Assessing Connective Understanding with Visual and Verbal Tasks.

Magali Boureux (1), Barbara Arfé (2), Margherita Pasini (1), Barbara Carretti (2), Jane Oakhill (3), Susan Sullivan (3)

(1) Università degli studi di Verona, (2) Università di Padova, (3) University of Sussex

Abstract The role of temporal and causal connectives is relevant in reading comprehension. Children with comprehension difficulties have problems in interpreting these connectives (e.g. Amidon, 1976; Feagans, 1980; Pyykkônen, Niemi and Järvikivi, 2003; Trosborg, 1982). The Adaptive Learning System (ALS) TERENCE aims to develop children's comprehension through the use of adaptive visual and verbal games. Within this framework, the purpose of this study was to assess connective comprehension with three visual and verbal tasks. Two hundred and eight English and Italian children participated in this study. The main results show that the use of pictures does not always support comprehension. Moreover, less skilled children perform better at simultaneous connective "while" compared to the temporal sequential connectives (before, after) and causal (because) ones.

Acknowledgments This research was supported by the European Commission through the Seventh Framework Programme for Research and Technological Development. Strategic Objective ICT- 2009.4.2 : ICT : Technology-enhanced learning for TERENCE project.

Introduction

Reading comprehension is a daily activity that we often take for granted; however in reading and understanding a text several complex cognitive processes are engaged (such as language, reasoning and memory skills). Approximately 10% of young readers acquire age-appropriate word reading skills but do not develop commensurate reading comprehension ability [7], which is below the predicted level for their word reading ability and their chronological age. These children are less likely than good comprehenders to integrate information in a mental representation of the text read [7]. In narrative texts, readers' ability depends on relating the narrated events to form a mental representation of their sequence. Readers use their knowledge of the language and their knowledge of the world to construct mental models of temporal and causal sequences of events narrated in a text. The

main difficulty in this process is that language does not always encode events chronologically in a text. Some studies showed that children aged 7 to 12 sometimes fail to reach the correct interpretation of temporal sentences [2,12,19,24]. On the contrary, adults and more expert readers tend to store sequential events in chronological order [3,16,20,25,27], and do not have difficulties in achieving a coherent mental model of the event order whatever the order of the encoded events [10,13].

Developing children's ability to understand temporal and causal relations in stories is the goal of TERENCE, a EU funded Project aimed at designing an Adaptive Learning System (ALS) for poor readers and their educators. A first step is to examine children's comprehension of temporal and causal relations expressed by explicit connectives, like "before", "after", "while" and "because". Connectives are the main linguistic devices that help readers to establish relations between the narrated events. They appear early in children's language production [23], but understanding of them is still developing in 10-year-olds [6], especially for connectives conveying complex cognitive relations, such as "while" [5]. We report the results of a study where the understanding of temporal and causal connectives was analyzed using tasks where the kind of information in support of the reader's reasoning was either visual (pictures) or verbal (text) (see material section).

Past studies of learning from text and pictures have shown that students learn better from text and pictures than from text alone [4,17]. In order to foster comprehension, information selected from the picture has to be integrated with information selected from text into a coherent mental representation [17,22,26]. Pictures in addition to text are especially suited for supporting cognitive functions that are not fostered by text alone [1,21]. Examples from visuo-spatial [15] or causal [14] reasoning show that such reasoning is easier when pictures support text. Some authors [9] argue that pictures can support critical psychological learning processes: they can support attention, help activate or build prior knowledge, minimize cognitive load and help to build mental models. On the basis of these observations, we predict that the comprehension of sentences with causal and temporal connectives should be easier when supported by pictures.

In our study, we compared the comprehension of causal and temporal connectives in a verbal context, given by a short narrative text, with comprehension of the same connectives in two tasks in which the context for interpreting the sentences was provided by pictures. Both sentence-pictures tasks respected the coherence between text and pictures, as suggested by Anglin, Vaez, & Cunningham, (2004) and Mayer (2005). In the first visual task, pictures helped the reader understand the events expressed by a sentence but not their (causal or temporal) relationship (Fig. 1) (tasks are described below). In this condition children's understanding of the relation between the events depended only on reading and processing the connectives in each sentence. In comparison, in the second visual task one picture depicted a situation that was coherent with the temporal or causal relation (and connective) expressed by only one of three presented sentences. Children

could understand both the events and their relationship looking at the picture, but they had to read (and understand) three sentences to choose the one that correctly described the situation in the picture (Fig. 2).

The performance of less skilled readers on the experimental tasks provides evidence concerning which tasks are more difficult, and the effects of visual aids on poor readers' performance. This information might provide indications for the development of the Artificial Intelligence Learning System (i.e. games).

Method

Participants

Sixty three English children (M=31; F=32) aged 7 to 11 years (M=9.03; SD=1.22) and 145 Italian children (M=76; F=69) aged 8 to 11 years (M=9.2; SD=.83) participated in the study. They attended schools situated in Sussex, UK (2 schools) and Veneto region in Italy (6 schools). All of the children spoke English or Italian fluently and had written parental consent to participate in the study. Data from those children with poor decoding abilities, or any known behavioral, emotional, or learning difficulties (provided by teacher reports) were excluded from the analyses reported in this paper.

Children were assessed with standardized reading tests: an adapted (listening) version of the Neale Analysis of Reading Ability—Revised British Edition [18] for English children, and, for Italian ones, "prove MT" - Revised Edition [11]. On the basis of their text comprehension score, children were classified as skilled comprehenders (SC) (SC English sample: N=35; Italian sample: N=102) or less skilled comprehenders (LSC English sample: N=28; Italian sample: N=43).

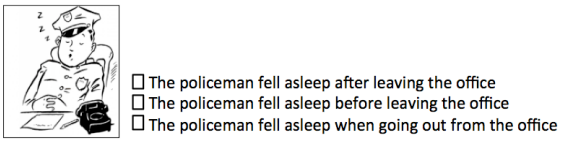
Materials

Three experimental tasks were set up to test the comprehension skills of temporal sequential (before, after), temporal simultaneous (while) and causal (because) connectives with different tasks, including pictures or not. Task 1 (T1) comprised 16 items. For each item, children had one sentence to read and 3 pictures portraying events expressed in the sentence, which were presented in a jumbled order. The child had to numerically order them (writing 1, 2 or 3 under each picture) according to the meaning of the sentence read (Fig. 1). In task 2 (T2), 21 items were presented. Each item included a picture that illustrated a situation or an event, and

three sentences differing only in their connective. The picture was consistent with one of the causal or temporal relations expressed by the connectives, but not with the others. Children had to choose the sentence that best matched the picture (Fig. 2).

Fig. 1. Example of Task 1 item. Children had to fill the blank space with the right number to order the picture story.

Fig. 2. Example of task 2 item. Children had to choose the correct sentence according to the picture.



Task 3 (T3) was a story of about 700 words (adapted from [8]). Twenty-four connectives of the story were substituted by groups of three connectives: one correct, in the verbal context of the text, and the other two wrong. Children had to choose the right one from the three, in order to restore the consistency of the story.

Design and procedure

The experiment took place in school. Children were tested in small groups of five students (in the UK), or altogether in their own classroom (in Italy). The standardized reading comprehension tests (NARA and MT) were administered to all children to assess their reading skills. In order to avoid tiredness both Task 1 and Task 2 were split and half of each of the two tasks were administered at two different times. The order of presentation of the different parts was counterbalanced across participants. Task 3 was completed in a separate session.

Data analysis

The results were analyzed for English and Italian children separately because of the differences between the languages and the reading tests used. Correlations be-

tween the scores on the reading tests and the three experimental tasks were run to test the validity of the tasks. We then conducted a mixed analysis of variance (ANOVA) to explore differences in correct responses (dependent variable), with task as the within factor (three levels: task 1, task 2, task 3), and skill group as the between factor (with two levels: SC and LSC). Since TERENCE is aimed at less skilled readers, a second analysis focused on this group was conducted. Two repeated measure ANOVAs were run, to verify differences in means of percentages of correct responses, one with the task as the within factor (T1, T2, T3), and one with the connective as the within factor (before-after; while; because), considering only the sample of LSC, separately for the Italian and English sample.

Results

The correlations between the comprehension scores and the tasks show differences between the two groups. For English children the correlation between reading comprehension scores (NARA) and Tasks 2 and 3 (picture-sentence match and verbal story tasks) was high ($r=.54$, $p<.001$ and $r=.51$, $p<.001$ respectively) and modest when Task 1 was considered ($r=.27$, $p<.05$). For Italian children, the results show that children's reading comprehension scores (MT tests) correlated with Task 1 and Task 3 (picture ordering task, $r=.36$, $p<.001$, and the verbal story task, $r=.38$, $p<.001$). No correlation was found between MT test and Task 2 performance.

The main effect of skill group was significant both for English ($F_{(1,35)}=3.68$, $p<.001$) and Italian children ($F_{(1,142)}=45.1$, $p<.001$), revealing that skilled comprehenders performed significantly better in all tasks. The analyses also revealed the main effect of task for English children ($F_{(2,70)}=27.409$, $p<.001$): Task 2 was easier than the other tasks. The same was found for Italian children ($F_{(2,284)}=54.875$, $p<.001$): the highest accuracy was for Task 2 and the lowest for Task 1. Also the interaction "Task" x "Skill Group" was significant for both English ($F_{(2,70)}=4.519$, $p<.05$) and Italian ($F_{(2,284)}=5.279$, $p<.05$) children. Task 3 was the best at differentiating between English SCs vs. LSCs. Task 2 was the one that differentiated the least between Italian SCs and LSCs: The higher accuracy of Task 2 yielded a ceiling effect for both groups (Tab.1).

The ANOVAs focused only on the less skilled readers showed that, in general, the performance was poorer in Task 1 than in Task 2. This difference was significant in both English ($F_{(2,34)}=17.210$, $p<.001$) and Italian ($F_{(2,84)}=23.731$, $p<.001$) children. The pattern of means was explored further with a series of paired sample t tests. For English children, performance on Task 3 was significantly poorer than performance on the other two tasks ($p<.01$). For Italian children, the poorest performance was on Task 1. However, Task 3 was performed less well than Task 2 ($p<.005$). These results confirm that the task supported by pictures (T2) is the

most simple for children with comprehension difficulties. In contrast, the most complex tasks were T3 for English children and T1 for Italian ones. These results suggest that pictures per se do not support reading comprehension more than verbal information, but do so only when they convey information about the relationship between events represented in the text. This information does not necessarily need to explicitly represent the relationship between two or more events, but could be inferred from the use of appropriate pictures that trigger children's world knowledge (as in Fig. 2).

Table 1. Percentage of Correct Comprehension responses as a Function of Comprehension Skill and Type of Task for English (UK) and Italian (IT) children.

		Task 1	Task 2	Task 3
English	LSC	65 (5.6)	80.7 (3.5)	46.6 (5.3)
	SC	66.2 (5.5)	87.9 (3.4)	69.2 (5.1)
Italian	LSC	60.3 (2.9)	86.5 (2)	74.8 (1.9)
	SC	77.4 (1.9)	91.3 (1.3)	87.5 (1.3)

Standard Deviations are shown in parentheses

The less skilled readers' comprehension of the connectives ("before-after", "while" and "because") revealed interesting results for both English and Italian readers. Indeed, we found that "while" was significantly better understood (UK mean=69.8, SD=4.2; It mean=83.5, SD=2.4) than "before-after" ($p<.001$) (UK mean=55.6, SD=4.1; It mean=66.7, SD=2.6) and "because" ($p<.05$) (UK mean=60.1, SD=3.8; It mean=71.6, SD=2.5) both by English ($F_{(2,54)}=5.633$, $p<.01$) and Italian ($F_{(2,84)}=19.091$, $p<.001$) less skilled comprehenders whereas we did not find differences in children's comprehension of "before-after" and "because" in either language. These results indicate that, in our Tasks, "while" relations were the easiest to understand for children with comprehension difficulties. Interestingly, the most complex connectives were the sequential ones "before" and "after".

Discussion

Correlational analyses showed that the experimental tasks requiring comprehension of temporal and causal connectives assess skills that are important for reading comprehension. However, whereas T2 discriminates well between English children with good and poor comprehension skills, it is less predictive of Italian children's comprehension because of ceiling effects. The differences between tasks results may be due to inherent characteristics of the two languages. Task 3 discriminates well between LSCs and SCs, mostly because, like the reading tests, it is a verbal task. This observation confirms the difficulty of children aged 7 to 11 years in interpreting connectives, as shown in [2,6,12,19,24].

As hypothesized on the basis of [4,17], pictures are useful for comprehension when they illustrate the situation described in the sentence (T2). In contrast, they do not support the comprehension of sentences when they do not illustrate the relationship between event and sentence (T1). In this case, accuracy is similar to that obtained in verbal task (T3). This finding shows that verbal tasks are not systematically more difficult than tasks supported by pictures. Pictures can make the task easier allowing inferences about the relation between events on the basis of the child's world knowledge, as in T2. When more complex cognitive processes are required, as in T1, pictures do not support verbal comprehension. In T1, readers could have difficulties not only when comprehending the sentence, but also when manipulating the pictures.

Interestingly, the sequential temporal connectives "before" and "after", and the causal one "because" were the most difficult, whereas "while" was the easiest. This pattern was found across tasks, and indicates that sequential events are probably more difficult to represent through language than simultaneous ones, contrary to that which was found in [5]. The difficulty for readers could be due to the fact they have to process the two sequential or causal events in the whole sentence context in order to understand which event is the first and which the second one. In contrast, "while" could be the most accurate because it mainly connects an event to a situation: its comprehension is linked more to reasoning processing and less to the sentence structure. Pictures can fully represent only one event at a time: thus, in the case of two sequential or causal events, the picture can represent only one of the two, and the reader has to infer the temporal or logical position of the one which is not represented. On the contrary, when representing "while" sentences, both pieces of information (event and situation) can be represented in the same picture. This observation seems to confirm the previous hypothesis that pictures help when they represent the relation between events.

Conclusions

The results of this research suggest some interesting implications concerning the comprehension of temporal and causal relations expressed by connectives in texts. Among them:

- verbal tasks are not systematically more complex than visual ones;
- pictures make reading comprehension easier when they allow inferences about the relation between events on the basis of the child's world knowledge, as in T2;
- the comprehension of "while" relations seems to be less sensitive to the kind of visual representation provided: a picture sequence or a single picture.

References

[1] Ainsworth, S. (2006). DeFT: A conceptual framework for considering learning with multiple representations. *Learning and Instruction*, *16*, 183–198.

[2] Amidon, A. (1976). Children's understanding of sentences with contingent relations: Why are temporal and conditional connectives so difficult. *Journal of Experimental Child Psychology, 22,* 423-437.

[3] Andersson, A., Garrod, S. C., & Sanford, A. J. (1983). The accessibility of pronominal antecedents as a function of episode shifts in narrative text. *Quarterly Journal of Experimental Psychology, 35A,* 427-440.

[4] Anglin, G. J., Vaez, H., & Cunningham, K. L. (2004). Visual Representations and Learning: The Role of Static and Animated Graphics. In D. H. Jonassen (Ed.), Handbook of Research for Educational Communications and Technology (pp. 865-913). NY: Simon & Schuster.

[5] Arfé, B ., Di Mascio, T., & Gennari, R. (2010). Representations of Contemporaneous Events of a Story for Novice Readers. *Studies in Computational Intelligence,* 314, 589-605.

[6] Cain, K., & Nash, H. (2011). The influence of connectives on young readers processing and comprehension of text. *Journal of Educational Psychology*, 103, 429-441.

[7] Cain, K., & Oakhill, J. (2006). Profiles of children with specific reading comprehension difficulties. *British Journal of Educational Psychology*, 76, 683-696.

[8] Cain, K., Patson, N., & Andrews, L. (2005). Age- and ability-related differences in young readers' use of conjunctions. *Journal of Child Language*, 32, 877-892.

[9] Clark, R. C., Lyons, C. (2004). Graphics for Learning: Proven Guidelines for Planning, Designing, and Evaluating Visuals in Training Materials. CA: Pfeiffer

[10] Claus, B., & Kelter, S. (2006). Comprehending narratives containing flashbacks: Evidence for temporally organized representations. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 32,* 1031-1044.

[11] Cornoldi C., Colpo G. (1995). Nuove Prove di Lettura MT per la Scuola Media Inferiore. Firenze: Organizzazioni Speciali.

[12] Feagans, L. (1980). Children's understanding of some temporal terms denoting order, duration, and simultaneity. *Journal of Psycholinguistic Research, 9,* 41-56.

[13] Gennari, S. P. (2004). Temporal references and temporal relations in sentence comprehension. *J. Exp Psychol Learn Mem Cogn, 30,* 877-890.

[14] Hegarty, M. (1992). Mental animation: Inferring motion from static displays of mechanical systems. *J. Exp Psychol Learn Mem Cogn, 18,* 1084-1102.

[15] Larkin, J. H., & Simon, H. A. (1987). Why a diagram is (sometimes) worth ten thousand words. *Cognitive Science, 11,* 65-99.

[16] Mandler, J. M. (1986). On the comprehension of temporal order. *Language and Cognitive Processes, 1,* 309-320.

[17] Mayer, R. E. (2005). Multimedia learning. New York, NY: Cambridge University Press.

[18] Neale, M. D. (1989). The Neale analysis of reading ability—Revised British edition. Windsor: NFER-Nelson.

[19] Pyykkönen, P., Niemi, J., & Järvikivi, J. (2003). Sentence structure, temporal order and linearity: Slow emergence of adult-like syntactic performance in Finnish. *SKY Journal of Linguistic, 16,* 113-138.

[20] Radvansky, G. A., Zwaan, R. A., Federico, T., & Franklin, N. (1998). Retrieval from temporally organized situation models. *J. Exp Psychol Learn Mem Cogn, 24,* 1224-1237.

[21] Scaife, M., & Rogers, Y. (1996). External cognition: How do graphical representations work? *International Journal of Human-Computer Studies, 45,* 185-213.

[22] Sless, D. (1986). In Search of Semiotics. London: Groom Helm.

[23] Spooren, W., & Sanders, T. (2008). The acquisition order of coherence relations: On cognitive complexity in discourse. *Journal of Pragmatics*, *40*(12), 2003-2026.