Representations of Contemporaneous Events of a Story for Novice Readers

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Abstract. We are working on a story comprehension tool for novice readers, among whom are 6–8 olds in Italy. The tool also asks them to reason on the temporal dimension of stories. In the design of the tool, we stumbled on the following question: how we can render qualitative temporal relations of a story with a visual representation that is conceptually adequate to novice readers. The question triggered the trans-disciplinary work reported on in this paper, written by a cognitive psychologist, an engineer and a logician. The work primarily consists in an experimental study with 6–8 old novice readers, first and second graders of an Italian primary school. We read them a story, and then asked them to visually represent certain contemporaneous relations of the story. The results of the experiment shed light on the variety of strategies that such children employ. The results also triggered two novel experimental studies that are reported on in the conclusion to this paper.

1 Introduction

Temporal reasoning is one of the many cognitive skills that children must develop in order to integrate well in our society [17, p. 3]: "of the many cognitive skills which children must master in order to become proficient members of their cultures, the acquisition of commonsense time concepts is among the

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most essential". The study of [4] supports the relevance of temporal features of texts as viable cues for facilitating the coherent interpretation of the texts.

Reasoning coherently with time concepts is acquired indirectly through narration, and evolves with age and experience. Language specific factors also affect the age at which temporal connectives are comprehended and mastered. In general, after the age of 5, normally developing children become able to make deductions with temporal relations, reasoning on sequences of events with "before" and "after" [13]. This ability seems to develop further from the age of 7 to that of 9, when children seem to be able to master the "while" temporal connective, e.g., see [5].

We are working on an e-story comprehension web tool. The tool's users include Italian primary-school children, who are novice readers [14]. It originates from LODE, a logic-based web system for the literacy of deaf readers, e.g., see [6] and [12]. The tool invites readers to reason on the temporal dimension of an e-story by using qualitative temporal relations, between pairs of events of the e-story, that can be expressed with "before", "while" or "after". An example is "Mammy hen is worried about her little Gino, while Gino is telling stories to the wolf".

Based on [15], numerous studies already showed significant comprehension gains when people can visualize while reading, as reported in [9]. Our web tool aims to be visual as for: (1) the interface; (2) the story's main events; (3) the e-story's qualitative temporal relations.

A non-trivial challenge comes forward in the creation of such a visual tool, namely, how we can render qualitative temporal relations of a story with a visual representation that is conceptually adequate to primary-school children, where the term "conceptual adequacy" is used in the sense of [10].

We took over the challenge and conducted an exploratory evaluation with fifty-six 6–8 olds in order to assess how they would visually represent "while" relations between events of a story.

This paper reports on the results of our experimental work with novice readers, and paves the way for the development of our visual tool. More precisely, Section 2 overviews related work on the visualization of qualitative temporal relations, mainly in the AI and HCI literatures. The overview lays the groundwork for Section 3, which gives the rationale and goals of our experimental work.

Then the paper delves into the details of the experiment. As we expect that this paper can appeal to a heterogenous class of readers, ranging from logicians working in the field of knowledge representation to cognitive psychologists and educators, we try to be as detailed as possible in the description of the experiment, without (we hope) sacrificing readability. So, Section 4 explains the experiment modus operandi. Section 5 is concerned with the user analysis that the experimenters conducted. Section 6 explains the experiment design. Section 7 details the user teaching. Section 8 reports on the experiment execution.

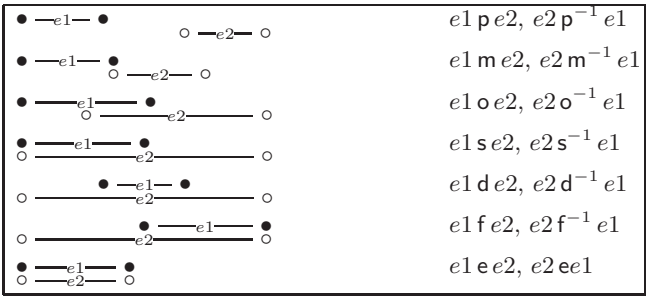

Fig. 1 The atomic Allen relations.

After the details of the experiment are so explained, we bite the crucial bit and analyze the results of the experiment in Section 9. We discuss about our results in Section 10. Section 11 reports on ongoing-work with two categories of progressively more skilled text comprehenders: ten old children (10-15 olds), and ten adults (16-30 olds). The goal of this experimental work is to start investigating whether the old children and adults would produce other visual representations. Section 12 concludes this paper.

2 Related Work

Stories' qualitative temporal relations can be expressed in terms of the so-called *atomic relations of Allen*. Figure 1 gives their standard representation over the real line. For instance, consider the following story excerpt:

> Mammy hen is worried about her little Gino, while Gino is telling stories to the wolf.

In terms of the Allen relations, the above story excerpt states that the relation d is feasible between the event "Mammy hen is worried about her little Gino" and the event "Gino is telling stories to the wolf".

According to the experimental studies of [10], the visual representation of the atomic Allen relations in Figure 1 seems to be cognitively adequate for adults. However the visualization of disjunctions of atomic Allen relations is challenging. As for this, [8] has an interesting proposal, capable of expressing certain disjunctions such as "before or meets", see Figure 2. More recently, [2] proposed three alternative visual metaphors, see Figure 3. Their metaphors are based on concrete objects and phenomena from the physical word: elastic bands, springs and paint strips.

Notice that all such visual representations of qualitative temporal relations are diagrammatic and meant for adults. Moreover, they are all based on linear spatial orderings.

Fig. 2 The visualization of [8].

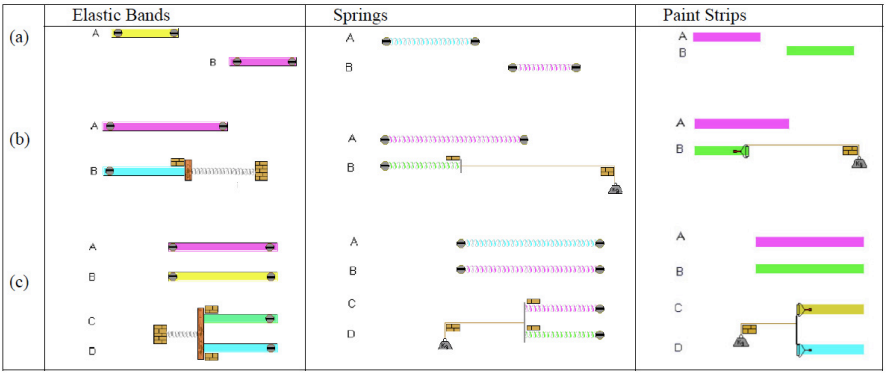

Fig. 3 Visualisations of [2].

Such a situation naturally triggers the following challenge: would novice readers spontaneously produce similar visual representations of the temporal information contained in a story, in general, and of qualitative temporal relations, in particular?

To the best of our knowledge, there are very few studies that assess such or similar questions with novice readers. For instance, the experimental study of [11] evaluates the preschool children's ability in mapping a sequence of three temporal events onto spatial relations on a panel. The authors tested whether the children would spontaneously produce and comprehend a spatial linear ordering. According to their results, children's "mapping appears to be influenced by cultural conventions (such as the left-to-right direction of reading and writing), but space is used to represent non-spatial relations spontaneously before these cultural conventions are learned" (ibidem, p. 394).

However, the spontaneous visual representations of contemporaneous temporal relations, like "while", seems by far less explored than that of sequential temporal relations, like "before" or "after". Our evaluation does not consider sequential temporal relations, which are more studied, and instead concentrates on "while" sentences of a story.

3 Rationale and Goals of the Evaluation

We asked 6–8 olds of an Italian primary school to represent "while" relations of an entire story by drawing, and by arranging the illustrations of the correlated events on an A4 paper.

We opted for a story in our evaluation instead of, say, brief isolated sentences like in [11]. First of all, a multiple-sense connective is particularly sensitive to the context. This is the case of "while" in English as well Italian. For instance, it can correspond to "during" as well as to "during or finishes". Secondly, stories give children a meaningful context, and in general children are more successful at interpreting texts where the context reinforces the interpretation of the temporal connective, as reported in [18].

We chose the first short story, of circa 250 words, from the picture-book [7] for children, older than 5. The story characters and settings are well defined and clearly depicted, there are "while" relations between significant temporal events, and the language is suitable for 6–8 olds alike.

We also decided to read the story, instead of letting the children read the story on their own. The decoding skills of some of the children involved in the evaluation might still have been rather immature, and this might have affected their story comprehension. Story telling, instead, is an experience familiar to all, from their preschool year.

The evaluation that we report on in this paper aims at assessing the following questions:

(G1) the type and quality of their visualization strategies, e.g., the dimension of events in drawing;
(G2) if class, grammar comprehension, and working memory capacity affect their visualization strategies.

In the following, we first give the necessary details about the experiment, and then report on our analyzes.

4 Method

The experimental evaluation we conducted is based on a classical HCI user based schema, e.g., see [3]. It consists of the following steps.

- User Analysis, that is, the description of the involved users and definition of users' categories.
- Experiment Design, that is, the definition and description of study models, metrics and tasks.
- User Teaching, that is, exhaustive explanation for people involved in the evaluation about the modus operandi in the experiment sessions.
- Experiment Execution, that is, the description of experiment sessions, a.k.a., experiment diary.
- Result Analysis, that is, the collection of data and description of significant results.

In the following, we describe the experimental evaluations, using the aforementioned steps.

5 User Analysis

Our experiment participants were fifty-six children at end of their school year. They were subdivided in classes as reported in Table 1.

Table 1 Class composition.

Class acronym	Class description
(1a)	First-year class, with seventeen 6–7 olds
(2a)	Second-year class, with nineteen 7–8 olds
(2b)	Second-year class, with twenty 7–8 olds

As for the (1a) and (2a) classes, their working memory was assessed by means of the digit span test (DS). Their grammar comprehension was assessed by means of an Italian standard receptive grammar test (briefly G). See [16]. Each child of (1a) and (2a) thus obtained a DS score (min 0, max 28) and a G score (min 0, max 16). This was not possible with (2b) due to time restraints. On (1a) and (2a), we can then compare:

- the children's DS scores to the DS median value (DSm), that is equal to 9 for (1a) and 12 for (2a);
- the children's G scores to the G median value (Gm), that is equal to 10 for (1a) and 12 for (2a).

The comparison allows us to group children of (1a) and (2a) in the DS/G categories of Table 2. Note that a child of the X class has *high DS score* (*low DS score*) if the child has DS score higher than or equal to DSm (has DS score lower than DSm).

Similarly, a child of the X class has *high G score* (*low G score*) if the child has G score higher than or equal to Gm (has G score lower than Gm).

Such categories and terminology are then used in the result analysis and discussion.

Table 2 DS/G categories, according to the DS (digit span) or G (grammar) scores.

Measured skill	DS/G categories	DS/G scores
Working memory	high DS score	DS $\geq$ DSm
	low DS score	DS $<$ DSm
Grammar comprehension	high G score	G $\geq$ Gm
	low G score	G $<$ Gm

6 Experiment Design

We divided our experiment into three phases:

1. the *Pre-test Phase* is the assessment of working memory and grammar comprehension;
2. the *Transparency Phase* is the arrangement of transparent illustrations on a white paper;
3. the *Drawing Phase* is the spontaneous drawing.

The Pre-test Phase served to classify children according to their working memory and grammar comprehension levels, as explained in Section 5.

The other two phases served to study the capability of visually representing the "while" relations. Whereas the children's preferred visual patterns of representation may emerge in the Transparency Phase, common drawing strategies of children can emerge in the Drawing Phase. We cannot assume that all the experiment's children equally comprehended the "while" relations, and we performed Pearson chi-square tests for these two phases.

The tasks for children in the three phases are summarized in Table 3. Note that all the sentences assigned to children narrate significant episodes of the story. According to the story, the "while" between the first and the second event introduced in the TW1 and TW2 tasks can be mapped into the "during" Allen relation. Notice that DW2 uses the same sentence as TW2 does. The "while" of DW3 is vaguer, and can be mapped to "during or finishes".

Table 3 Task description.

Phase	**Task acronym**	**Task description**
Pre-test	DS	Repeat aloud the sequence of numbers read by the evaluator.
	G	An examiner reads a sentence. The child is asked to point to one out of four pictures, which he or she thinks to portray the sentence best.
Transparency	TW1	Represent the following with transparencies: "The wolf reaches Gino while Gino is picking up strawberries in the woods".
	TW2	Represent the following with transparencies: "Mammy hen and the other animals go to the wolf's house while Gino is telling stories to the wolf".
Drawing	DW2	Draw "Mammy hen and the other animals go to the wolf's house while Gino is telling stories to the wolf".
	DW3	Draw "While mammy hen is worried about her little Gino, Gino is telling stories to the wolf".

7 User Teaching

Before performing the experiment, on June 1 2009, the two experimenters met the classes' teachers and school dean. During the meeting, they discussed the organization of the experiment (e.g., meeting time, sequence of tasks), and their respective roles in the experiment. More precisely, teachers were asked to support the experimenters and children in all the phases of the experiment. Teachers were asked to provide considerable support in the Pre-test Phase. This phase is a sort of vis--vis interview with each child, and as such it requires a considerable amount of time.

Then the experimenters explained the experiment modus operandi, detailed as follows.

- There should be a relaxed and playful atmosphere during the experiment, e.g., the story is told imitating the animals' voices.
- The absolute respect of privacy must be clear to children. A personal number identifies each child, unequivocally but anonymously.
- The usage of transparent illustrations is explained.
- One side of the A4 sheet is dedicated to spontaneous drawing (for DW2 and DW3). The other side is used for transparencies (TW1 and TW2).

Finally, experimenters and teachers fix the amount of time that children can spend on each task, especially DW2 and DW3.

8 Experiment Execution

The experiment took place at school, a familiar environment for children. At 8:00, the two experimenters met the teachers at their school. Then the experiment is divided in three consecutive sessions, one session per class.

Session I is carried on with (1a), a first-year class. The experiment phases are in the following order: Pre-test; Transparency; Drawing. The correlated tasks are assigned in the following order: DS, G; TW1; DW2.

Session II is carried on with (2a), a second-year class. The experiment phases are in the following order: Pre-test; Drawing; Transparency. The correlated asks are assigned in the following order: DS, G; DW3; TW2.

Session III is carried on with (2b), a second-year class. There is only the Drawing Phase with the DW2 task.

In Sessions I and II, drawing and placing transparencies are executed in different order so as to augment the independency between the DS/G scores, and the child's capability of visually representing "while" relations. In Session III, time restraints compelled us to choose either transparencies or drawings. We opted for the latter as it gives more freedom to children.

The remainder of this sections explains the three sessions in details, whereas Table 4 gives only the essential information.

Session 1, date: 05 June 2009

S1.1 08:3008:45. The evaluators meet the (1a) children in the classroom. They explain children the assigned tasks, e.g., "... children, please, help us! We need to explain 'while Gino is telling stories, mammy hen is worried' to younger children...". Then the evaluators give each child his or her personal number.
S1.2 08:4509:15. First, one of the evaluators demonstrates how the DS and G tasks must be performed with the aid of one child. Then the evaluators and the teacher record the DS and G data.
S1.3 09:159:30. First, one of the evaluators read the story while children are listening carefully. Then the evaluators distribute a transparency set, and an A4 white sheet per child. Finally, the evaluators ask the children to write their number on their paper sheet.
S1.4 09:3009:50. First, one of the evaluators reads the sentence of the TW1 task. Then the children arrange transparencies on the paper sheet. Finally, the evaluators trace the pattern created by the children on the white paper.
S1.5 09:5010:30. First, one of the evaluators reads the sentence of the DW2 task. Then the children draw on the blank side of the paper sheet.
S1.6 10:3010:40. The experimenters and teacher collect paper sheets, leaving the transparencies as presents.

Session 2, date: 05 June 2009

S2.1 10:4511:00. As (S1.1) of Session 1.
S2.2 11:0011:15. As (S1.2) of Session 1.
S2.3 11:1511:30. As (S1.3) of Session 1.
S2.4 11:3012:00. Like (S1.5) of Session 1 with DW3.
S2.5 12:0012:20. Like (S1.4) of Session 1 with TW2.
S2.6 12:2012:30. As (S1.6) of Session 1.

Session 3, date: 05 June 2009

S3.1 12:4513:00. As (S1.1) of Session 1.
S3.2 13:0013:15. Like (S1.3) of Session 1.
S3.3 13:1513:30. Like (S1.5) of Session 1.
S3.4 13:3014:00. Like (S1.6) of Session 1.

Table 4 Sessions, classes and assigned tasks.

Session	Class	Phase order	Task order
I	(1a)	Pre-test, Transparency, Drawing	DS, G, TW1, DW2
II	(2a)	Pre-test, Drawing, Transparency	DS, G, DW3, TW2
III	(2b)	Drawing	DW2

9 Results Analysis

This section only gives the most significant results.

9.1 Pre-test Phase for Measuring the Working Memory and Grammar Comprehension

The Pre-test Phase is concerned with the grammar (G) and working memory tests (DS) of the (1a) and (2a) classes. In our analysis, children get grouped using the DS/G categories of Table 2 above. The analysis results are shown in Table 5 below.

Table 5 Results of the Pre-test Phase.

School class	DS/G category	Number of children
(1a), 17 children	high DS score	10
	high G score	11
(2a), 19 children	high DS score	10
	high G score	11

9.2 Transparency Phase

The Transparency Phase is concerned with the TW1 and TW2 tasks of arranging transparencies. TW1 is administered to the (1a) first-year class, whereas TW2 is conducted with the (2a) second-year class.

In order to represent each event, children had to arrange the transparencies of the involved actors and background elements on the paper sheet. For instance in case of TW1, one out of the two events is "Gino is picking up strawberries in the wood". The correlated transparencies are the strawberries in the wood, and Gino.

9.2.1 The TW1 Transparency Task with the (1a) Class

Let us recall the sentence that children were asked to represent: "The wolf reaches Gino while Gino is picking up strawberries in the woods". Children from (1a) employed three major strategies in arranging transparencies:

Strategy 1: the transparencies of each event are horizontally arranged; one event is aligned above the other;

Strategy 2: the transparencies of one event are vertically aligned, those of the other event are horizontally aligned; the two events are horizontally aligned;

Strategy 3: the transparent actors of the two events are horizontally aligned, and the correlated background elements are aligned beneath.

The top image of Figure 4 shows an example of Strategy 3. Circa 11,8% children opted for Strategy 1, 23,5% went for Strategy 2, and 23,5% of them chose Strategy 3.

Only the relation between the grammar comprehension and the adoption of Strategy 3 is close to significance: $\chi^2(1) = 3,66$, $p = .056$.

9.2.2 The TW2 Transparency Task with the (2a) Class

Let us recall the sentence that children were asked to represent: "Mammy hen and the other animals go to the wolf's house while Gino is telling stories to the wolf". Children from (2a) employed three major strategies in arranging transparencies:

Strategy 1: the transparencies of each event are horizontally arranged; one event is aligned above the other;
Strategy 2: only one event is represented and its transparencies are horizontally aligned;
Strategy 3: no clear arrangement emerges.

The bottom image of Figure 4 shows an example of Strategy 1. The horizontal linear arrangement of both events (Strategy 1) is the most frequent for the TW2 task with (2a): 50% of them chose it. Only 17% of the (2a) class represented only one event, adopting Strategy 2. 33% of (2a) gave no clear order between events, or used only the transparency of one character without representing any event (Strategy 3).

The (2a) children with higher G scores employed Strategy 1, aligning the events horizontally, significantly more frequently than the children with lower G scores: $\chi^2(1) = 5,84$, $p < .01$.

9.3 Drawing Phase

The Drawing Phase is concerned with the DW2 and DW3 tasks of drawing. DW2 is conducted with the (1a) and (2b) classes, whereas DW3 is with the (2a) class. Strategies for representing the "while" relations can be grouped as follows:

(A) spatial arrangement of the events,
(B) other drawing strategies.

As for the spatial arrangement, three major linear arrangements emerged:

(A1) horizontal, that is, two separate events along a horizontal line,
(A2) vertical, that is, two separate events on a vertical line,
(A3) diagonal, that is, two separate events on a diagonal.

Representations consisting of one single event or no clear distribution of events are reported as "other".

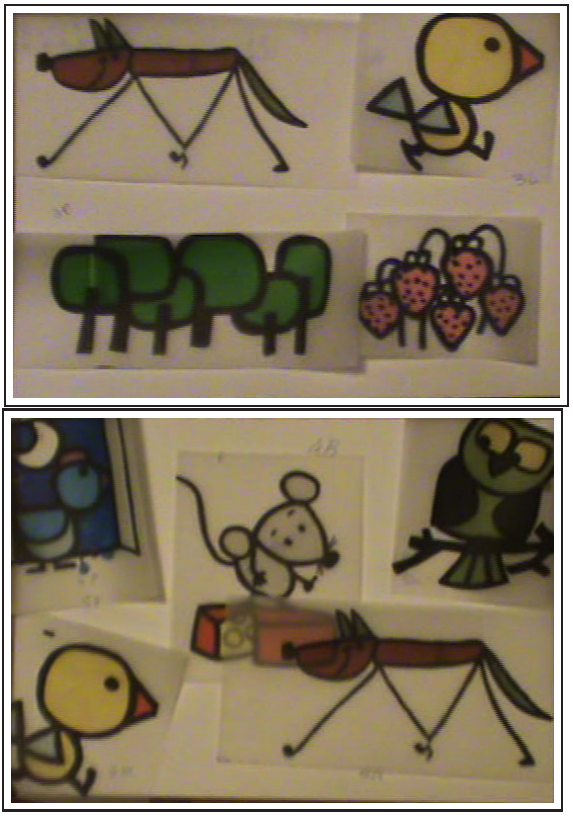

Fig. 4 The top image shows the TW1 task by a (1a) child, placing actors horizontally at the top and background elements beneath. The bottom image shows the TW2 task by a (2a) child, placing one event below the other.

Then we found out three other drawing strategies, explained as follows.

(B1) Children draw a background common to both events. That is, the child represents the two events within the same background frame (e.g. sky, ground).
(B2) Children blend both events in a unique scene or keep them in two separate scenes. The child represents the two events as part of a single scene (e.g., mammy hen and the other animals are close to Gino, while Gino is telling stories).
(B3) Children represent two separate events and join them with a link (e.g., a path), albeit they happen in different locations in the story.

Let us see such strategies in the context of the DW2 and DW3 tasks.

9.3.1 The DW2 Drawing Task with the (1a) and (2b) Classes

Let us recall the sentence that children were asked to draw: "Mammy hen and the other animals go to the wolf's house while Gino is telling stories to the wolf". Table 6 recaps the most frequent linear arrangements, adopted by (1a) and (2b) children. Table 7 shows how many of the (1a) and (2a) children drew a common background; see also B1 in Subsection 9.3. Table 8 shows how many of the (1a) and (2a) children represented the two events in two separate scenes; see also B3 in Subsection 9.3.

Table 6 Spatial (linear) arrangements in DW2.

Class	Horizontal	Vertical	Diagonal	Other
(1a)	77,00%	12,00%	0,00%	11,00%
(2b)	67,00%	9,50%	0,00%	23,50%

Table 7 Background strategy in DW2.

Class	Common background	No background	Other
(1a)	59,00%	12,00%	29,00%
(2b)	19,00%	62,00%	19,00%

Table 8 Scenario strategy in DW2.

Class	Single scene	Two scenes	Other
(1a)	65,00%	12,00%	23,00%
(2b)	48,00%	29,00%	23,00%

According to Table 6, the predominant representation is horizontal. Moreover a horizontal representation with the core event ("Gino was telling stories to the wolf") on the right and the other on the left was predominant for all the experiment participants. A representation with the core event on the left and the secondary on the right was rare, but significantly more frequent among the younger children, that is, (1a) children: $\chi^2(1) = 3,75$, $p < .05$. For an example, see the two drawings in Figure 5.

Note also that the younger children adopted the common background strategy (59%), which is instead the least employed by (2b) children (19%), see Table 7.

As Table 8 shows, the majority of children employed the single scene strategy for representing the "while" of DW2 ("Mammy hen and the other animals go to the wolf's house *while* Gino is telling stories to the wolf").

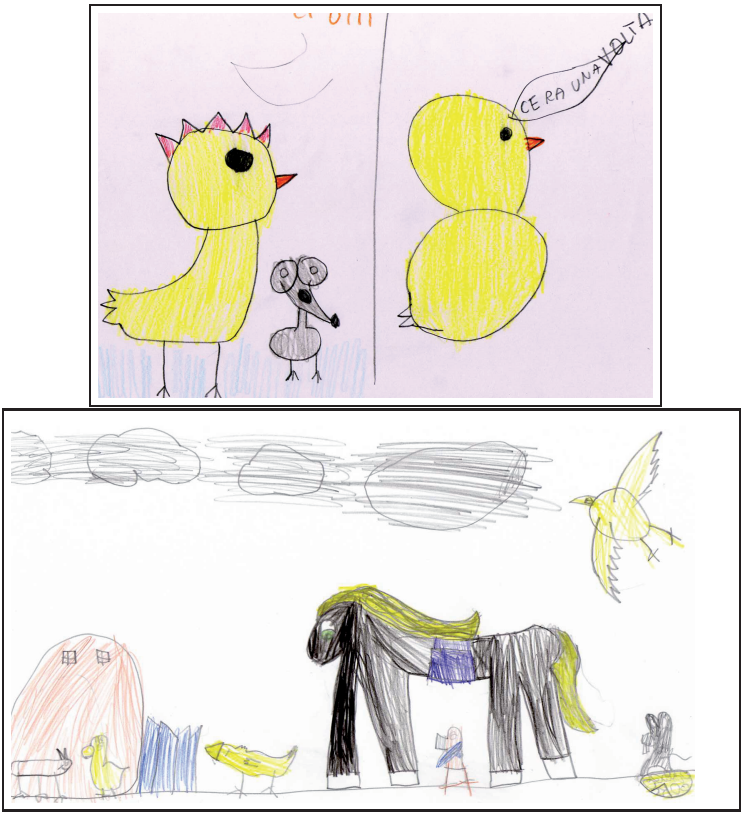

Fig. 5 The top drawing for task DW2 is by a (2b) child, and the bottom one for the same task is by a (1a) child.

9.3.2 The DW3 Drawing Task with the (2a) Class

Let us recall the sentence that children were asked to draw: "While mammy hen is worried about her little Gino, Gino is telling stories to the wolf". The (2a) children tended to mostly represent the two DW3 events diagonally (33%). The majority of them (61%) represented the two events in two separate scenes (see B2 in Subsection 9.3), depicted as physically separate, and distant on the paper sheet. Circa 50% of them also tended to include a common background. Circa 44% of them correlated the two events with a link (see B2 in Subsection 9.3).

Such results seem to contrast with those of their (2b) peers on DW2. Moreover, (2a) children, with low G scores, tended to adopt the common background strategy more than their peers with high G scores, $\chi^2(1) = 3,53$, $p = .06$.

10 Discussion

Let us revisit the two main goals of our evaluation, as stated in Section 3:

(G1) the type and quality of 6–8 olds' visualization strategies;
(G2) if class, grammar comprehension, and working memory capacity affect their visualization strategies.

As our result analysis shows, linear representations are frequently used by first and second graders alike, across tasks.

In the drawing tasks, other interesting strategies emerged and that we can use in the design of our visual tool, like the predominant adoption of a common background by first graders, the drawing of a concrete link (e.g., a path) between the correlated events when these are placed in two different scenarios. See also Subsection 9.3.

Our results also show that class and grammar comprehension skills (DS and G scores) can have an impact on the child's visualization strategies. Contrary to our expectations, verbal working memory did not affect the children's performances at any level in our study.

Given the same task, older children (in second-year classes) tended to represent the "while" relation more abstractly, e.g., the younger children adopted the common background strategy (59%), which is instead the least employed by (2b) children (19%) in the DW2 task. A representation with the core event on the left and the secondary on the right was rare, but significantly more frequent among the younger children. More generally, the visual patterns of the younger children seemed more conventional, with a dominant horizontal orientation.

The visual representation of the "while" between events also seems to depend on the type of events, and the type of Allen relation that the "while" corresponds to, as the DW3 drawing task suggests (it is vague, in that it corresponds to the Allen relation "during or finishes", and it happens in two different locations). In fact, when the "while" is as in the DW3 task, a number of second graders opt for more concrete drawing strategies, that is, the introduction of a common background (50%) and a link between the two events (44%). However, other studies are needed to assess such hypotheses.

Noticeably, grammar skills seem to play a role in discriminating those children that can be in trouble in representing the temporal relations of a story. For instance, children with low G scores in our study tended to represent a single event, when asked to depict relations between two events. This result is confirmed across the different types of tasks.

A final remark on the evaluation methodology is in order: according to our preliminary findings, drawings offer a richer set of information than transparencies, not only about the patterns of visual representations that are most common among children, but also on the strategies that children spontaneously adopt to render complex temporal relations.

11 Ongoing and Future Work

The adoption of linear strategies across tasks and types of children (according to their grammar comprehension, working memory, and class) is a relevant information for the design of our visual story-comprehension tool. The choice of a spatial linear representation is also supported by the preliminary results of [1], which seem to indicate that 7–8 olds can comprehend certain qualitative temporal relations of a story better with a spatial linear representation, based on the one in Figure 1, than with a choice-box textual visualization.

Moreover, an assumption consistent with the results of this paper is that the level of abstraction of the produced visual representations depends on the age and the type of "while" (see Section 10).

Currently, we are investigating whether old children and adults would indeed produce other or more abstract visual representations than young children did. In order to evaluate this, we conducted a preliminary experimental study with old children and adults, divided in two categories according to their experience in reading: ten old children (10–15 olds), and ten adults (16–30 olds). All underwent the Pre-test Phase, and their results with the digit span and grammar receptivity tests were high (see also Section 5). The experimenters let them read the experiment story, and handed out the transparencies of the Transparency Phase (see Table 3). Therein, a remarkably different strategy emerged: circa 70% of the experiment groups overlapped transparencies in order to represent the "while" relation, a strategy that 6–8 olds never employed.

In order to completely assess our assumption, a forthcoming study will extend the exploratory evaluation reported in this paper to a richer variety of "while" temporal relations, and thus provide us with a solid insight on the level of abstraction that novice readers may employ in such diverse cases.

12 Conclusions

This paper mainly discusses our experimental study with 6–8 old novice readers, first and second graders of an Italian primary school. Our analyzes reveal interesting common strategies that children employ for visually representing "while" temporal relations of a story. In particular, literacy maturity seems to play a relevant role in discriminating the sophistication and abstraction of the children's visual representations. The results of this work have triggered the novel evaluation that we are currently analyzing, and that involves old children and young adults, and a forthcoming one with a richer variety of temporal contemporaneous relations. In the conclusion to this paper, we also briefly reported on them.

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References

1. Arfé, B., Gennari, R., Mich, O.: Evaluations of the LODE Temporal Reasoning Tool with Hearing and Deaf Children. Tech. rep., TR of the MCES 2009 AAAI symposium (2009)
2. Chittaro, L., Combi, C.: Representation of Temporal Intervals and Relations: Information Visualization Aspects and their Evaluation. In: IEEE (ed.) Proc. of TIME (2001)
3. Di Mascio, T., Catarci, T., Santucci, G., Dongilli, P., Franconi, E., Tessaris, S.: Usability Evaluation in the SEWASIE project. In: L.E.A. (ed.) Proc. of HCI 2005 (2005)
4. Duran, N.D., McCarthy, P.M., Graesser, A.C., McNamara, D.S.: Using Temporal Cohesion to Predict Temporal Coherence in Narrative and Expository Texts. Behavior Research Methods (2007)
5. Ge, F., Xuehong, T.: Temporal Reasoning on Daily Events in Primary School Pupils. Acta Psychological Sinica 34, 604–610 (2002)
6. Gennari, R., Mich, O.: Constraint-based Temporal Reasoning for E-learning with LODE. In: Proc. of the Thirteenth International Conference on Principles and Practice of Constraint Programming (2007)
7. Gunthorp, K., Cassinelli, A.: Gino il pulcino e altre storie. Giunti (2002)
8. Hibino, S., Rundensteiner, E.A.: User Interface Evaluation of a Direct Manipulation Temporal Visual Query Language. In: Proc. of the ACM Multimedia Conference (1997)
9. Johnson-Glenberg, M.C.: Web-based Training of Metacognitive Strategies for Text Comprehension: Focus on Poor Comprehenders. Reading and Writing 18 (2007)
10. Knauff, M.: The cognitive adequacy of allen's interval calculus for qualitative spatial representation and reasoning. Spatial Cognition and Computation 1(3), 261–290 (1999), http://dx.doi.org/10.1023/A:1010097601575
11. Koerber, S., Sodian, B.: Preschool children's ability to visually represent relations. Developmental Science 11(3), 390–395 (2008)
12. Lode, the demonstration (2009), http://lodedemo.fbk.eu (retrieved June 11, 2009)
13. McColgan, K., McCormack, T.: Searching and planning: Young children's reasoning about past and future event sequences. Child Developmental Science 11 (2008)
14. Orsolini, M., Fanari, R., Cerracchio, S., Famiglietti, L.: Phonological and Lexical Reading in Italian Children with Dyslexia. Reading and Writing 22, 933–954 (2009)
15. Paivio, A.: Dual-coding Theory: Retrospect and Current Status. Canadian Journal of Psychology 45, 255–287 (1991)
16. Rustioni, D., Lanscaster, M.: Prove di valutazione della comprensione linguistica. In: Organizzazioni Speciali (1994)
17. Scott, C.L.: The Development of Some Working Time Concepts in Pre-school Children. Tech. Rep. ED407155, ERIC (1997)
18. Winskel, H.: The acquisition of temporal reference cross-linguistically using two acting-out comprehension tasks. Journal of Psycholinguistic Research 33 (2004)