulty but nonetheless challenging; (P2) progresses in text comprehension are to be achieved by associating reading and playing, within sessions with a warm-up (reading a story), peak (playing with smart games), and relax (playing with relaxing games) structure; points and improving games are designed as tangible rewards. The feature selected as primary guide for adaptation mechanisms is the reading comprehension (RC) skill, introduced by TERENCE experts and measured on a scale with four levels, taking into account comprehension of lexicon and grammatical skills, global coherence and local cohesion skills.
RC skills are also the guiding concept for the TERENCE innovative *graded text simplification* approach, working at cognitive level and based on text coherence [2]: according to this approach, and to obey to principle P1, TERENCE stories are versioned and presented in four difficulty levels. To obey to principle P2, inference-making about stories is achieved through question-answer smart games classified into different levels of difficulty to stimulate text comprehension according to increasingly demanding tasks: in particular *temporal games* focus on temporal relations (i) before-after, (ii) before-while after and while after, and (iii) before-while-after [7]. By solving games, children progress through story levels. The overall design of the TERENCE “read&play” visual interaction environment is based on the *dual-coding theory*, which states that verbal and pictorial information, processed separately along distinct channels in the human mind, re-enforce each other when adequately paired [23] (see screenshots in Fig. 1).

**Fig. 1.** Sample screenshots from the TERENCE system (displays are based on a common template including system communication on the left – carried on by an avatar – and interaction with content in the main area [10]): (a) *reading a story episode*. Stories are structured as sequences of illustrated episodes presented according to a focus+context carousel pattern allowing children to focus on single episodes while maintaining a global vision on the whole story and on the order of episodes; (b) *a temporal game* – before-after game. The content area of games is divided into three portions: a lower bar displaying three cards corresponding to possible choices, a middle area displaying the question to be answered, and an upper part depending on the specific games. The child has to select the card corresponding to the correct answer and drag it into specific elements of the upper part.

**Evaluating TERENCE** Evaluating an educational system requires to assess both usability and psycho-pedagogical effectiveness in terms of learning material and stimulation plan [3]. Within the framework of an iterative design, the TERENCE evaluation was articulated in two expert based rounds and two user-based rounds; according to the principle of repeated learning experience, evaluation rounds required a number of different sessions with the same children. Usability was evaluated according to customary methods [22], while for evaluation of learning outcomes a variety of quantitative and qualitative techniques are commonly used [11]. In particular, evaluation aimed to investigate (i) pre/post difference in an experimental group and in the single schools that made up of the experimental group, (ii) pre/post difference of the experimental group and the single schools with respect to a control group, (iii) whether a different effect can be identified in poor comprehenders than in good comprehenders (see [6] for details on evaluation findings): the evaluation showed that (1) the stimulation plan significantly improved comprehension in the experimental group, (2) TERENCE improved reading comprehension also in comparison with a control group, and (3) TERENCE improved comprehension both in poor and good comprehenders, demonstrating, de facto, that the choices implemented in the visual interface in terms of visual representations for temporal relations are appropriated for a children-oriented system. Moreover, the absence of drop-out confirmed the effectiveness of the classical psycho-pedagogical stimulation plan.

**Reflection 1 – Supporting reasoning about time: children vs adults** Within the context of reading activities the TERENCE visual model addresses relative time occurrence of episodes while leaving it to the verbal narration to convey temporal information about events contained in episodes. This may seem surprising at first, and in contrast to the literature about visual representation of temporal data and temporal connectives, generally based on (crowded) timelines and visualization of intervals. Anyhow, it has to be underlined the crucial difference between adult-oriented time and child-oriented time representation: in the first case we build on a pre-existent mental model of time and temporal connectives, while in the latter case we have to induce the construction of a mental model of time and temporal connectives. Relying on his/her mental model, an adult can grab temporal information from the exploration (and possibly the filtering) of timelines (often characterized by huge quantity of data) that would on the contrary overwhelm a child who is trying to acquire common sense time concepts. Furthermore this would be inconsistent with consolidated pedagogical approaches built on question-based games. For these reasons, in TERENCE individual visualization of events and of their temporal relations are associated to smart games and playing activities, which were therefore used as the primary
mechanism for supporting the construction of a mental model of time (evidences from the evaluation of the system proved their efficacy). Furthermore, though events have a duration, the level of granularity and the degree of indeterminacy of temporal information in learner-oriented stories make interval-based visualizations (such as typical adult-oriented techniques based on Allen’s relations [1]) not adequate. In TERENCE we adopted a simple dual-coded card-based representation for the events, including an illustration and a verbal sentence; as to before/after connectives, we maintain the sequentiality of Allen’s relationship while ignoring the distinction between ‘before and ‘meets’ cases; as to while connectives, we maintain Allen’s suggestion to use parallelisms while ignoring the distinction among different cases of partial and complete overlapping.

**Reflection 2 – Designing the gamified environment: children vs adults** A general observation, related to the design of interactive applications, refers to the *degree of juiciness* of an interactive system, and in general to the different approaches of adult and children with respect to interactions: in adult-oriented systems the focus is on productivity, with a consequent requirement of minimality of the interface in order not to distract users from their tasks, which made raise a number of concerns around the very nature of gamification, the way it is often pursued (as a “pointification” and with lack of playfulness), and its very applicability in HCI (see, e.g., [8,9,15,16,17,26]). According to our experience, these concerns cease to bother in children-oriented application, where the focus is on playfulness, with a requirement of juiciness of the interface, and with achievement of tasks as side-effects of the activities carried on by the children. From the evaluation, beside the pedagogical effectiveness in terms of improvement in text comprehension, clearly emerged the positive attitude of children towards a gamified environment, with children engaging competition with each other, showing eagerness to use the system, and developing more and more affection towards their avatars and books. Avatars in particular, and the relationship that children engaged with them, deserve additional comments: differently from adult-oriented games where avatars are considered mostly as a personification of the player, in the children case the avatar was considered as a person distinct from the child, a kind of “helping character” acting as a surrogate of the teacher (usability evaluation showed a high level of stress when children felt to be left alone with the system). For this reason TERENCE assigned to the avatar a conversational behavior, providing instructions, suggestions and rewards in case of correct answers.

**References**


