Modeling collaborative construction of an answer by contextual graphs

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Abstract

How is it possible to model the dialog between two partners collaborating to answer a general question? In this paper, we describe how contextual graphs allow analyzing oral corpus from person-to-person collaboration. The qualitative data obtained will be used to correlate with behavioral data (eye-movements obtained during subsequent reading) in order to get a dynamical perspective of comprehension during collaboration.

Keywords: Contextual graphs, collaboration.

1 Introduction

How collaboration can improve document comprehension? Starting from the C/I comprehension model [4], we have set up a series of several experiments aiming to test whether the ideas evoked during a prior collaborative situation can affect the comprehension processes and at which representation levels. The hypothesis was that collaboration affected directly the construction of the situation model. In order to test this hypothesis, we have built an experimental design with two phases: 1) collaboration phase 2) comprehension phase (reading and questionnaire). As far as the comprehension phase is concerned, we run several experiments (with eye-tracking technique) where participants of the experiments had to read a set of texts varying both semantically and from the lay-out. The general purpose was to correlate the verbal interactions occurring during the collaboration and the behavioral data (eye-movements and correct answers to questions) recorded during reading. In this paper, we describe *only how the collaborative verbal exchanges between two partners can be modeled using contextual graphs* [1].

As a side effect, this study concerns also two important points: first, the explicit consideration of the shared context for building the answer, and, second, the relative position of cooperation and collaboration which each other.

The shared context is the background from which the two participants of the experiments will build the answer. Even if one of the participants of the experiments knows the answer, s/he tries to build this shared context, and then the answer building is enriched with the generation of an explanation for the other participant.

Our goal is to provide a representation of the different ways to build an answer according to the context of the question. Along this view, the context of the question is the shared context where each participant introduces contextual elements from his/her individual context. The shared context contains contextual elements on which participants of the experiments agree, organize, assemble and structure to build the answer. The result of this answer building is a proceduralized context as defined in section 2.2. This situation can be replaced in a larger framework that distinguishes a procedure and the different practices developed for accounting for the contexts (like contextualization of the procedure); the prescribed task and the effective task, etc.

Thus, the goal is to analyze how an answer is built, its basic contextual elements and the different ways to assemble these elements. The modeling of the answer building is made, thanks to a context-based formalism of representation called the contextual graphs [1]. Contextual graphs provide a uniform representation of elements of reasoning (answer building) and contexts.

Contextual graphs are a context-based representation of a task execution. Contextual graphs are directed and acyclic, with exactly one input and one output, and a general structure of spindles. A path (from the input to the output of the graph) represents a practice (or a procedure), a type of execution of the task with the application of selected methods. There are as many paths as practices. Note that if a contextual graph represents a problem solving, several solutions can be retained. For example, in the collaborative building of the answer to a question, the building can result from one participant alone, both of them or none of them. A contextual graph is an acyclic graph because user's tasks are generally in ordered sequences. For example, repeating the question is always made at the beginning of the answer building, never during the process. A reason is that this is a way to memorize the question and retrieves all the elements more or less related to the question.

Elements of a contextual graph are: actions, contextual elements, sub-graphs, activities and parallel action groupings.

- An **action** is the building block of contextual graphs. We call it an action but it would be better to consider it as an elementary task. An action can appear on several paths. This leads us to speak of instances of a given action, because an action which appears on several paths in a contextual graph is considered each time in a specific context.

- A **contextual element** is a couple of nodes, a contextual node and a recombination node; A contextual node has one input and N outputs (branches) corresponding to the N instantiations of the contextual element already encountered. The recombination node is [N, 1] and shows that even if we know the current instantiation of the contextual element, once the part of the practice on the branch between the contextual and recombination nodes corresponding to a given instantiation of the contextual element has been executed, it does not matter to know this instantiation because we do not need to differentiate a state of affairs any more with respect to this value. Then, the contextual element leaves the proceduralized context and (globally) is considered to go back to the contextual knowledge.

- A **sub-graph** is itself a contextual graph. This is a method to decompose a part of the task in different way according to the context and the different methods existing. In contextual graphs, sub-graphs are mainly used for obtaining different displays of the contextual graph on the graphical interface by some mechanisms of aggregation and expansion like in Sowa's conceptual graphs [7].

- An **activity** is a particular sub-graph (and thus also a contextual graph by itself) that is identified by participants because appearing in several contextual graphs. This recurring sub-structure is generally considered as a complex action. Our definition of activity is close from the definition of scheme given in cognitive ergonomics [5]. Each scheme organizes the activity around an object and can call other schemes to complete specific sub-goals.

- A **parallel action grouping** expresses the fact (and reduce the complexity of the representation) that several groups of actions must be accomplished but that the order in which action groups must be considered is not important, or even could be done in parallel, but all actions must be accomplished before to continue. The parallel action grouping is for context what activities are for actions (i.e. complex actions). This item expresses a problem of representation at a lower granularity. For example, the activity "Make train empty of travelers" in the SART application [3] accounts for the damaged train and the helping train. There is no importance to empty first either the damaged train or the helping train or both in parallel. This operation is at a too low level with respect to the general task "Return back rapidly to a normal service" and would have otherwise to be detailed in three paths in parallel (helping train first, damage train first, both in parallel) leading to the same sequence of actions after.

A more complete presentation of these ideas and their implementation can be found in [1].

2. Materials and Methods

2.1 Experimental design

Eleven pairs of participants of the experiments were constituted. The participants were face to face, but did not see each other because they were separated by a screen. The experiment setup had two phases:

1. The collaboration phase lasted during 1mn30. Collaboration was induced by a general question: (ex: "How does the oyster make pearls?").
2. The reading/comprehension phase during which eye movements and answers to question were analyzed.

See Figure 1 for description.

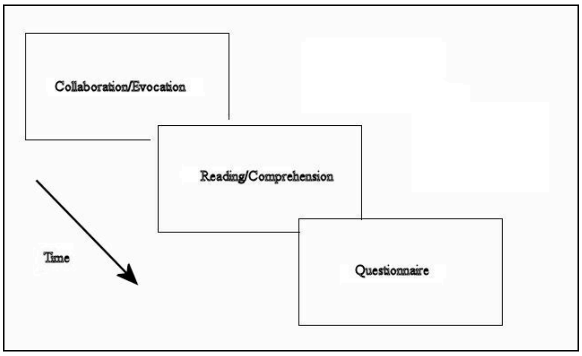

Figure 1: Experimental setup.

2.2 Collaboration analyses

A. Introducing our view on context

Brézillon and Pomerol [2] defined context as "what constrains a focus without intervening in it explicitly." Thus, context is relative to a user's focus (e.g. the user, the task at hand or the interaction) and gives meaning to items related to the focus. The context guides the focus of attention, i.e. the subset of common ground that is relevant to the current task. Indeed, context acts more on the relationships between items in the focus than on the items themselves.

For a given focus, Brézillon and Pomerol [2] consider context as the sum of three types of knowledge. There is the relevant part of the context related to the focus, and the irrelevant part. The former is called contextual knowledge and the latter is called **external knowledge**. External knowledge appears in different sources, such as the knowledge known by the partner but let implicit with respect to the current focus, the knowledge unknown to the partner (out of his competence), etc. **Contextual knowledge** obviously depends on the partner and on the decision at hand. Here, the focus acts as a discriminating factor between the external and contextual knowledge. However, the boundary between external and contextual knowledge is porous and evolves with the progress of the focus. A sub-set of the contextual knowledge is proceduralized for addressing the current focus. We call it the **proceduralized context**. This is a part of the contextual knowledge that is invoked, assembled, organized, structured and situated according to the given focus and is common to the various people involved in the answer building.

2.3 Qualitative analyses

A. Records as MP3 files

MP3 file corresponds to the construction of the answer by two participants of the experiments for one question and 1mn30 is let for providing the answer.

There are 11 couples of participants of the experiments having to address 16 questions. We analyzed the 176 files in two ways.

B. Analysis of the interactions

We analyze the answer building for all the questions for each pair of participants of the experiments. The goal was to establish a correlation inter-pairs in question management, and thus to have a relative weighting partner with respect to each question management.

We also were looking for some particular roles in each pair between participants of the experiments, such as a "master-slave" relationship between them, and also for comparing participants of the experiments (background, level of interest in the experiment, previous relationships between participants of the experiments, etc.). This observation allows understanding the type of roles between participants of the experiments.

C. Analysis of the content

<u>- Building the models</u>

For each question, we studied the answer building by all the pairs of participants of the experiments.

First, we look on the Web for the commonly accepted answer to the question in order to evaluate the quality of the answers provided by couples of participants of the experiments.

The quality of a given answer was estimated from:

The "distance" to the consensual answer on the Web,

-The answer granularity with respect to question granularity (same level, too detailed or in too general terms).

- The education of the participants of the experiments estimated in the other phase intervenes also here.

This is a delicate phase because one can give the right answer without knowing deep elements of the answer. For example, anybody can describe roughly the function of a refrigerator, but few know that this function relies on the 2nd principle of the Thermodynamics.

Second, we chose a sampling of 4 questions (with the 11 pairs of participants of the experiments). This allowed us to identify four main building blocks in the answers, these building blocks appearing in one order or another. Sometimes, a building block was not present in an answer building. This led us to point out four paths corresponding to four sequences of these 4 building blocks. As a limit of our approach, we have not been able in this preliminary phase to note a conflict situation.

Third, it has been possible to specify more clearly the paths from the types of interaction inside each group and the quality of the answer. Finally, a contextual graph met these first results.

File	E1	E2	E3	E4
1-01	**1**	**3c**	**2**	
1-02	**1**	**3c**	**2c**	
1-03	**1**		**2c**	**3**
1-04	**1**	**3**	**2c**	

Table 1: Dialog model application

- <u>Transcription and Analysis of the content</u>

The whole analysis of the 176 MP3 files was then done.

In a first time, the full transcription of the verbal exchange during the phase 1, for each participant, has been done from the MP3 files (transcription for partners working by pairs, answering at the sixteen questions). In a second time, the attended answers for each of the sixteen questions were set up. For example, for the question: "How does the oyster make pearls?" the answer expected is "A pearl borns from the introduction of a little artificial stone inserted into the oyster sexual gland. The oyster neutralizes the intrusive, the stone, surrounding it of the pearlier bag. Once closed, this pearlier bag secretes the pearlier material: the mother-of-pearl". Then, the analysis applies the *dialog*

3. Results

From the initial subset of MP3 files, two models have been built, the *dialog model* and the *contextual graph model*, and these models have been validated a posteriori on the whole set of MP3 files as mentioned in the previous section.

The *Dialog model* contained 4 phases:

E1. Reformulate the question

E2. Find an example

E3. Gather domain knowledge (collection)

E4. Build the answer either by looking for characteristics or by assembling explanation elements (integration)

For each pair of participants and for each question, the information was reported in a table (Table 1) allowing firstly to know in which order the 4 phases of the model dialog appeared, whether they appeared all four; and secondly, which of this phase is a collaboration phase. The participants reach the phase E4 only when they really built an answer, otherwise they collected the information without integrate them (phase E3). So, for each file, we have to identify in which order the phases appeared, to note which of these phases were collaboration phases and to report the information in a table. Results are summarizing into table 2.

	Colla	**Range**	**Freq**
E1	1	**1,27**	70
E2	10	**2,05**	58
E3	**120**	1,98	**133**
E4	71	1,77	**129**

Table2: Different mean values for phases E1..E4: frequencies into the collaboration (Col.1), Range of occurrences (Col.2), and Frequencies of occurrences (Col.3).

For example, column 1 indicates that collaboration used mostly phase E3 (i.e, gathering domain knowledge) and unlike phase E1 (Reformulation of the question). Column 2 shows that phase 1 appeared mostly at the beginning of exchange and phase E2 (Find an example) at the end. Column 3 reveals that phase E3 and phase E4 (construction) are the most frequent phases carry out into the exchange. Furthermore, collaboration appeared the most often at the beginning of exchanges.

The *contextual graph model* represented in Figure 2) possesses 4 paths:

- Path 1: Both partners do not know the answer
- Path 2: Both partners do not know the answer but have elements of explanation,
- Path 3: Co-building of the answer,
- Path 4: One of the partners knows exactly the answer and provides it. This information was reported in Table 2.

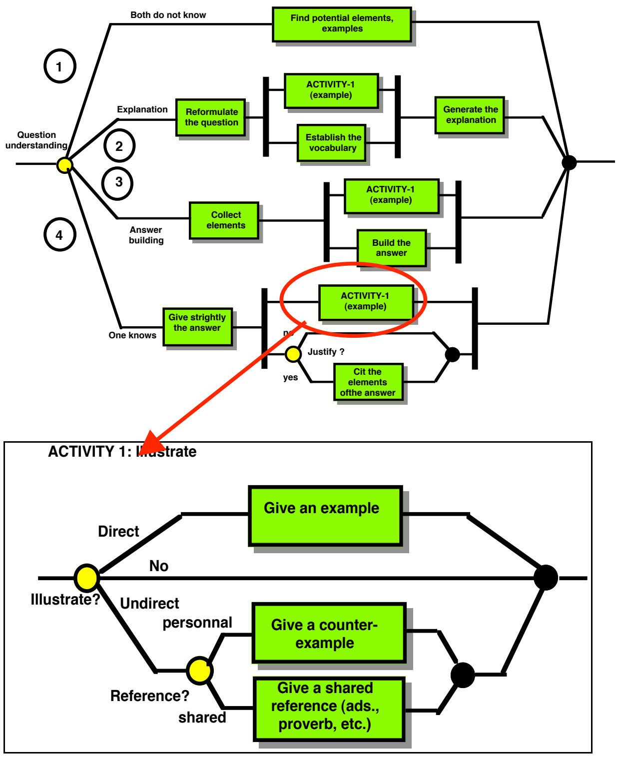

Figure 2: Contextual Graphs of the dialog with four branches and the details of the activity.

Path 1: *No knowledge about the answer*
Both partners do not know the answer. They have no elements of the answer at all. However, they try to utter some rough ideas (example, a parallel with a known topic) in order to trigger a constructive reaction of the other.

Path 2: *Elements of the answer*
Both partners do not know the answer but think to have elements for generating an explanation. Generally, a participant leads the interaction by proposing elements or asking questions to the other. Explanation generation is a kind of justification or validation to themselves of their general understanding of the question, without trying to build an answer.

Path 3: *Two-ways knowledge.*
Both partners have a partial view of the answer, know some of the elements of the answer and try to assemble them with the elements provide by the other. They have the same position in the answer building, and there is not need for explanations between them or for external observer. This is a situation of maximal cooperation. However, without external validation, the quality of the answer is rather variable.

Path 4: *One-way knowledge*
One of the partners knows exactly the answer, provides it immediately and spontaneously, and spends his/her time after to explain the other participant. Here the cooperation is unidirectional like the information flow.

Indeed, there is a relatively continuous spectrum between the path where one participant knows exactly (Path 4) and the situation where none of the participants knows (Path 1).

Typology of the answers or explanations
PB> Est-ce un sous-titre ou non? Semble bizarre ainsi car tout seul en plein ilieu de la section.

The typology aims to classify whether the answer has been given and the granularity.

a. Answer required at the right granularity
b. Answer required but at a superficial level
c. Answer required but too detailed
d. Partial answer
e. Answer partially false
f. False answer
g. No answer.

Participants	7 (sparkling water)	9 (hereditary diseases)
1	2-b	3-d
2	3-a	2-b
3	1-e	4-c
4	3-e	1-e
5	1-f	3-b

Table 2: Few paths and type of answers according to the typology.

In Table 2, the numbers represent the path in the contextual graph and the letters represent the typology of the answer. So, 3-b means Path 3: co-building of the answer and answer b: answer required but at a too superficial level.

The distribution of the type of answers across the 4 main paths is given in Figure 3. Interestingly, results show that when partners collaborated by co-building the answer (Path 3), they gave mostly the correct answer either at superficial level (b) or partial answer (d). When either Path 2 (elements of answers) or Path 4 (One-Way) has been used, no difference in the type of answers emerges.

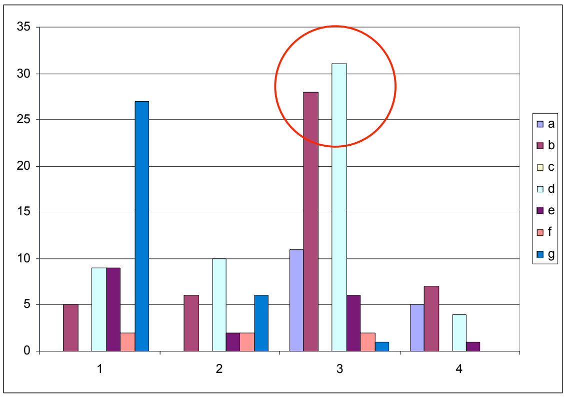

Figure 3: Frequencies of type of answers according to the 4 paths.

4. Discussion

Cooperation and collaboration are two ambiguous notions that have different meanings across domains, and sometimes from one author and another one. The difference between cooperation and collaboration seems related to the sharing of the participants' goal in the interaction. In cooperation (co-operation), each participant aims at the same goal and the task is divided in sub-tasks, each sub-tasks being under the responsibility of a participant. Thus, each participant intervenes in the shared goal through a part of the task. In collaboration, participants have different goals but interact in order to satisfy at least the goal of one of them, or one of his sub-goal. An example is the Head of a service and his secretary, often called a collaborator. The secretary takes in charge a part of the Head's task, but only as a support.

However, we think that the difficulty to agree between cooperation and collaboration relationships is the lack of consideration for the dynamic dimension of relationships. Two participants may cooperate at one moment and collaborate at another moment. The shift comes from their background (their individual contexts) with respect to the current focus and their previous interaction (the shared context). If one participant can fix the current focus, then the other only agrees, and there is a minimal cooperation, i.e. collaboration for validating the answer. If none of the participants knows how to address the current focus, they try together, first, to bring (contextual) elements of an answer, and, second, to build the answer as a chunk of knowledge [6] or a proceduralized context [1]. This is a full cooperation.

Several observations could be made from these typologies:

- Participants of the experiments have a problem for finding the right granularity of their answer.
- One can know the answer but not the elements. As a consequence, partners give an external and superficial viewpoint.
- Repetition of the question is when the participants of the experiments wish to be sure to understand correctly the question, i.e. to be able to find some relationships between elements of the questions and contextual elements of their mental representation of the domain.
- An answer can be given at different levels of granularity. Thus, we observe correct answer at the right level as well as at a too low level of granularity (too many details) or too high level (rough description of the answer). For example, “gaz” instead of “CO2”.
- Collaboration as a minimal expression of cooperation: one leads the interaction and the other only feeds in information (or only agrees), reinforce the statement of the other.
- When participants of the experiments gather contextual information, the goal is not to build immediately the answer because they want first to determine the granularity that their answer must have. Once, the level of granularity identified, the selection of pieces of contextual knowledge to use in the proceduralized context is direct. When they can not identify the right level of granularity, they enter the process of an explanation generation.
- An explanation is given to: (1) justify a known answer, (2) progress in the co-construction of the answer by sharing elements and their interconnection; (3) when participants are not sure of the granularity of the answer (e.g. partners speak of ‘gaz’ instead of ‘CO2’ for sparkling water). The explanation (given for an answer) is frequently less precise than an answer (generally at a macro-level), and is often for use between the partners.

- Several groups were confused and explain instead of giving the answer (thus with additional details not necessary).
- The answer appears to be a kind of minimal explanation.

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References

[1] Brezillon, P. "Task-realization models in Contextual Graphs." In: Modeling and Using Context (CONTEXT-05), A. Dey, B. Kokinov, D. Leake, R. Turner (Eds.), Springer Verlag, LNCS 3554, pp. 55-68, 2005.

[2] Brézillon, P. and Pomerol, J.-Ch.: Contextual knowledge sharing and cooperation in intelligent assistant systems. *Le Travail Humain*, **62**(3), Paris: PUF, (1999) pp 223-246.

[3] Brézillon, P., Cavalcanti, M., Naveiro, R. and Pomerol, J-Ch.: SART: An intelligent assistant for subway control. Pesquisa Operacional, Brazilian Operations Research Society, 20(2) (2000) 247-268.

[4] Kintsch, W. (1998). Comprehension: a paradigm for cognition. Cambridge: Cambridge University Press.

[5] Leplat, J. and Hoc, J.-M.: Tâche et activité dans l'analyse psychologique des situations. Cahiers de Psychologie Cognitive, **3** (1983) 49-63.

[6] Schank, R.C.: *Dynamic memory, a theory of learning in computers and people* Cambridge University Press (1982).

[7] Sowa, J.F.: Knowledge Representation: Logical, Philosophical, and Computational Foundations. Brooks Cole Publishing Co., Pacific Grove, CA (2000).