Logical constraints on spontaneous conversations *

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abstract

Few studies on natural use of language make use of logic to describe the content of successive replies and explain why all imaginable utterances are not admissible at a given point of a conversation. The study of spontaneous conversation at the logical level reveals that speakers non consciously obey very specific constraints when introducing a new topic. Whenever these constraints are violated (in experiments or after a misunderstanding) we observe reactions like "Why do you say this?" or "So what?".

Our model of conversations that we will describe using several real excerpts, allows only three logical ways of introducing a new topic during an unconstrained conversation. Furthermore it claims that every reply must have a logical effect on the alleged interlocutor's knowledge and that the list of these effects is dramatically limited.

This description of conversation as a sequence of logical actions is accurate enough to allow a computer program to reproduce the dynamic linking of arguments, by merely using the static logical knowledge each speaker has on the subject.

Keywords: conversation, logic, argumentation, relevance, Artificial Intelligence, CAL

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1.Natural use of natural language

Everybody is involved many times a day in conversations. Sometimes when we stop talking and begin to listen, we can hear the incredible noise made by other speaking humans. We spend much time in this linguistic activity which seems to be a distinctive characteristic of our species. So it is quite surprising to observe that spontaneous conversations are the object of a limited number of studies compared to the huge number of papers devoted to other aspects of natural language (e.g. syntax or semantics). Furthermore several authors consider that most models of "higher" aspects of language are still unsatisfactory (e.g. [Trognon & Brassac 1988:212]). Are all aspects of conversations so complex that they appear totally unconstrained?

Goodwin & Heritage [1990] explain the late interest of scientists for studying conversations by the fact that "both sociology and linguistics defined the scope of their subject matter in such a way that the relevance of talk-in-interaction fell between disciplinary boundaries". H. Bunt [1991] shows the difficulty of the conversation modeling task:

> "dialogue theories need other devices than, say, constituent structure diagrams and truth-conditional semantic rules. Instruments are needed to model such things as what each of the partners knows and believes and what communicative intentions they pursue. The representation of such things and how they can be used by an intelligent linguistic agent to perform successfully in a dialogue is far beyond the means of traditional linguistic theories".

Scientists became more concerned about studying conversations as such two decades ago when it became easier to record them and work on objective reliable data. This last point is crucial and unusual: when concerned with other levels of language like syntax, linguists take their examples most of the time from their own language production capability. They work on sentences that may never have been uttered by anybody in life situation. Such an approach may be fully justified for a study at the syntactic level. However studying conversations without relying on the use of real corpora may prevent from discovering important regularities.

Some scientists do study higher aspects of natural language without making use of any corpus, e.g. Discourse Analysis (see [Coulthard 1977]) and many studies using the paradigm of Speech Acts [Searle 1969]. However for our purpose, such a limitation seemed to be an obstacle.

Our approach is much closer to the *Conversation Analysis* method for at least one reason: we consider unconstrained conversation as a natural behavior that has to be studied as it occurs, and thus we decide to work only on data gathered on real situations. All the excerpts given in this paper come from conversations that really occurred (for discussions about differences between this approaches, see [Reichman 1989], [Goodwin & Heritage 1990], [Moeschler 1990], [Norman & Thomas 1991]).

Conversations can be studied from very different points of view. Many authors are concerned with sociological aspects: rules governing turn taking (how we know if we can or even must utter a reply at a given moment), conversational style (describing recurrent differences between speakers), how social relations are expressed in conversation (e.g. dominance, aggressiveness, politeness, cooperation), what kind of social acts are performed during conversation (perlocutionary acts), etc..

Other authors are more concerned with micro-features of conversations: interruptions, intonation, hesitations, etc.

Some authors are studying relationships between structure and function in conversations: how explanations, complaints, etc. are expressed through utterances, how decisions or truth are negotiated in interaction, and so on. For instance Drew & Holt [1987] show how idiomatic expressions are used under certain circumstances to express and summarize complaint during conversation; Reichman [1985] tries to identify "a conversation 'deep structure' in terms of structural relations between discourse elements"; Heritage [1990] shows how explanations are expressed depending on the social situation.

Our approach is closer to this last trend. In the present study, we are looking at the content of utterances, trying to describe how they are functionally linked together and with the topic. We are not describing social aspects of conversations[1], and wording details are relevant here as far as they can help us understand the meaning and context of replies. We will build a model of some aspects of argumentation, in which utterances appear to be logically constrained. This model will allow us to make some predictions about what an utterance can or cannot express at a given moment of a conversation.

But what do we consider here as a conversation? An extreme position may be to consider that every naturally occurring use of language has to be considered as a conversation. Our aim is of course much more limited: we are trying to find some constraints that people seem to observe under the following conditions:

- speakers with equal status
- relaxed speakers
- speakers knowing each other well
- speakers meeting frequently
- speakers not involved in a task-oriented conversation
- speakers being (at least momentarily) serious

We could summarize this by saying that we take only "banal" conversations into account. As we will see, their appear to be more constrained as more formal dialogues (cf. [dessalles 1992a]). Counter-examples that we shall avoid here are, for instance, a quarrel between wife and husband (as in [Schank & Lehnert 1979]), work conversations (such as operative language or dialogues occurring during design activities, studied for instance by Falzon [1991]), or very short interactions, like "What time is it please?".

In contrast, our own data consist mainly of more than 30 hours of family conversations involving most often more than three adult speakers. This approach to conversation claims to be "ecological", since it starts from the unprejudiced observation of human beings behaving normally. Some of the recordings were made "secretly", but most of the time the recorder was placed on the table and quickly forgotten, even by the observer. It was simply presented in fact as a way of taking a "sound photo".

I was always present and often participated in these recorded situations. One may be surprised by the fact that we did not keep our distance from the data. But this was necessary for at least two reasons: first it is understandable from an ethical point of view, and secondly, as we shall see, it is the best way to have a *perfect knowledge of the context*, and it was thus the only way we found to gain

[1] Our concern here is, as A. Trognon puts it, conversations, not people involved in conversation. This option will have many consequences here. For exemple, people are often said to cooperate during conversation. But replies themselves will be shown to have most of the time destructive effects on each other, even when uttered by the same person!

some insight into some of the rules governing conversations. But we will also use here data from other corpus whenever it is possible.

This last point which concerns the context must be stressed: many authors (see for instance [Sperber & Wilson 1986]) consider that the main goal of pragmatics is to find an objective way to determine what the relevant context is. I partially agree with this point of view, but our work claims to go further than a mere context identification (however, no doubts our work belongs to pragmatics) : our study of logical aspects of argumentation in spontaneous conversations begins as soon as the context is known. Having currently no way to extract relevant contextual knowledge, we study only conversations for which this context is unambiguously known.

summary: Conversation is a natural behavior, but few authors study it as such, trying to find a structure in their actual content. We work on real data the context of which is perfectly known.

2.Introduction

One of the main aims of research in Pragmatics, in our view, is to determine a list of constraints that limit the options of interlocutors during verbal interaction. If anything could be said, there would be no Pramatics ! However, at a given moment of an interaction, everybody knows that the range of options for the next speaker, though wide, is dramatically limited compared to what may be thought of. A very good indicator of such limits is the existence of *breakdowns* (like "What do you say that ?", or "So what ?"). These breakdowns, which are quite seldom in the spontaneous interactions that we recorded, suggest that a constraint was violated for one reason or the other (*e.g.* after a misunderstanding).

Our aim in this study is to propose a model of some constraints that limit logically what can be said during conversations. The observation of the type of conversations that are our concern here (see above) and for which the context is perfectly known will allow us to show that from the very beginning, when a new topic is introduced, conversations are logically constrained. A new topic must appear as problematic: either paradoxical, or improbable, or highly desirable or undesirable.

We will give a logical description of the part of shared knowledge that we call "logical context" and that makes the new topic problematic, and then show how next replies perform logical actions on this context. Only a few such actions will be allowed by the model: logical invalidations, "banalization" and "antagonistic" reactions.

We will give some indications on how further replies can be logically linked according to their type during conversation. Then we will test the model by briefly describing a program, PARADISE, which is able to reconstruct this linking of replies, thus filling the gap between mere static logical knowledge and argumentation.

The model presented here is claims to give an accurate and predictive tool to describe some aspects of argumentation in spontaneous conversations at the logical level. But it may also lead to technical applications. We will illustrate this possibility by describing the SAVANT3 program that is used to negotiate conceptual knowledge with students during a kind of "free" conversation.

3.Constraints and spontaneous conversation

In this paper we want to describe some of the constraints that restrict the interlocutors' freedom at the logical level during spontaneous conversation (these are not necessarily conscious of such constraints). This claim may be surprising, since it is not usual to consider daily conversations as heavily constrained. Admittedly one cannot say anything when involved in a conversation:

everybody has experienced the trouble caused by an abrupt topic change, provoking reactions like "What does it have to do with what we are saying?" or reactions showing misunderstanding ("remedial responses"), as shown in experiments performed by Vuchinich [1980]. But one may forget that there are many other constraints, as, for instance, the following excerpt reveals:

[ex_lunch]
context: A had a special lunch at his workplace, as is usual just before Christmas, and thought B had too.
A1- Et toi, ça va? Tu as bien mangé, à midi?
B1- Pourquoi tu me demandes ça?

A1- And you, are you okay? Did you have a good lunch?
B1- Why do you want to know?

B's reply was pronounced like a protest. A question like A1 seems to be not admissible out of context, as it was the case at the beginning of this conversation. Every time we observe a question like "Why do you want to know?", or some aggressive reaction showing a failure to understand the intended meaning of the last utterance, we may conclude that some conversational rule has been violated. In the following excerpt, the protest is expressed first through a grimace, and then by a sarcastic question:

[ex_train]
context: A (the author) comes home everyday by train. He utters A1 intentionally as an experiment, to observe B's reaction.
A1- J'ai pris le train.
B1- [grimace]... c'est un exploit?...

A1- I came by train
B1- [grimace]... Is that such a great feat?...

In these examples, the conversational problem arising between both speakers cannot be the consequence of any misunderstanding. In the first excerpt, it would have been easy for B simply to give the information required. B actually never did so during the rest of the conversation. In the second one, B could have simply acknowledged the very simple statement A1. This may indicate, if necessary, that spontaneous conversation *is not a mere exchange of information*, but another kind of game, a much more complex one, with its own rules.

It is highly surprising that scientists did not devote much work on such constraints which limit the *content* of what can be said at a given point of a conversation, regardless of social conventions. One may hope that obtaining results in studying these constrainsts may lead to a better understanding of natural language and to a better design of human/machine interfaces.

In his famous paper "Logic and Conversation" [Grice 1975], H.P. Grice mentions several "maxims" that speakers may follow normally in a conversation (unless they want to "implicate", i.e. insinuate, some fact or remark). One of these is simply "Be relevant". The main purpose of this paper to try to define some logical aspects of this concept of relevance more accurately, and to explore all the manners of being logically relevant.

4.Are spontaneous conversations logical?

Our attempt to model conversations led us naturally to make use of logic. But human conversations are not usually considered as logical: "If people behaved logically during conversations, disagreement would never occur!". This simple statement is often uttered together with 'people are illogical' or 'he reasons with his own logic'. Conversation topics may have little to do with truth. When we speak about beauty, love, art or wine, logic often seems absent. Moeschler, considering examples like "I am too late, but I will have a coffee", concludes that language, unlike classical logic, does not care about logical contradictions [Moeschler 1985:48] !

But our way of linking language to logic is different: we do not to consider here Logic as a Truth maintenance system. We shall not apply Logic to conversations in the same way as Russel, Carnap, Quine, Wittgenstein and many others did to language, but simply use it as a tool to represent the conversational meaning of each reply. The question will not be to know if a given reply expresses a truth, but to translate this reply using a logical syntax, as shown in the following example, taken from [Tannen 1984:62]:

[ex_Goffman] (from [Tannen 1984])
context: A,B and C were speaking about sociology, and B showed a fairly good knowledge of Erving Goffman's books. A and C are surprised, since they thought this author was known only among specialists.

A1- But anyway. ... How do you happen to know his stuff?
B1- Cause I read it.
C1- What do you do?
A2- [??] *are you in ... sociology or anything?*
B2- Yeah I read a little bit of it. [pronounced reed]
A3- Hm?
B3- I read a little bit of it. [pronounced red]
A4- I mean were you... uh studying sociology?
B4- No.
A5- You just heard about it, huh?
B5- Yeah. No. I heard about it from a friend who was a sociologist, and he said read this book, it's a good book and I read that book 'n
A6- I had never heard about him before I started studying linguistics.
B6- Really?
A7- Yeah.

In the preceding conversation, B appeared to have a very good knowledge of Erving Goffman's books, which was surprising since they are intended for sociologists. To quote D. Tannen, who is A in this excerpt: "Both C and I expected B to tell how his life - and more likely his work or education - led him to Goffman's books". We know enough to express the "knowledge" underlying the replies, first in English and then with a logical representation:

reply	contextual knowledge
A1, A2, A4:	*if somebody knows E.Goffman's books, then he must be a sociologist. B knows E.Goffman's books. Is B in sociology?*
B1, B2, B3:	*B read some of E. Goffman's books and then B knows them.*
B5:	*B has a friend, he is a sociologist, and he recommended E. Goffman's books and then B knows these books.*
A6:	*As long as A was a sociologist, A did not know E.Goffman's books*

This simplified version of the excerpt can be represented using a logical formalism[2] :

context of A1:	*knows*(**X**, Goffman's_books) ⇒ *sociologist* (**X**)
B1, B2, B3:	*read*(B**,**Goffman's_books) ⇒ *knows*(B, Goffman's_books)
B5:	*knows*(friend, Goffman's_books) **&** *sociologist*(friend) **&** *recommends*(friend, B, Goffman's_books)
A6:	**not** *sociologist*(A) ⇒ **not** *knows*(A, Goffman's_books)

This kind of logical translation suggests three remarks:

- it is not unique
- it does not capture all of the meaning
- some of its elements are not present in the replies as they are worded

For instance, the above representation does not make the distinction between all Goffman's books ("his stuff") and the single book mentioned in B5; the three replies B1, B2 and B3 are considered as equivalent; no distinction was made between sociology and linguistics in A6, and between *knows* and *read* in the context of B5, etc. The context of A1, as given here, is never expressed during the conversation. So how can we consider this representation as objective?

There is a single answer to the three previous objections. Since we are unable to perform this logical representation automatically, we are speaking about a kind of translation, made by hand. Like any translation, the logical representation cannot be unique, it is partial and involves implicit elements. Let us use an analogy. It is still impossible to perform automatic translation between two natural languages (on all subjects). But we use and trust translations made by interpreters, because we know that experts in both languages would agree to consider that they retain most of the meaning, and because they are always perfectible when precision is required. We will do the same with logical translations. But as a consequence it will be necessary to verify that any interpretation based on a logical translation of a given conversation will remain unchanged with another valid translation.

From a technical point of view, when we give a logical translation of a given excerpt, we use of a logical formalism that is fully in conformity with propositional logic or first order logic. The meaning of connectors like ***&***, ⇒, ***not*** is rigourously the meaning they are usually given, for instance in mathematics. Names of symbols are mnemotechnic and define an interpretation of symbols (predicates, domains of variable assignements, constants) in the real world in which the conversation takes place.

For instance, if *[p ⇒ q]* has the value "True" in the interpretation given by the situation, then *[p **&** **not** q]* will be regarded as "False" by interlocutors, while *[**not** q ⇒ **not** p]* wil be accepted as true. Moreover, if they know that *p* is "True", then *q* will be considered as "True". But if *q* is known instead, then *p* may be either true or false (have in mind an example like *p* = "*Peter drinks alcohol*" et *q* = "*Peter is over 18 years old*"). The semantics of implication is thus rigorously identical to the meaning of logical implication.

The choice of symbols depends on the precision wanted. For example, in the preceding excerpt, "*B knows Goffman's books*" can be represented by :

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[2] Here we make use of first order logic to represent this excerpt. Predicates are in italics, variables are in bold. [*knows*(**X**, Goffman's_books)] represents the fact that **X** knows Goffman's books. See annexe.

B_knows_Goffman's_books
knows(B, *Goffman's_books*)
knows(B, **L**) **&** *books*(**L**) **&** *author*(Goffman, **L**)
etc.

Symbol names reveals their meaning. For instance *knows(**X**, **Y**)* is a two-place fonctor syntactically, and a binary relation acting on the product of two sets, semantically. Our use of logic is thus perfectly "standard".

Going through a logical translation cannot be avoided. How could we find another way to represent the puzzle expressed by A and C in the preceding excerpt ? It is thus crucial to get a reliable logical translation.

But how can we trust a logical translation if people are making mistakes of logic? One of the results confirmed by this study is that definite mistakes of logic are indeed extremely rare. I could notice only three or four. Here is one of them:

[ex_animist]
context: A_and_B were speaking about religion. A provocatively identifies religion with animism, and wonders that such beliefs can be compatible with higher education.
A1- Je comprends pas qu'on puisse être animiste en ayant fait des études supérieures!
B1- Ca n'a rien à voir. Moi, j'ai pas fait d'études, et je suis pas animiste.

A1- I don't understand how people with higher education can be animists
B1- It has nothing to do with higher studies. I myself did not study, and I'm not an animist.

We can translate this by two formulas:

[A1]: *higher_educated*(**X**) $\Rightarrow$ **not** *animist*(**X**)
[B1]: **not** *higher_educated*(myself) **&** **not** *animist*(myself)

When reading this excerpt, we cannot imagine that B may be expressing in B1 anything but the negation of A1. This is also suggested by B1's beginning: "It has noting to do with...", which is a way to express that q is not related to p when $p \Rightarrow q$ was asserted. However the negation of A1 should be:

[B1']: *higher_educated*(somebody) **&** *animist*(somebody)

It is then very likely that B spoke too fast. That is actually what he acknowledged a few seconds later. It can be noticed here that this way of translating conversations into logic was not spoiled by a speaker's mistake of logic. On the contrary, it seems to be the only way to make this mistake obvious.

It is now possible to study spontaneous conversations from a logical point of view and to observe that even the very first intervention is heavily constrained.

Summary: without suggesting in any way that interlocutors exchange true statements that can be considered as logical by reference to an "absolute truth", we can make use of logic to locally describe the content of conversational utterances.

5.Logical representation of spontaneous conversations

5.1.Implicit knowledge

It's not good to say everything when you initiate a conversation. As Coulthard [1977:79] puts it, "if one's sister becomes engaged, some relatives must be told immediately, others on a first meeting after the event, whereas some of one's friends might not know the sister or even that one has a sister, and for them the event has no importance or even interest". When analysing a conversation between relatives about this sister, an external observer has to reconstruct the fact that she is not yet married, or that she changed her boyfriend recently. Such facts belong to implicit knowledge, and here lies the difficulty for the observer. This knowledge is shared by the speakers, what makes it possible to talk about the subject. But it is precisely because of this sharing that the major part of this knowledge is left implicit !

Implicit shared knowledge has so much importance during communication that slight gestures or knowing looks may stand for a whole conversation in certain contexts, where many words would be necessary to explain the situation to a stranger. Will conversational analysis be ever possible in such conditions? It must be clear that the information contained in exchanged words cannot be sufficient to allow a reconstruction of implicit knowledge. If somebody simply says "I'm hungry", the context may include the fact that the restaurant is about to close, or that the person addressed is supposed to cook something, or that the speaker did not have time to have lunch, etc.. This hidden knowledge is necessary to analyse the intervention "I'm hungry", but also to simply understand its meaning which may be "hurry up, it's going to close", or "this time it's your turn to cook", or "sorry, I must go and eat something."

This shared knowledge also includes, of course, common sense and cultural knowledge, and no artificial system is able nowadays to isolate the context from this huge quantity of information, i.e. the relevant items which are necessary to confer meaning on a conversational excerpt. Pragmatics has just begun to bring out some principles and definitions about what a relevant context may include. But our situation here is much more comfortable, since we study only conversations for which we already know the context. The problem is then simply to extract from this context the few elements that are necessary for our modeling purposes.

5.2.The logical context as part of the shared knowledge

Everyone is fully able and trained to isolate relevant implicit knowledge during a conversation. People do this spontaneously, but as for many psychological processes, they don't know how. But can we be sure that this implicit knowledge is shared? People understand perhaps what they wish to hear, as in many political discussions. Of course they attribute inference capabilities to each other which allow them to decipher what was not said. But how can one be sure that no misunderstanding may go unnoticed?

One indication is that when misunderstandings are cleared up during everyday conversations, this rectification occurs very soon after the origin of the divergence. The following excerpt contains an example of misunderstanding. It comes from a conversation about longevity, which started with a joke about a 78-year-old man who still had his mother.

[ex_Abraham]
context: previous conversation was about exceptionally old people who are in good health.
A1- Hé, quel âge il avait, Abraham, quand il a procréé?
B1- Oui, mais tu sais, on est pas très sûr ...
A2- L'état-civil n'était pas très sûr.
C1- Je sais pas si on a enregistré un record. Ca doit être assez élevé. C'est sûrement supérieur à 80 ans.
B2- Mais, de quoi tu parles?
C2- comme ...
B3- comme géniteur?

A1- How old was Abraham when he procreated?
B1- Yes, but you know, you can't be sure ...
A2- The government archives were not very exact.
C1- I don't know if the record holder is registered in Guiness' book. He must be quite old. He must be more than 80 years old.
B2- But, what are you speaking about?
C2- a...
B3- a procreator?

When listening carefully to the recording, one is convinced that B believes that C is talking in C1 about a longevity record. B had indeed initiated this topic, and Abraham's name is usually associated with the idea of an exceptionally old man. She is thus quite surprised to hear C1 this way: "The longevity record is certainly above 80 years old", and she reacts with B2. But she understands what C had in mind (B3) even before he had time to explain. The misunderstanding that B was able to detect was neither at the semantic level (after all what she understood makes sense), nor at the level of contextual pragmatics (she relied on a context, even if it was not the correct one). What our model will suggest is that B detected logical misunderstanding in B2. Such logical troubles are rare, quickly detected and experienced as intolerable in usual conversations.

This proves our capability of extracting the logic which lies in the interlocutors' replies and which often remains implicit. The words '*logical context*' will be used here to denote this *implicit or explicit part of the shared knowledge which gives its logical meaning to each reply*. The logical context must be obvious to the speakers, or else they express their trouble and a breakdown occurs. It is quite easy to provoke this kind of problem consciously by starting a conversation with a intentionally uninteresting statement, as was the case in [ex_train]:

[ex_train2]
context: A comes home everyday by train. He utters A1 intentionally as an experiment, to observe B's reaction.
A1- J'ai pris le train.
B1- [grimace]... *c'est un exploit?... Ah! C'est parce qu'il y a des grèves.*

A1- I came by train
B1- [grimace]... *Is that such a great feat?... Oh! It's because they are striking.*

A1 is devoid of interest because A catches the train everyday. It is striking to notice that the person addressed succeeds in constructing a plausible, though groundless, logical context (there was actually no strike at all) which gives A1 a logical relevance: *if* they are striking, *then* trains are overcrowded, *and then* catching an overcrowded train is highly undesirable. But before this, she reacted aggressively, as a consequence of the lack of any context that could provide logical relevance to A1.

This concept of logical context could be thought to be non-operational. How can we decide what in the shared knowledge should or should not be part of the logical context, when this context is not made explicit by the speakers? Sperber and Wilson [1986] try to solve this problem, but in a way which is not convenient here since it does not allow to predict breakdowns. It may seem very difficult to obtain the logical context. Fortunately a procedure exists which gives an experimental way to bring it out. Simply say: "So what?", "Why do you want to know?", "Why do you say this?", or "What are you getting at?", and the first speaker will spontaneously make explicit some elements of the logical context of her/his intervention (your difficulty has to appear clearly motivated, or else answers may be different, involving aggression or humour).

5.3.The "So what ?" experiment

The "So what ?" experiment may sometimes occur naturally as here:

[ex_Mercedes]
context: On the highway from Paris to Germany. Big Mercedes are common. B does not notice that the mercedes just passing had a Hungarian license number. At the time, when Hungary was a communist country, individuals were supposed to be not rich.
A1- T'as vu la Mercedes ?
B1- Hé bé quoi ?
A2- Tu savais que les hongrois, ils avaient des voitures comme ça ?

A1- Did you see the Mercedes?
B1- So what?
A2- Did you know that Hungarians had such cars?

Elements given in A2 (Hungarians were not supposed to own big cars) allows to isolate the logical context from shared knowledge unambiguously:

$$\textit{Hungarian}(\mathbf{X}) \Rightarrow \mathbf{not}\ \textit{rich}(\mathbf{X})$$
$$[\textit{has}(\mathbf{X}, \mathbf{Car}) \ \&\ \textit{big}(\mathbf{Car})] \Rightarrow \textit{rich}(\mathbf{X})$$

Sometimes the logical context is spontaneously made explicit by the first speaker before other participants ask for it. We could observe this phenomenon in [ex_Goffman, p.6], where the logical representation of A6 was exactly an instantiation of the logical context of A1 (with **X** instantiated to A). In the next excerpt, we observe an ironic reply as a consequence of a misunderstanding about the context, which will be made more explicit by the first speaker.

[ex_antenna]
context: 1987 near Paris; parabolic TV antennas are very rare on private houses, while every house has its "comb" antenna.
A1- Tu sais, j'ai vu une antenne sur une maison de la rue des Roissys
B1- Dis donc, quel événement!
A2- mais non, une antenne comme... une antenne parabolique

A1- you know, I've seen an antenna on a house of the Roissys street
B1- gee, what an event!
A2- but no, an antenna like, a parabolic antenna

Something interesting happens here: there are two contexts: "A saw a 'comb' aerial in the neighbourhood", and "A saw a parabolic antenna in the neighbourhood", but only the second one makes A1 relevant while the first one, which is what B perceived, provokes the ironic reply B1. The relevance of A1 comes clearly from the fact that seeing a parabolic antenna in the neighbourhood is *a priori* very improbable (while it is not the case for usual antennas). It seems that pure logical formalism is unable to represent the meaning of A1-A2. That is why we introduce a new modality, **IMPR**, which denotes a highly improbable fact. So we get something like:

$$[\ \textit{parabolic\_antenna}(\mathbf{X})\ \mathbf{\&}\ \textit{neighbourhood}(\mathbf{X})\ ]\ \Rightarrow \mathbf{IMPR}$$

Here ($p \Rightarrow \mathbf{IMPR}$) simply means that p is *a priori* highly improbable (see annex). In [ex_Abraham, p.10], this modality would have been also necessary to express the logical context: the fact that being a procreator when being very old is *a priori* highly improbable. Here the variable ***X*** denotes any object, since the assessment of the *a priori* probability holds for any object and not only for the specific object A saw.

Notice that in these excerpts where a breakdown occurs ([ex_Abraham, p.10] B2, [ex_Mercedes] B1, [ex_antenna] B1), the second speaker did not experience any trouble at the semantic level or at the level of contextual pragmatics : the meaning of what was heard was unambiguous, it was linked to the context and thus could fit in pragmatically. The trouble was essentially *logical*.

Most of the time, the logical context remains implicit, especially when nobody needed to ask about it. But fortunately, one can perform this "So what?..." experiment as a thought experiment. This way the observer knowing shared knowledge can often understand what the logical context consists of. In the following excerpt, we can imagine what A would answer if B had said "why do you say this?".

[ex_card]
context: A had bought several postcards for different friends, and has begun writing on them.
A1- Oh zut, je me suis trompée de carte. J'ai écrit cette carte à C.
B1- Pff, qu'est-ce que ça peut faire?

A1- Hell! I got the wrong card. I wrote this card to C.
B1- Oh, does it matter?

A chose cards for specific friends, and suddenly realizes that he made a permutation. This is undesirable, if each card was intended for a specific friend. Once again, we need a new modality to represent this context:

$$[\textit{intended\_to}(\mathbf{Card}, \mathbf{Friend1})\ \mathbf{\&}\ \textit{written\_to}(\mathbf{Card}, \mathbf{Friend2})\ \mathbf{\&}\ \mathbf{Friend1} \neq \mathbf{Friend2}] \Rightarrow \mathbf{UND}$$

This time [$p \Rightarrow \mathbf{UND}$] stands for "p is highly undesirable". This modality would have been also necessary to represent the logical context of [ex_train2, p.10] as it was perceived by B after B2: catching an overcrowded train is highly undesirable. Notice here again the use of variables ***Card***, ***Friend1*** and ***Friend2*** that make the logical context more general than the actual situation.

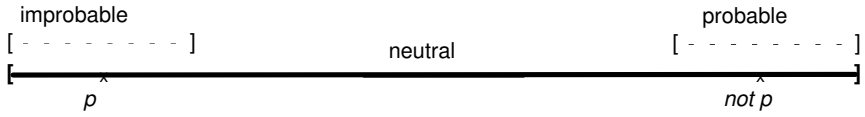
5.4.Conversational logic

One could fear that a new modality will have to be introduced every time we come upon a new excerpt. As it turns out, this is not the case. To put it differently, three modalities, **F**, **IMPR**, **UND,** will be sufficient in our model to represent the logical meaning of replies. **F** stands for an ever false proposition, and is used to rewrite first order logic in a symmetrical way. So [p1 $\Rightarrow$ p2] will be rewritten as [(p1 **& not** p2) $\Rightarrow$ **F**]. [(a **&** b) $\Rightarrow$ **F]** will thus mean that a and b are logically incompatible. For convenience we will also use the modality **DES** (highly desirable fact) as a synonym of not **UND**, and also **PROB** instead of not **IMPR**. We can sum up the semantics of this conversational logic:

p $\Rightarrow$ **F**	p is false
p $\Rightarrow$ **IMPR**	p is highly improbable
PROB $\Rightarrow$ p	p is highly probable
p $\Rightarrow$ **UND**	p is highly undesirable: the occurrence of p is sufficient to make the speaker unhappy
DES $\Rightarrow$ p	p is highly desirable: the speaker cannot be happy without p
p $\Rightarrow$ **DES**	p is desirable: the occurrence of p is sufficient to make the speaker happy
UND $\Rightarrow$ p	p is undesirable: the speaker cannot be unhappy without p

Notice that with this semantics, formulas like $p \Rightarrow$ ***PROB*** or $p \Rightarrow$ ***T*** (avec ***T* = *not F***) are superfluous, since they impose no constraint on *p*.

In this representation, if *p* is improbable, then (***not*** *p*) is probable (but nothing can be said when *p* is neither improbable nor probable). We must be clear on this relationship between logic and probability. Figure 1 shows an axis on which we can ideally locate any event (represented here by a proposition *p*) according to its *a priori* probability. If *p* is located in the improbable zone, then ***not*** *p* is symmetrically located in the probable zone. For instance to win on the national lottery is highly improbable, while not to win is highly probable[3] .



---------- figure 1: probability axis ----------

This formalism allows us to make a difference between ($p \Rightarrow$ ***UND***) and (***UND*** $\Rightarrow p$). We will give real examples that illustrate each case.

[3] This axis should not be confused with a space showing $\{x|imp(x)\}$ and $\{x|\neg imp(x)\}$ as complementary sets, where $imp(x)$ would be a predicate giving the improbability of events *x*.

Of course ($p \Rightarrow$ ***UND***) is strictly equivalent syntactically to [***DES*** $\Rightarrow$ ***not*** p] (see annex). The meaning of this is that happiness requires highly undesirable fact to be suppressed. Conversely, [***UND*** $\Rightarrow p$] is the same as [***not*** $p \Rightarrow$ ***DES***], and means typically that [**not** p] is a nice event to be noticed, without p having undesirable consequences. We will avoid mixing both modalities ***IMPR*** and ***UND*** in the same formulas because, as it turns out, it is unnecessary.

It will be further verified that this formalism can be successfully used to represent the logical meaning of replies and contexts. We will begin to show how some of the constraints that speakers have to place on the first intervention can be easily modeled using conversational logic.

Summary: we cannot study or even understand a conversation if the shared (and most often implicit) knowledge is unknown. Logical context is part of the shared knowledge. Some breakdowns during conversation may occur if this logical context is wrongly perceived even when the semantics of what was said and the pragmatics of the situation were correctly detected. The "So what" experiment is a way to make the logical context explicit, and a simple logical formalism using the modalities **IMPR** and **UND** can be used to represent this context.

6.How spontaneous conversations start

Introducing a new subject during a conversation is not made anyhow by people. For our purpose we will observe that they do this in only three different ways which we can represent in our model. The first way is to mention an improbable event.

6.1.The improbability mode

We are going to model first a kind of conversation which occurs very frequently: conversations that start with the mention of some unusual event. This includes current facts (we feel compelled to draw attention on the fact that a tortoise is walking through the garden), or past "incredible" stories. All these facts share the property of being *a priori* improbable, and this is precisely what we should expect if we look at conversations using the Shannon paradigm. Let us begin by giving an example.

[ex_car]
context: A is speaking to his son C, whose sister ordered a new car the same week.
A1- Je t'ai dit que B a commandé une nouvelle voiture?

A1- Did I tell you that B ordered a new car?

In this context where B buys a car every ten years, C can *a priori* assign a very low probability to one of his sisters buying a new car at the beginning of that week : we can consider that since there are about 50 weeks in a year, the event had less than 10^{-2} chances to occur on that week. It is easy to make the logical context explicit as:

orders(**X**, car, this_week) $\Rightarrow$ **IMPR**

How can we link this to the Shannon model? Spontaneous conversations are often presented as an information exchange. But what exactly is information? When a person you know is about to speak to you in a situation suitable for conversation (during lunch for instance), you may assume that she is going to give you some piece of information: for instance that X bought a new car. This concept of information is widely used when speaking about language. However we wish to use it here in its narrow meaning as it was established by Claude Elwood Shannon [Shannon 1948]. The

amount of information contained in a symbol coming from the message source is measured by *log(1/p)*. In this formula *p* stands for the symbol's *a priori* probability. It seems actually normal that a very improbable event (reception of a rare symbol) produces much information when it occurs.

Using this definition of information may have surprising consequences in our context. It seems natural that the mentioning a rare event brings more information. But the analogy can be carried further. In the Shannon paradigm (digital communications), the message *source* (for us the speaker) emits *symbols* (for us here: mention of facts or events) towards the *destination* (here the listener) where they are supposed to be **RE**cognized. This means that the receptor has to know in advance which symbols may occur and which is the *a priori* probability of each of them! Let us see how we can transpose these restrictive features into a model of informative utterance.

Can we imagine that the listeners "know" in advance all the events that can be told to them? In a sense yes. This means that all events that can be mentioned at the beginning of a conversation in the improbable mode are known by the listeners as possible. Moreover, the listeners have to be able to assess the *a priori* probability of such events, and this assessment is hoped to be very low by the first speaker.

This is qualitatively consistent with the Shannon definition. However these probabilities are qualitatively estimated, and cannot be assigned precise quantitative values [Savage 1972:31]. We had this situation in the last excerpt, but also with [ex_antenna, p.11] A1-A2 (a parabolic antenna in the neighbourhood is *a priori* improbable) and with the question [ex_Abraham, p.10] A1 (Abraham was improbably old when he became father).

The transposition of the Shannon model is particularly suggestive and fits very well with our data. More precisely, it allows to express constraints on what can be replied after an introduction in the improbable mode.

In these examples, in which a conversation starts with the mention of an improbable event, the information transmitted from the first speaker to the listeners results from the combination of two elements: the actual message (which mentions an event explicitly) and the logical context (most of the time implicit), the role of which is to allow an estimation of the message's improbability. We will now have other occasions to check the usefulness of logical context.

6.2.The paradoxical mode

All natural conversations do not function in the improbable mode. In other words, one cannot consider each initiating utterance as carrying information, in the restrictive Shannon sense. We will describe here a kind of conversation that everybody can experience daily: conversations that begin with an astonishment, like those beginning with "That's strange..." or "I never understood why...".

[ex_twin-towns]
context: A had been driving through a village where a sign indicated that it was twinned with a town in the same country. A expected twin-towns to belong to different countries.
A1- Tout l'heure, j'ai vu un village jumelé avec une ville d'Alsace!

A1- I've just seen a village that is twinned with some place in Alsace !

In A1, the two places belong to different regions of France. This is not an *a priori* improbable fact, since the logical context is not "I have seldom the opportunity to notice such twinnings". If we

asked A "Why do you say this", he would answer something like: "I thought that twin towns have to be in different countries". The context can be represented by:

[*twins*(**Town_A**, **Town_B**) **& not** *foreign*(**Town_A**, **Town_B**)] $\Rightarrow$ **F**

Using this knowledge, if we wanted to compute an *a priori* probability for twin towns being in the same country, this probability would be found strictly zero. Can we seriously consider A1 as infinitely informative? The answer is no, and we must admit that A1 was not intended to bring an information in mentioning an event of infinite rarity.

The first speaker tells about a fact which appears to him as a paradox, as a contradiction between the observed fact and what he knows, but not as a rarity[4]. We had the same situation with [ex_Goffman, p.6] A1, [ex_Mercedes, p.11] A1 and [ex_animist, p.8] A1. In each case the logical context allows the interlocutors to draw the negation of the uttered event through a logical proof: B was *a priori* expected not to know Goffman's books because he was not a sociologist; Hungarians were expected not to own big cars because they were known to be poor; higher educated people were expected not to be animists. This is why we speak of contradictions, or paradoxes.

We will see below other reasons to make a qualitative difference between paradox and improbability, and not to consider the former as a limit of the latter. One of these lies in the different forms of replies that are admissible in both cases. But for now, we have yet to observe another kind of topic introduction that is radically different from a paradox or an improbability.

6.3.The (un)desirable mode

We will describe here the very frequent introduction of topics that involve a fact or contingency presented as undesirable.

[ex_hungry]
context: students speaking together
A1- Bon sang j'ai rien bouffé ce soir.
B1- [mangeant un hamburger] *Tu veux un peu de mon hamburger ?*
A2- Non, non, merci, pas de hamburger.
C1- Vous voulez des gâteaux ? J'ai des cookies.
A3- Et tu attends 9H pour les proposer ?!

A1- Damn I didn't eat anything tonight.
B1- [eating an hamburger] *Do you want a bite of my hamburger?*
A2- No, no hamburgers, please.
C1- Do you want cookies? I got cookies.
A3- And you waited till 9 o'clock to offer them?!

We could hardly find anything paradoxical or improbable there. A1 is obviously the manifestation of an undesirable fact, what the following representation of the logical context makes clear:

dinner_skipped $\Rightarrow$ *hungry*
hungry $\Rightarrow$ **UND**

[4] We will see that facts presented by locutors as paradoxical can even be frequent.

We had a similar case with [ex_card, p.12] A1. Here is an example of an introduction in the desirable mode. A speaks about a ski resort (one of the largest in the world):

[ex_ski]
context: the group of skiers stops for lunch. They are in a ski resort which is said to be the biggest in the world.
A1- Ce qu'il y a de bien ici, c'est que c'est très étendu. C'est pas étouffant, la vallée.
B1- oui
A2- Partout où je suis allée,...

A1- What is nice here is that it is spread out. The valley isn't stifling.
B1- yes
A2- Everywhere I have been, ...

We can represent the context by:

spread_out $\Rightarrow$ **not** *stifling*
not *stifling* $\Rightarrow$ **DES**

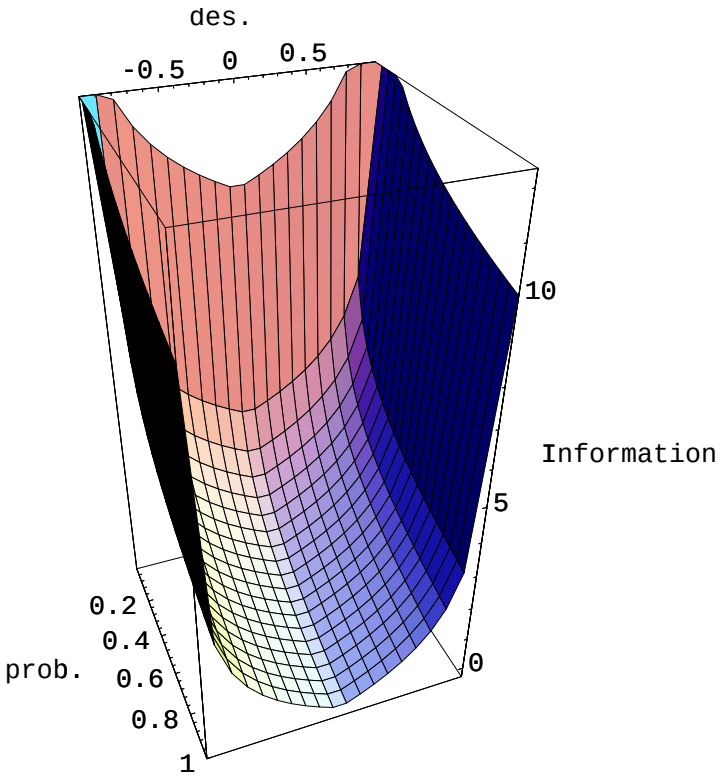
Here we chose [**not** *stifling* $\Rightarrow$ **DES**] instead of [**DES** $\Rightarrow$ **not** *stifling*]. A2 (the record of which is incomplete) seems indeed to indicate that A usually tolerates "stifling" ski resorts. Thus [**not** *stifling*] appears to be a sufficient way to change a normal situation into a desirable one.

These introductions in the (un)desirable mode bear some resemblance to the improbability case. We may assume that the speakers are able to assign *a priori* a positive or negative desirability value to each imaginable event. One can even see in this parameter a second dimension of information. For instance, the event "X has been elected" brings only one bit of information in the Shannon sense if the two candidates are more or less equally matched. But it may bear a very high (un)desirability value depending on who you favored, if you feel concerned by the election.

One could thus think of extending the Shannon definition to a two-parameters function which links each event that may be mentioned to a couple of numbers *(p,d)* where *p* measures the *a priori* probability of the event, and *d* its *a priori* desirability (between -1 and 1). We can define a *Conversational Information* function this way:

Conversational Information: $$I_c(p,d) = \log_2 \frac{1}{p\,(1-|d|)}$$

where *p* and *d* are characteristic of a given event. This formula is a simple extension of the Shannon formula for a single event. Conversational Information appears to be a growing function of desirability ($d > 0$) or undesirability ($-d > 0$), with infinite values reached on extreme values of *d* ($|d| = 1$). It is thus shaped like a V-shaped valley between three mountains.



---------- figure 2: conversational information ----------

This conversational information represents information in the improbable and (un)desirable modes, but not in the paradoxical mode. It is not possible to measure the information brought by a logically impossible fact (such a fact is different from a fact with probability zero, see p. 36).

6.4.Classification of conversations

Three different ways of introducing a new topic have been illustrated. Since, as it turns out, the linking of further replies depends crucially on the introduction mode, it is essential to get the complete gamut of admissible topic initiations. The main prediction of the model presented here is that, for the kind of conversations considered here, the three modes evoked above: improbability, paradox, (un)desirability, form an exhaustive classification.

First principle of logical relevance :

Every conversation relies on a problematic (improbability, paradox, (in)desirability).

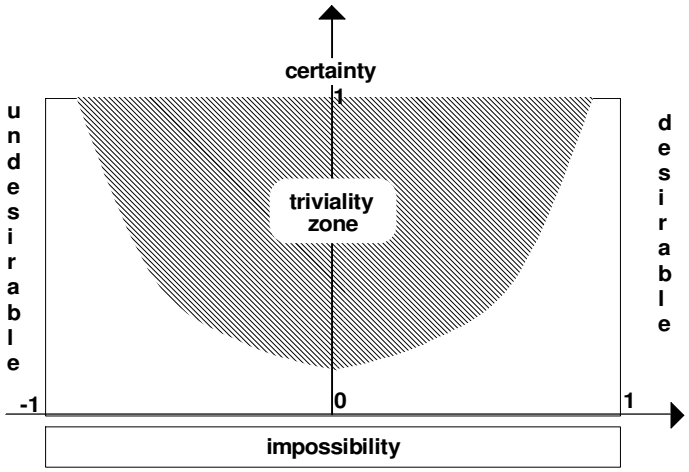
Such a limitation could be surprising. What about conversations that begin with a question? And could we not think of other kinds of introductions? Could we have for instance a conversation starting with a mere true statement, or with the expression of an opinion, without them mentioning a paradoxical or improbable or (un)desirable event? This may be possible for other types of conversations (in experimental or goal-oriented situations). However the model presented here with the three above mentioned modes fits very well with the data I have gathered, and we claim that it may apply to most unconstrained situations (as defined previously p. 3) accurately.

This classification of the logical properties of introductions in spontaneous conversations into three classes: improbability, paradox, (un)desirability, is a predictive, and therefore falsifiable, model. The model predicts that heavy constraints affect the first speaker behavior: in the kind of spontaneous conversation we described at the beginning of this paper, any new topic has to be placed into a logically problematic[5] context. But the listener's behavior is constrained as well. If the introduction cannot be heard as belonging to one of the three types by the listener, then the model predicts that we will systematically observe a *breakdown* like "So what?" or whatever. We had this situation in [ex_Mercedes, p.11] B1, and in the first part of the intentionally provoked reaction [ex_train2, p.10] B1. In the natural situation of [ex_Mercedes], A1 was actually intended in the paradoxical mode, but B failed to perceive this because he was lacking one element of the logical context.

It could be argued that this classification of introductions in three types does not consist of clear-cut categories. Consider the imaginary utterance: "I came across a car that was driving the wrong way on the highway!". This may be perceived as a paradox if one has some reasons to think that this event is impossible under normal conditions ("- and the driver didn't notice anything?"), or as an improbable fact ("- once it happened to me as well"), or has an highly undesirable event ("- How did you react ?"). The criticism is justified at this point, but we can give two answers. First, in many of the real situations, contextual mode appears unambiguous to the interlocutors (see [ex_Como] p.35). Second, even when the introduction may be perceived as belonging to different modes, the reaction is unimodal, as we will see in a further section.

It appears convenient to situate new topics in a two-dimensional space. Analysis of further replies will indeed indicate that probability and desirability can vary independently, and can be considered as two degrees of freedom. An admissible topic has to be presented as having an extreme value for at least one of these two parameters. The initial intervention will appear as "normal" if and only if it is placed by the listeners outside of the triviality zone of figure 3. The hyperbolic shape of the border of this zone corresponds to a constant conversational information (cf. p. 17). The first utterance will be represented in the impossibility zone if the mentioned event is paradoxical, just above if it is improbable, far to the right if it is desirable or to the left if it is undesirable. This bidimensional representation allows a new topic to be for instance undesirable and improbable at the same time, by locating it in the lower left corner of the diagram. This representation will prove to be very useful when we study the effect of replies on logical context.

[5] This term does not take the desirable mode into account, but it is a convenient way to summarize how a new topic should logically appear.



---------- figure 3: relevance space ----------

6.5.Apparent exceptions

Before asserting that there are obvious exceptions that do not fit the model, the reader is invited to imagine them in context. It seems indeed difficult to imagine somebody initiating a new topic by an assertion that would not appear clearly as paradoxical, improbable or (un)desirable in situation. Such an assertion would be perceived as a banality and would provoke repair reactions.

But one thinks immediately of initiations that consist not of assertions, but of a question. Let us first say that new topics are quite often introduced in an assertive way, unlike what some models seem to take as granted[6] . But questions are nevertheless frequent and they need to be integrated into our model. Indeed when asking a question, the first speaker does not necessarily say anything (un)desirable, improbable or impossible. But there are constraints also on questions, as the excerpt [ex_lunch, p.5] shows: any question is not admissible in a given situation, even such a insignificant question as "And you, are you okay? Did you have a good lunch?".

In fact the constraints that are listed in our model are not expected to act on the question itself, but on the answers the questioner may anticipate. Let us see this on examples.

[ex_Channel] (from [Crystal & Davy 1975:52])
context: two couples (B and C, A and D) have been comparing holiday experiences. Discussion came upon the best means of crossing the English Channel.
C3- I see. How did you get - I mean how did you find that side of it, because...
A4- marvellous
C4- you know some people say that... that driving a car across a ferry is the devil of a job
A5- well this was...
D3- across a...
C5- I mean taking a car across to the continent on a ferry is... is hell
A6- no it isn't at all
D4- why
C6- I don't know but...
[. . .]

[6] For instance in the IRF model of conversation structure, which is often mentioned ([Coulthard 1977:135]; [Stubbs 1983:136]; [McTear 1985:35]), the role of initiation is most often played by a question.

C9- well I'll tell you the sort of thing I've heard, I mean ev every summer, you see stories of tremendous queues at the...
D8- but they're people who haven't booked

Here logical context is not made fully explicit by C before C9 (after first attempts in C4 and C5) which shows that C is checking an undesirable fact. In asking C3, C expected comments about queues, because queues are highly undesirable ("it's hell").

We could observe questions checking the occurrence of a paradox with [ex_Goffman, p.6] A1, C1, A2, A4, and with [ex_Mercedes, p.11] A1. Questions may also contribute to recount or confirm an improbable event, as in [ex_Abraham, p.10] A1 (if Abraham was really old when he procreated, then the event is improbable) or in [ex_car, p.14] A1 (if I forgot to tell you that your sister ordered a new car, then it is still an improbable event to you).

We may of course ask questions for which we have no idea of the answer: "What is the capital of Burundi?". But one has again to imagine such a question in situation, as a way to introduce a new topic. What would be said after a reaction like "Why do you want to know?"? According to the model, the first speaker would then reveal a problematic[7] situation. It may go from an undesirable lack of instantiation (e.g. if the speaker is doing crosswords) to a more structured problem (e.g. some inconsistency when reading a novel about Africa). But even the lack of instantiation has to be specifically problematic. In other words, the model excludes unmotivated questions.

Our model predicts that every time a speaker introduces a new topic by asking a question during an spontaneous conversation (s)he has a precise idea of at least one possible answer or of some of its characteristics[8], and that **this expected answer is logically problematic** (either paradoxical, or improbable, or (un)desirable). Furthermore, the listeners most of the time need to be aware of this anticipation [cf. Fox 1987:375]. When they fail to perceive it, as in [ex_lunch, p.5] A1, they utter a protest (remember that interlocutors are supposed to know each other well). In [ex_lunch] , A thought B had a special lunch at her workplace, as is usual just before Christmas. A was thus checking a desirable fact.

Questions cannot therefore constitute exceptions to the introduction rule as such, and the model take them into account when the context is known. But we may find other cases where the first utterance seems to conflict with the model, as for instance this reply heard after an interlocutor left the room, hearing her baby crying:

[ex_calm]
context: a baby is crying. His mother stood up and went upstairs to comfort him. Somebody makes a comment:
A1- Je ne crois pas que le fait d'y aller, ça aide à les calmer.

A1- I don't think that going there helps to calm them.

This statement has nothing to do with any improbable or impossible event. "Going there" is not presented as having disastrous consequences. Did we find a case unpredicted by the model? One feels that something is undesirable in this situation (as the remainder of the conversation shows): the possibility that the baby keeps on crying. Everybody around the table heard a baby crying and could have said: "Listen, he is crying again!", indicating by this an undesirable event. This implicit

[7] or desirable.

[8] in the crossword example, this may be some known letters, but this example is extreme as introduction of a topic.

utterance logically precedes A1, and our model of the first intervention should be applied to it, and not to A1. These situations where first utterances are not uttered seem to be quite rare (there are only a few examples in the corpus, which all coincide with obvious external events). Speakers, except when trying to be humorous (but it is not our concern here), seem to make special efforts to be explicit, even to the point of unnecessary redundancy.

6.6.Defining the subject

Our model of the first utterance can be expressed in these words: a topic will be successfully introduced if and only if the logical context (which is part of the pragmatically relevant knowledge associated with the topic) includes a problematic link that we can write this way[9] :

$$[\ p_1\ \&\ p_2\ \&\ \ldots\ \&\ p_n\ ]\ \Rightarrow\ \mathbf{MOD}$$

where **MOD** represents one of the modalities **F**, **IMPR**, **DES** and **UND**, and where all the p_i are believed to be true. We will refer to this relation by the term *saturated clause*.

This model of the first utterance allows us now to give a precise definition of what the subject or the topic of any current conversation is. The topic is said generally to be a possible answer to the question "what were you speaking about?". But such a definition is too vague and may range between a single word and the replay of the conversation.

According to our model, the saturated clause is essential to characterize a given conversation, and we propose to consider it as defining the subject. As soon as this saturated clause changes in the run of conversation, the topic can be said to have changed.

We have now to study what can be the logical effect of further replies on the topic, and to understand better what "logical relevance" means.

Summary: according to the model, a new topic must obviously appear either as paradoxical, or as highly improbable, or as highly desirable or undesirable. It must bring a high *conversational information*. If not, then the model predicts that a breakdown will occur.

7.The second utterance

The first utterance was shown to be heavily constrained. But when all constraints have been perceived as being respected, are there still limits on what can be answered by interlocutors? This is the subject of this section.

7.1.Reactions to a paradoxical fact

Consider the following excerpt, in which A is amazed at a paradox:

[ex_chicken]
context: "farm-raised" chicken are much more expensive, but many people prefer to buy them. A is amazed at this behavior, since "farm-raised" is for him only a word, not a genuine guarantee.
A1- Alors ce qui impressionne les populations, c'est le mot garantie . Un gars qui fait des poulets d'élevage, il met garanti fermier, alors tout le monde se précipite.

[9] Here only propositions are represented for the sake of simplicity. p_i may involve a negation. See annex.

B1- Mais il y a des labels
A2- Oui, mais garantis par qui?
B2- Mais ils le disent, par qui, parfois... par la chambre syndicale des machins...

A1- So people [illegible]
raises chicken, he puts "guaranteed farm-raised", then everybody buys.
B1- but there are official seals
A2- yes, but who guarantees them?
B2- But they say it, sometimes... guaranteed by a poultry producers' association...

According to A, trust a mention which is not guaranteed is illogical. For him, the context includes the piece of knowledge that we represent with the following clause:

[*purchase-caused-by*(**Mention**) **& not** *guaranteed*(**Mention**)] $\Rightarrow$ **F**

The logical context, when A1 is uttered, contains this saturated clause, but also the following facts that we represent using negative clauses[10] :

guaranteed(farm-raised-mention) $\Rightarrow$ **F**
not *purchase-caused-by*(farm-raised-mention) $\Rightarrow$ **F**

The paradox can be represented by the first clause, where all terms become true when the two other clauses are taken into account, with [**Mention]** being instantiated to [farm-raised-mention]. What is then the logical action performed by B1? With B1, B tries to establish [*guaranteed*(farm-raised-mention] by adding a piece of knowledge to the logical context, what we represent by adding the following clause:

[*seal*(**L**) **&** *goes-with*(**L**,**Mention**) **&** *guaranteed*(**L**) **& not** *guaranteed(***Mention**)] $\Rightarrow$ **F**

and by assuming that some guaranteed seal **L** may exist. The preceding clause can be indeed rewritten as:

[*seal*(**L**) **&** *goes-with*(**L**,**Mention**) **&** *guaranteed*(**L**)] $\Rightarrow$ *guaranteed(***Mention**)

The effect of B1 is thus to invalidate A's paradox by directly denying one of its terms [**not** *guaranteed*(farm-raised-mention)]. We will call this type of reaction *direct invalidation*.

Since there are two terms in the saturated clause, our logical translation would predict another possibility for a direct invalidation. B could have said something like: "they don't buy because they see a label; these chickens look actually better", thus denying [*purchase-caused-by*(farm-raised-mention)]. Direct invalidation, which consists in denying one of the terms making up the saturated clause, or at least casting doubt on it, offers a quite limited number of possibilities and is thus easily anticipated by the model.

[10] Any knowledge base expressed in propositional logic can be rewritten as a (conjunctive) set of negative clauses like [p_1 **&** p_2 **& . . . &** p_n] $\Rightarrow$ **F.** This is a mere reformulation of the normal conjunctive-disjunctive form. We extend this representation to conversational logic by using the three modalities **IMPR**, **IND** et **DES**. See annex.

Notice that the logical context is modified as the conversation moves on. Here a piece of knowledge was made "active" by B and had to be added to the logical context. We are going now to observe cases in which the saturated clause itself is modified. Indeed many reactions to paradoxical introductions cannot be represented by direct invalidations. We saw one example of this in [ex_Goffman, p.6]. At the beginning, the paradox was represented by the saturated clause :

[*knows*(**X**, Goffman's_books) **& not** *sociologist* (**X**)] ⇒ **F**

In this dialogue, B5 ("I heard about it from a friend who was a sociologist, and he said read this book, ...") has no effect on both terms of the saturated clause, and thus B5 is not what we called a direct invalidation. However, we get the feeling that the paradox is invalidated after B5. This can be understood is we notice that the preceding clause is no longer correct and has to be replaced by :

[*knows*(**X**, Goffman's_books) **& not** *sociologist* (**X**)
& not *recommends*(Y, X, Goffman's_books)] ⇒ **F**

In other words, when denying the last term above, B5 does not invalidate the initial saturated clause, but a modified, augmented, version of this clause.

That is why we speak of *indirect invalidation*. Indirect invalidation differs from direct invalidation by the denied term : here this term was "forgotten" in the saturated clause. When asserting [*recommend(friend, B, Goffman's_books)*], B5 denies a term which appears as a forgotten premise in the initial context. The possibility of indirect invalidation for a given context is fundamental, and the distinction between direct and indirect invalidation is syntactically obvious as soon as the logical context is expressed in logical form.

The possibility of indirect invalidation should not give the impression that this way of replying is poorly constrained. All the modifications of the saturated clause are indeed not admissible ! The modified paradox has to be accepted by the first speaker. Just imagine A's reaction if B had replied "it's because I am hungry". More precisely, if the saturated clause is (in propositional logic):

$[p_1 \,\&\, p_2 \,\&\, \ldots \,\&\, p_n] \Rightarrow \mathbf{F}$

a direct invalidation is a negation of one of the p_i, while an indirect invalidation involves the negation of an added premise p_{n+1}:

$[p_1 \,\&\, p_2 \,\&\, \ldots \,\&\, p_n \,\&\, p_{n+1}] \Rightarrow \mathbf{F}$

An indirect invalidation is admissible as long as the surprised speaker can accept it as denying a forgotten premise p_{n+1}. In other words, this speaker has to accept that what we represent with the preceding clause really represents the actual incompatibility that (s)he had brought up.

We should not wonder that some premises like p_{n+1} may be "forgotten" by the first speaker. After all, any incompatibility noticed in real life presupposes that the world still exists, that people are at a single location at any time, and so on. But requiring that a given fact p_{n+1} can be recognized as part of the initial incompatibility remains a very strong constraint on what can or cannot be considered as an admissible invalidation. In the preceding excerpt, A would have accepted (without necessarily agreeing) that B denies hypotheses like:

- people do not read a book by chance
- one reads only books of ones domain of competence
- reading a book cannot be the consequence of a bet
- etc.

because these terms can be acknowledged by her as being part of the saturated clause. But presumably, she would not have admitted arguments denying:

- Goffman is blond
- Goffman's books have an even number of pages
- the climate in Oregon is mild

because she would not accept to consider them as part of the incompatibility, and because in this case the truth value of these terms has no effect on the paradox.

The admissibility of an invalidation is totally dependent on what the logical context is or on how this context could be augmented to integrate forgotten premises. The procedure by which we can tell if such a premise is admissible is exactly the same as the procedure by which the logical context was obtained. This role is normally devoted to pragmatics. But in the absence of a reliable method, this job can be done by any observer who knows the situation perfectly well. We will see that under certain circumstances an artificial system can recognize indirect invalidations when having "conversations" with humans.

The total range of replies predicted by the model after an introduction in the paradoxical mode is thus quite limited. Any reply must be acknowledged as an admissible invalidation of the saturated clause (unless this invalidation is delayed by some reaction of co-astonishment as we will see p. 37). Remember, in [ex_Goffman, p.6], how A and C were dissatisfied with B1, B2, B3, and B4, which had no effect on the saturated clause: the fact that B read the books did not invalidate any term in the saturated clause. On the contrary! They eventually obtained an indirect invalidation in B5.

Any invalidation of a paradoxical context can always be described as an *explanation*. After an utterance in the paradoxical mode (which we described as a model-based surprise in [dessalles 1992b]), an explanation is due. Conversely, any spontaneously occurring utterance that looks like an explanation of an uttered or anticipated surprise can be considered as an indication of some underlying paradox.

In this section we showed how the model constrains the second reply, at least in the case of paradoxes. Let us examine now what can be an acceptable reply following an introduction in the improbable mode.

7.2.Reactions to an improbable fact

7.2.1.Invalidation of an improbable fact

The following excerpt is in the improbable mode:

[ex_sting]
context: A calls B to see a strange insect
A1- Tiens, regarde le dard qu'elle a
B1- ça alors!

A2- C'est marrant
B2- C'est pas un dard, c'est une trompe

A1- Look at this sting!
B1- You don't say!
A2- That's funny!
B2- That's not a sting, That's a proboscis!

A brings an information because insects' stings are supposed to be much shorter. This one is improbably long. We can write this this way:

[*sting*(**S**) **&** *length*(**S**, **L**) **&** (**L** > 1cm)] ⇒ **IMPR**

This context breaks down after the direct invalidation B2. We see that an invalidation (here a direct one) may occur in the improbable mode. So is there any distinction between the paradoxical and the improbable mode, or should we consider the former as a limit of the latter? As it turns out, we must maintain this distinction, since, as we will see, there is another way of replying in the improbable mode that is not acceptable after a paradoxical introduction.

7.2.2.Banalization of an improbable fact

[ex_thirst]
context: A and B are speaking about D, their great child. D (one year old) seems to remember them after a separation of several months. B claims not to be surprised: the boy laughed when hearing their voice at the phone. A few seconds later C notices that D swallows a big quantity of water.
A1- Apparemment, il nous avait pas oubliés.
B1- Non. Il nous a pas oubliés quand ... il riait aux éclats quand il entendait notre voix.
[pause]
C1- Hé ben, il avait soif!
B2- Oui, il avait soif. Je m'en suis douté, qu'il avait soif!

A1- It seems that he didn't forget us.
B1- No. He didn't forget us when ... he laughed when he heard our voice.
[pause]
C1- Gee, he was thirsty!
B2- Yes, he was. I suspected that he was thirsty!

The first topic is about a child (D) that A and B see after a long separation. D is so young that it was *a priori* improbable that he could remember them. A1 brings information, in the Shannon sense. B1 does not invalidate the reasoning leading to **IMPR** in any way. If we could ask B why she uttered B1, she would certainly "answer":

laughed_when_hearing(E, *A_and_B*) ⇒ **not** *forgot*(E, *A_and_B*)

The logical context initially was:

[*young*(E) **&** *long_separation*(E, *A_and_B*) **&** **not** *forgot*(E, *A_and_B*)] ⇒ **IMPR**

So B1 performs no invalidation. On the contrary, it seems to confirm A1! This excerpt is quite remarkable, because B shows exactly the same behavior with C one second later, on the next topic.

C is impressed by the quantity of water D is swallowing, and thus brings information by focusing on an improbable fact. B2 seems once again to be a confirmation.

Many authors consider conversation as a kind of cooperation in which information and confirmation play important roles. However, at the logical level at which we look at this excerpt, we can see that B's utterances, in both cases, do not merely acknowledge the interlocutors' statements. It is very important to see that B1 and B2 aim at *diminishing the originality* of A1 and C1 respectively. From this point of view, we can hardly see B1 and B2 as cooperative replies.

What A and C assert is not so much the event they noticed as its *a priori* improbability. B twice changes this probability. After B1, for instance, Prob(**not** *forgot*) has to be replaced by Prob(**not** *forgot* | *laughed_when_hearing*), which is much greater (it is actually equal to 1 if we consider that [*laughed* $\Rightarrow$ **not** *forgot*]). In other words, with the knowledge that D laughed when hearing A and B, it is much less improbable that he remembers them. Again with B2, B simply indicates that the probability of D being thirsty was for her not so low since she suspected he was.

This kind of reaction will be called *banalization reaction*. When uttering an invalidation, the second speaker destroys the reasoning leading to the conclusion of improbability, and thus the improbability vanishes. On the contrary, a banalization just lowers the improbability value, but does not eliminate it.

We will define the banalization effect as the difference between the information brought by event *Ev* before and after the banalization reaction :

Banalization effect : $$\log_2 \frac{1}{\Pr_1(Ev)} - \log_2 \frac{1}{\Pr_2(Ev)} = \log_2 \frac{\Pr_2(Ev)}{\Pr_1(Ev)}$$

When banalization is obtained through the mention of an additional event, like in B1, the effect is measured by :

Banalization through additional information : $$\log_2 \frac{\Pr(Ev \mid Ev_1)}{\Pr(Ev)}$$

7.2.3.Banalization of rare events

The model allows us to anticipate several ways for a speaker Y to raise the *a priori* probability $P(Ev_0)$ of a given event Ev_0 reported by X as improbable. Y can simply indicate that her/his own estimation is above X's, as was the case in B2:

$$Pr_Y(\ Ev_0\ )\ >>\ Pr_X(\ Ev_0\ )$$

Y can also reveal that (s)he knows additional facts F_1, ... F_n so that:

$$Pr\ (\ Ev_0 \mid F_1, \ldots F_n\ )\ >>\ Pr\ (\ Ev_0\ )$$

This was what B did with B1. Now Y may also adopt another strategy in order to lower X's information, when Ev_0 is a *rare* event, i.e. an event which is expected to occur several times, but very seldom (consider for instance the event reported in [ex_car, p.14]). If we write $Ev_0 = Ev(Sit_0)$ to represent the fact that Ev_0 is a realization of a generic event Ev() in the current (or recounted) situation Sit_0, we can model the assessment of the *a priori* probability of such a rare event by the statistical estimation:

$$\Pr(Ev(Sit_0) = \sum_{Sit \in \Omega} \frac{\delta(\mathrm{Ev}(Sit))}{card(\Omega)}$$

Ev(Sit) est vrai si l'événement *Ev* s'est produit dans la situation *Sit*, et $\delta(Ev(Sit)) = 1$ ssi *Ev(Sit)* est vrai. Ω est l' "univers" des situations prises en compte.
Ev(Sit) is true whenever *Ev* was realized in the situation *Sit*, and $\delta(Ev(Sit)) = 1$ iff *Ev(Sit)* is true. Ω is the "universe" of situations taken into account. It contains all the situations which are analogous to the recounted event, i.e., which are obtained by considering that some parameters in Sit_0 may take other values. The universe Ω is built by interlocutors *when hearing* the improbable statement. This important phenomenon by which people elaborate a relevant universe for any event should be thoroughly studied. Let us give a few indications which should be sufficient four our purpose.

The universe Ω is built using Sit_0 and Ev_0 . The situation Sit_0 is generalized by dropping irrelevant features. For example the parabolic antenna of [ex_antenna, p.11] was seen in a street 300m far from the interlocutors' home. The universe Ω will include all antennas, wether parabolic or normal, that are located at a distance of less than 300m. The precise location of the mentioned antenna, the name of the street, etc. are pragmatically irrelevant in the situation:

Sit_0 : white TV antenna seen on a big house n°124 Roissys_street by sunny weather ...

Sit : TV antenna seen in a 300m range from home

A very important feature of Ω is that it is *egocentric*. Characteristics of Sit_0 are generalized according to a conceptual hierarchy which is centered on the speaker (and then on the listener). In the preceding example, the street where the parabolic antenna was seen is not generalized to *any* street, but to any street in the neighbourhood of the interlocutors' house. Sit_0 and **Sit** can be said to be "egocentrically analogous". We may speak of Ω as an *egocentric sphere*, since irrelevant characteristics of the situation are dropped under the following constraint: the "conceptual distance" to the speaker must not increase. This distance may be concrete, as with the antenna, but it is most often abstract. It is evaluated over space, or time, or degree of kinship, or degree of familiarity, etc.. Any information about space or time, or any characteristic involving a point of view defines such a distance. For instance changing *seen* into *heard_of* in the preceding generalization from Sit_0 to **Sit** would increase this conceptual distance.

Notice that, all things being equal, the smaller the "radius" of this egocentric sphere, the smaller the probability of Ev_0. Knowing how to introduce a new topic in the improbable mode thus implies being able to select improbable facts that are egocentrically close. We will see an example of this p. 30 with the recency effect.

Two interlocutors X and Y will not use the same universe for the same event: Ω(X) and Ω(Y) will not have the same "center". A very common strategy used by the second speaker Y to make a rare event Ev_0 banal is to indicate that the estimation of $P(Ev_0)$ on Ω(X) may be incorrect. Let us investigate this further with the following excerpt which comes after a discussion about the relative mildness of the weather on a 1st of January.

[ex_weather]
context: this conversation comes after some remarks about the weather which allowed the children to play outside. The temperature seems exceptionally mild for this New Year period.

A1- De toutes manières, la température qu'on a aujourd'hui, c'est le MAximum qu'on puisse espérer jusqu'à, jusqu'à la mi-février!
B1- Ca c'est vrai
C1- Je te dis, moi, en 77 y avait eu un temps de Föhn, l'hiver [...] *Il faisait 20° au 1er janvier.*
B2- Je me rappelle une année, quand nous étions petites, je m'en souviens très bien. Le 20 décembre, à peu près. [...] *On avait, D et moi, des robes...les robes d'été! Des robes d'été! Et ça avait été une année vraiment très exceptionnelle.*

A1- Anyway, today's temperature is the MAximum we may expect till, till the middle of February!
B1- That's true.
C1- What I say is that in 1977 we had foehn weather, in winter. We had 20° on the 1st of January.
B2- I remember, when we were little, I remember very well. Around the 20th of December. D and me, we had summer dresses. Summer dresses! And it was a really very exceptional year.

With A1, A notes that the temperature as high as, say, 16°, is improbably mild for a New Year's period:

$$\Pr(\text{temperature(January\_1st\_1987)} \geq 16^\circ) = \Pr(\text{temperature}(\mathbf{D}) \geq 16^\circ \mid \text{New\_Year}(\mathbf{D}))$$

$$= \sum_{\mathbf{D} \in \Omega} \frac{\delta(\text{temperature}(\mathbf{D}) \geq 16^\circ)}{\text{card}(\Omega)}$$

where Ω is the set of situations which are "egocentrically analogous" to the current situation. If we replace Ω by $\Omega(A)$, $\Omega(B)$ or $\Omega(C)$ depending on who is speaking, $\Omega(\mathbf{X})$ is the set of New-Year periods that **X** has previously experienced and can remember in a recent past (i.e. here a few years). A1 is perceived as saying that no instance of (temperature(**D**) $\geq$ 16°) can be satisfied in $\Omega(A)$. Thus the *a priori* probability of this event must be very low:

A1: $\Pr(\text{temperature(January\_1st\_1987)} \geq 16^\circ) << 1 / \text{card}(\Omega(A))$

But C is able to mention at least one analogous example from his own sample that enters the above sum, thus indicating that A's evaluation of the present situation's probability may be too low.

C1: temperature(January_1st_1977) $\geq$ 20°

$$\Pr(\text{temperature(January\_1st\_1987)} \geq 16^\circ) > \Pr(\text{temperature(January\_1st\_1987)} \geq 20^\circ)$$

$$\cong 1 / \text{card}(\Omega(C))$$

The banalization effect (see p. 27) can be assessed by the gain of at least one order of magnitude on the probabilities, *i.e.* to make things more concrete, about 3 bits ($log_2\ 10$). We also see how the fact that C goes one better by reporting a 20° temperature increases the banalization effect (we may consider that $card(\Omega(\mathbf{X}))$ is independent of $\mathbf{X}$).

7.2.4.Role played by analogy in a banalization of rare events

When the interlocutor wants to perform a banalization of a rare event Ev_0 by mentioning another event Ev_1, this event Ev_1 has to belong to $\Omega(X)$ which is the universe on which $P(Ev_0)$ was estimated. But it is not always possible.

For example B's reply B2 is performing a banalization as well. But it starts with a handicap, since it replaces *New_Year(**D**)* by *around(**D**,New-Year)*, and the new event [*temperature(**D**)* $\geq$ *16°* | *around(**D**, New-Year)*] is more easily satisfied, all the more so since it includes less cold periods. It is thus easier to mention another instance of this weakened event.

So when the second event Ev_1 which was uttered as a banalization is not totally analogous to the improbable event Ev_0, the universe $\Omega(X)$ has to be augmented to include both Ev_0 and Ev_1. But estimation of $P_{\Omega'}(Ev_0)$ on this augmented universe $\Omega'(X)$ will be greater than $P_{\Omega}(Ev_0)$. The banalization effect (voir p. 27) can be measured by the difference between information brought by Ev_0 before and after the intervention :

Banalization by an analog event : $\log_2 \frac{\Pr^2_{\Omega'}(Ev_0)}{\Pr^1_{\Omega'}(Ev_0)}$

Changing $\Omega(X)$ into $\Omega'(X)$ has a bad effect on the banalization efficiency, since $\Pr^1_{\Omega'}(Ev_0) \geq \Pr^1_{\Omega}(Ev_0)$. We understand now why the more analogous Ev_1 is to Ev_0, the more efficiently the banalization works. The event mentioned in B2, taking place around New Year, is not as good as the event of C1 to perform a banalization. That is why B insists on the other hand in B2 upon the improbable temperature reached on that exceptional year, thus strengthening the constraint ($T \geq 16°$).

This excerpt is a short example of *story round* [Tannen 1984]. Story rounds occur quite frequently after an introduction in the improbable mode. After a first story telling some improbable event, the next speaker tells another story about an analogous event. The more analogous, the more efficient it is as a way to reduce the information brought by the first story, since both events belong to the same category (i.e. the same universe).

However, next story in a story round leads most of the time to a topic change, since listeners forget about the preceding story, and the new topic is then considered as an improbable fact in itself. But conversation linking lie outside of the scope of this paper.

7.2.5.Recency effect in a banalization of rare events

Speakers very often tell a recent fact when introducing a new topic in the improbable mode. Or they may draw attention to a present fact or a current event. This "recency" effect is a particular instance of the necessity for the egocentric sphere to have a small radius (see p. 28). A recent fact has more chance to be improbable. Having experienced an improbable event in the past ten years is itself not so improbable. It is, if you look at the past ten days or ten hours (depending on whom you are speaking to). So begin a conversation by telling some "incredible" story that happened since last meeting brings more information that telling an old one. You may say "Guess what happened to me yesterday!" to emphasize the unexpectedness of some recent event. But asking such a question would not work to introduce old adventures, because many answers become possible.

But recency plays also a role in banalization. If you want to mention an analogous fact Ev_1 to make a recent event Ev_0 banal, then a recent Ev_1 will work better. This is a particular example of the

role played by analogy in banalization. But it is possible to model these two roles played by recency, in introduction and in banalization, more precisely.

The initially mentioned event Ev_0 is a rare event anyway. Let us consider that the *a priori* probability of this event occurring *n* times per time unit is given by a Poisson law: $e^{-\lambda}\ \lambda^n/n!$. λ is the average number of occurrences of Ev_0 per time unit. It is unknown, but has to be considered as fixed when Ev_0 is uttered (actually the first locutor considers λ as being very small).

If Ev_0 took place at time $-t_0$ (present being time zero), then we have to estimate the *a priori* probability that Ev_0 occurred at least one time for the duration t_0. This probability is given by:

$$\Pr(Ev_0) = 1 - e^{-t_0/t_1}$$

and the banalization effect due to the recent event is measured by :

$$\log_2 \frac{1 - e^{-t_0/t_1}}{1 - e^{-\lambda t_0}} \cong \frac{1}{\lambda t_1}$$

We see thus that a recent event (t_0 small) is more improbable than an old one, and thus carries more information. Let us now see why another event Ev_1 which aims at making Ev_0 banal, has also to be recent.

The purpose of Ev_1 is to give a different estimation of λ. By mentioning Ev_1, the second locutor indicates that an event analogous to Ev_0 (i.e. belonging to the same universe) has occurred at least one time in the past t_1. The effect is to suggest that λ may be not so small, and has to be replaced by $1/t_1$. The new *a priori* probability that Ev_0 occurred is now given by:

$$P(Ev_0) = 1 - e^{-t_0/t_1}$$

This explains why the banalization effect is better if t_1 is smaller, because $P(Ev_0)$ is increased by a greater value. In this respect, C's reply C1 is not very efficient: if C had said "ten years ago we had the same temperature", the banalization would have been weak. But C strengthened the constraint (temperature > 16°) and thus obtained a better banalization. B2, which tells an event that occurred not ten years, but fifty years before, is even worse than C2. But again the temperature constraint is increased by comparing a New-year period with summer.

7.3.Reactions to an (un)desirable fact

Both invalidation and banalization do exist as possible replies after an introduction in the (un)desirable mode. First an example of direct invalidation:

[ex_cupboard]
context: A and B had some trouble with moisture in their house. The house had not been heated during the weekend, and the clothes are still cold in the cupboard.
A1- C'est humide même là [dans le placard]
B1- C'est pas humide, c'est froid

A1- It's also wet here [in the cloth cupboard]
B1- It isn't wet. Its cold

B explains that touching cold clothes gives the undesirable impression that they are wet, but they are not.

The possibility of *indirect* invalidations in the undesirable mode is illustrated by [ex_channel, p.20] D8. But the role of indirect invalidation may be played also by *suggestions*[11] like [ex_hungry, p.16] B1 or C1. There is no logical difference, but suggestions speak about actions, when other types of invalidations make use of facts. This distinction between facts and actions is not of great relevance here.

Banalization may also occur in the (un)desirable mode. If we extend the banalization concept to any quantitative lowering of Conversational Information (as defined p. 17), then we will observe a banalization effect in the (un)desirable mode each time $|d|$ is lowered. We could observe such a banalization with [ex_card, p.12] B1. The banalization effect may be extreme, as here:

[ex_corrosion]
context: B and is wife are going to buy a second-hand car. A is warning them against the danger of corrosion.
A1- Votre problème, c'est d'avoir une voiture qui résiste à la corrosion.
B1- Non, notre problème, c'est pas la corrosion

A1- Your problem is to buy a corrosion resistant car.
B1- No, our problem is not corrosion

If we express the logical context simply by:

not *corrosion_resistant* $\Rightarrow$ *rusted*
rusted $\Rightarrow$ **UND**

then we see that B1 does not deny a premise used to deduce dissatisfaction, and cannot be seen as an invalidation. It denies the modality itself. After B1, the previously undesirable corrosion becomes a neutral eventuality. Actually B does not care if his car gets rusted. B1 has thus a banalization effect.

Now the situation looks like what we had with introductions in the improbable mode. However, some replies in the (un)desirable mode cannot be considered as invalidations or banalizations.

[ex_sailing]
context: discussion about a French skipper who competed in the America's cup challenge, with the support of many people in France.
A1- Alors Marc Pajot s'est fait écraser encore.
B1- Deux minutes, c'est pas écrasé!
A2- Deux minutes quarante secondes, si.
C1- Oui, mais enfin, tu sais, hein, il a quand même tenu le coup jusqu'au dernier moment, hein, lui.
A3- Quel coup?
C2- Hé ben enfin, il a pas sombré, il est pas tombé, il est arrivé!
A4- Tu veux dire qu'il est arrivé, il est arrivé en demi-finale
C3- en demi-finale, écoute!

A1- So Marc Pajot was beaten badly once more.
B1- Two minutes, you can't say he was beaten badly

[11] Notice that suggestions may appear as cooperative at the sociological level. This was the case for the cookies or the hamburger in [ex_hungry, p.16]. But from a logical point of view, they play the role of invalidations.

A2- Two minutes forty seconds, yes he was.
C1- Yes, but you know, he was in the running till the last moment, wasn't he?
A3- What kind of running?
C2- Now, he didn't sink, he didn't fall, he finished!
A4- You mean, he reached the semi-finals
C3- Yes, the semi-finals, it isn't that bad!

C's first utterance C1 does not call into question the undesirable fact that M. Pajot was beaten after his last race in the America Cup (contrary to what the banalization B1 did). C speaks about another aspect of the situation, namely the desirable fact that M. Pajot reached the semi-finals:

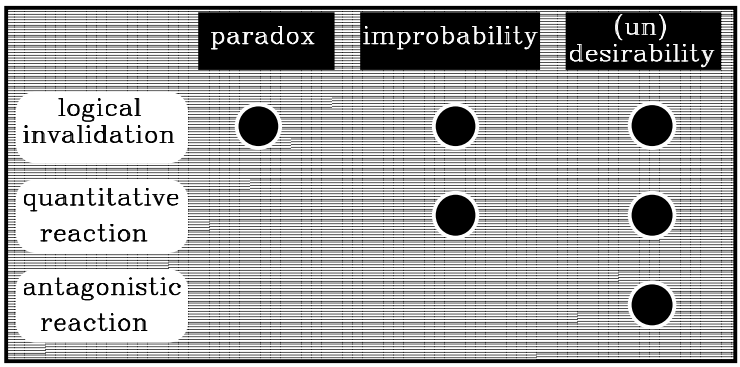
context of A1: [*French*(**X**) **&** *important*(**Race**) **&** *beaten*(**X**, **Race**)] ⇒ **UND**
context of C1: [*French*(**X**) **&** *important*(**Race**) **&** *reaches_semi-final*(**X**, **Race**)] ⇒ **DES**

The same situation is presented by C as being sufficient to provoke dissatisfaction and satisfaction at the same time. This kind of reply will be called *antagonistic reaction*. The model actually predicts four possibilities for antagonistic reactions, which we can sketch this way:

first utterance	antagonistic reply
p ⇒ **UND** *or* **DES** ⇒ **not** p	p ⇒ **DES** *or* **UND** ⇒ **not** p **not** p ⇒ **UND** *or* **DES** ⇒ p
p ⇒ **DES** *or* **UND** ⇒ **not** p	p ⇒ **UND** *or* **DES** ⇒ **not** p **not** p ⇒ **DES** *or* **UND** ⇒ p

The above excerpt belongs clearly to the first case. We will see examples illustrating some of the other cases below. The antagonistic reaction consists in balancing advantages and drawbacks of the situation or of a solution, in other terms to "weigh the pros and the cons".

All the results obtained so far are summed up in figure 4.



---------- figure 4: admissible reactions according to modality ----------

The cases which are missing in this schema are "prohibited", *i.e.* they will provoke reactions of incomprehension, or "repairs", or even aggressive reaction.

According to the model, as it was presented up here, there is no possibility of giving a *relevant* reply, other than by invalidating what was said before, or by restricting it, or by giving an antagonistic argument (two other possibilities of less importance will be mentioned in a next section p. 37). All these possibilities share a common feature which may underlie conversational art.

7.4.The art of conversing

We can use the bidimensional representation of figure 3 to illustrate how the logical action performed by the second reply affects the context (figure 5).

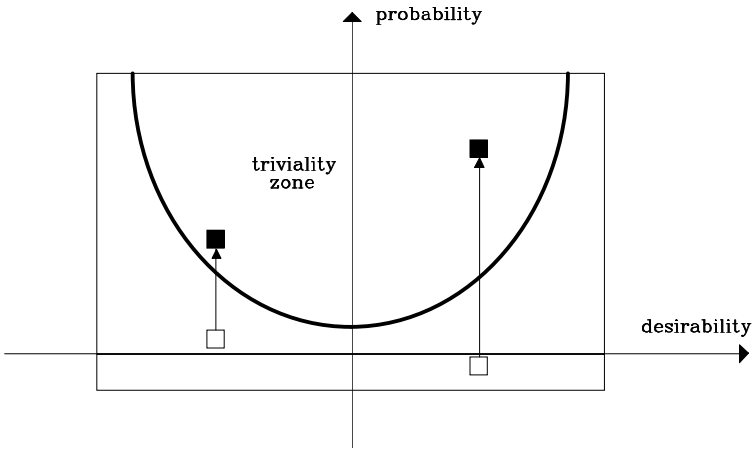


fig.5-a: effect of banalization and invalidation in the improbable and paradoxical mode resp.

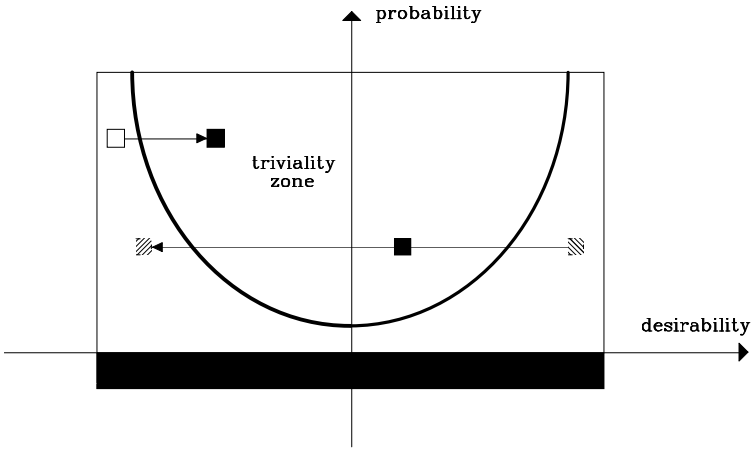


fig.5-b: effect of banalization and antagonistic reaction in the (un)desirable mode

---------- figure 5: logical effect of replies on context (see fig. 3 p.20) ----------

Each reply moves the point representing the observed or mentioned situation from an edge towards the triviality zone. After an invalidation in the paradoxical mode, a fact no longer stays in the impossibility zone, but recovers coordinates specified according to the remainder of the shared knowledge. The representation of banalization is straightforward (either in improbable or (un)desirable modes) and corresponds to a lowering of the modal intensity. An antagonistic reaction results in a ground medium as a consequence of a balance between two extreme desirability values.

The first impression we get from this representation is that the first intervention may be multi-modal (e.g. improbable and undesirable at the same time) if it places the topic in a lower corner of the diagram, while further replies cannot. It is indeed hardly conceivable that the same reply would, for instance, increase probability and desirability at the same time. We can see this on the next excerpt:

[ex_Como] (from [Morel 1983:44])
context: The lake of Como is a very elongated lake. A is telling about a trip in Italy.
A1- enfin ce Lac de Come est insup - est vraiment insupportable -
B1- tous les bords de lac sont insupportables -
A2- il fait deux cents kilomètres de long - c'est incroyable ce truc -

A1- This Lake of Como is unbear - is really unbearable -
B1- all lake sides are unbearable -
A2- it is two hundreds kilometers long - incredible, that thing -

As external observers, we could perceive A1 as telling an undesirable event. But B's reaction B1 is a typical banalization in the improbable mode which A2 emphasizes eventually: this lake is improbably ("incredibly") long, and traveling alongside it is improbably boring.

[*lake*(Lake_of_Como, **Length**, **Width**) **& Length >> Width**] $\Rightarrow$ **IMPR**

So there is a clear-cut distinction between the improbable and the (un)desirable modalities when it is time for replying. But what about the distinction paradox / improbability? Here is an interesting excerpt from this point of view:

[ex_ping-pong]
context: A is amazed at the strange technique of a Chinese student who is playing table tennis.
A1- T'as vu comment il tient sa raquette ?
B1- C'est un Chinois, les Chinois ils tiennent tous leur raquette comme ça
A2- C'est pas naturel ! Comment ils arrivent à jouer ?
B2- Oh ! C'est pas un sport ça !
A3- Enfin, tu transpires !
B3- Un sport où tu cours pas, c'est pas un sport.
A4- Alors le tennis, c'est la même chose...
B4- Ouais. Le basket tu cours oui.
C1- Le volley aussi.
B5- Tu parles !
C2- Enfin, à haut niveau, smasher et tout...
A5- Mais comment ils font pour smasher, les Chinois ?

A1- Did you see how he holds his paddle?
B1- He is Chinese. They all do the same
A2- It isn't natural! How do they manage to play?
B2- Oh ! you can't call it a sport
A3- Well, you do sweat
B3- If you don't run, it isn't a sport
A4- You could say this of tennis as well
B4- Yes. When playing basket-ball you have to run, yes.
C1- Volley-ball also.

B5- You're telling me!
C2- But, when playing at a higher level, doing smashes and all...
A5- But how do the Chinese succeed in smashing?

B1 is clearly a banalization, showing that B understands A1 as reporting an improbable event. But there is no doubt that A, in A1, was amazed at a paradox, since he shows his puzzlement in A2 ("how can they manage to play?") and again in A5. Thus we must make a qualitative distinction between paradox and improbability, since in case of a paradox, as here, no banalization is admissible. A cannot be satisfied by B1 because he has in mind a logical model making him conclude that nobody can play correctly holding the paddle this way. And this conclusion remains valid even if one billion people play this way. A's puzzle has nothing to do with improbability, and could only be eliminated by a logical invalidation which never occurred in this excerpt[12] .

This allows us to make some remarks about the art of conversing. Most linguists or sociologists consider conversation as a typical example of cooperation between speakers, at the sociological level. The latter are observed constructing a common knowledge by adding pieces of truth with each reply. This influential opinion is often attributed to Grice:

> "After Grice [1975], it is universally accepted that cooperation is the crucial feature which any theory of dialogue has to account for." [Airenti & al. 1989:148].

However, the above examples and their interpretation within our model indicate that this way of considering conversational behavior of *interlocutors* is of little relevance when the problem is to describe the logical structure of *conversations*(see note **Erreur! Signet non défini.** p. 3). At the logical level, a good reply is not a mere constructive elaboration on what was said before. On the contrary, it is a kind of logical destruction, a heavily constrained one, as we saw.

It may be argued that what we call destruction (invalidation, banalization, etc.) at the logical level appears to be a cooperative act at a higher level. This may be possible. An invalidation would thus be a way to be helpful with a person puzzled by a problem of understanding. But we could conversely see social aggression in the act of pointing out a lack of knowledge or a reasoning flaw in an interlocutor's speech [Ducrot 1972]. Anyway we see no reason why we should consider all utterances as cooperative at some sociological level. Discussing sociological issues is not our concern here. Our model does not say anything about interlocutors, but about the logical structure of their productions.

As far as logical level is concerned, we can thus hardly describe all replies as cooperative[13] . But we will observe now that not all of them are destructive.

7.5.Reply Taxonomy

Are invalidation, banalization and antagonistic reaction the only three possible ways of replying after the introduction of a new topic? Let us consider the following excerpt:

---

[12] This excerpt is quite remarkable for a variety of reasons. The argument B2 appears as a meta-argument: if ping-pong is not a serious sport, then the previous topic about the possibility of playing holding the paddle this way is no longer interesting. Meta-arguments also occur for instance when an interlocutor is said to be insincere. The discussion B2 --> C2 is a meta-discussion only because the interestingness of the initial topic is at stake (what seems to be quickly forgotten). To all other aspects, it is a normal conversation, with invalidations A3, A4, B5, C2. Notice the perfect explicitation of a rule of the logical context in B3, and the attempt to perform a *reductio ad absurdum* in A4. Notice also the effect of the word "smashes" which reawakens A's unsoved puzzle in A5.

[13] In case of more than two speakers, some replies that are directed against the same utterance could be said to cooperate (e.g. [ex_ping-pong, p.36] B4 and C1).

[ex_christmas-tree]
context: three weeks after Christmas, the Christmas tree is still green.
A1- Mais c'est toujours le sapin? C'est formidable, ça!
B1- Mais oui! Il n'est pas encore sec!
A2- Et sans racines?
B2- Sans racines. Il perd même pas ses... On a déjà coupé toutes les branches du bas.
A3- C'est curieux qu'il ne perde pas ses...
B3- Ben oui, je ne comprends pas.
A4- Il est en plastique

A1- Is that still the same Christmas tree? This is incredible!
B1- Oh yes! It hasn't dried up yet!
A2- And without its roots?
B2- Without its roots. It doesn't even lose its... We already cut the lower branches.
A3- It's surprising that it does not lose its...
B3- Yes it is. I can't understand why.
A4- It must be made of plastic.

B's replies B1 and B2 could be perceived as mere answers to A's questions (with not "destructive" effect at all). However, as B3 perfectly reveals, B correctly perceives the paradox expressed in A1. But she can find no argument to invalidate it (note the humorous invalidation A4). B's replies, especially B3, are *co-astonishment reactions*. This kind of replies can be found after paradoxical, but also improbable initiations (e.g. [ex_sting, p.26] B1). After (un)desirable initiations, we may encounter co-disappointment or co-rejoicing.

[ex_wind]
context: wind is lacking for windsurfing
A1- Y a pas beaucoup de vent
B1- Oui, c'est pas terrible!

A1- There isn't much wind
B1- Yes, you can say that!

Here the context is windsurfing, and the lack of wind is undesirable. These "co-reactions" do not modify the logical context. They hardly contribute to the argumentation. But they are often a way for the second speaker to go one better.

[ex_arms]
context: this discussion comes after a long discussion about the compared efficiency of several weapons.
A1- Enfin, voilà bien du pognon, hein?
B1- Tu parles des armements?
A2- mmm
B2- C'est faramineux
A3- Et ça diminue pas
B3- C'est le gros problème des russes. C'est pour ça que [...]

A1- Now, this is a lot of money, isn't it?
B1- Are you speaking about the arms race?
A2- mmm
B2- It's astronomical
A3- And it is not diminishing

B3- This is the big problem, for Russians. That's why [...]

Here A1 and A3 are in the undesirable mode. B2 pushes the mentioned fact further to the left side of the diagram of figure 3, but also to its bottom. It is perhaps an attempt to change the topic's modality towards improbability.

Up to now, we saw that the model recognizes several possibilities for replies: "destructive replies" (invalidations, banalizations, antagonistic reactions), and "co-reactions". What about *agreements*? Many authors who study conversations at the sociological level wrongly describe as agreements reactions that actually have a specific function at the logical level: invalidations (as in [ex_ping-pong, p.36] B4, where B validates a conclusion considered as absurd by A), banalizations (as in [ex_thirst, p.26] B2), co-reactions ([ex_arms] B2), or clarifications (as in [ex_arms] A2, see next paragraph). Real agreements are fully compatible with the model. However we did not insist on them because they are quite rare in the corpus (perhaps because they often tend to close the topic, e.g. in a next excerpt [ex_doors, p.41] B4).

We must mention a last possibility of reply. Some replies aim at making the logical context more explicit. We could observe some of them in [ex_train2, p.10] B1, [ex_Goffman, p.6] A6, [ex_arms] B1, A2 or [ex_Channel, p.20] C4, C5, D4, C9. Here is a less obvious example:

[ex_smack]
context: A is a teacher. He is known as a very peaceful person.
A1- Jeudi dernier, c'est ma onzième année d'enseignement, j'ai mis la première gifle de ma..., depuis onze ans.
B1- Mais il était spécialement dur, comme gamin?

A1- Last Thursday, and I've been teaching for eleven years, I gave the first smack of my..., in eleven years.
B1- But was the boy particularly unruly?

The logical context is made explicit in A1. The recounted event is presented as rare, since its frequency is explicitly given an estimation: the event is said to have occurred for the first time in eleven years. We can express this by:

$$[\ \textit{never\_smacks}(A)\ \mathbf{\&}\ \textit{smacks}(A,\ \text{boy})\ ] \Rightarrow\ \mathbf{IMPR}$$

([*never_smacks(A)*] means here that A did not smack any boy in eleven years). We could have asked B why she uttered B1. We did this, although a long time after the conversation occurred: "it means that this boy was special, because otherwise he won't have waited eleven years to give his first smack". Let us change this formulation to make the translation into logic easier:

it means that this boy was special,
otherwise [he won't have smacked him or] he would have smacked boys much more often

We propose to consider both sentences as contrapositions, and to represent the first one by:

$$[\ \textit{never\_smacks}(A)\ \mathbf{\&}\ \textit{smacks}(A,\ \text{boy}\ )\ ] \Rightarrow\ \textit{very\_unruly}(\ \text{boy})$$

and the second one by:

not *very_unruly*(boy) ⇒ [**not** *smacks*(A, boy) **or not** *never_smacks*(A)]

which is totally equivalent. Thus B asks for a validation of a more complete context:

[*never_smacks*(A) **&** *smacks*(A, boy)] ⇒ *very_unruly*(boy)
very_unruly(boy) ⇒ **IMPR**

thus transferring the "scoop" onto an alleged improbable unbearabitity of the boy. B1 appears thus to be a *context clarification*. Let us sum up the different possibilities one has to form an admissible reply:

"destructive" replies	co-reactions	agreement	context clarification
invalidation	*co-astonishment*		
banalization	*co-disappointment*		
antagonistic reaction	*co-rejoicing*		

One could believe that the introduction of "co-reactions" makes the model non-falsifiable. Whenever the second speaker's reply goes in the same direction as the first utterance, we could say that it is a "co-reaction"; otherwise it would be described as a "destructive" reply, and no example would ever contradict the model. But this is not what happens, since the model predicts much more:

- the structure of a "destructive" reply is perfectly determined: such a reply must perform a definite logical action on the context (invalidation, banalization, antagonistic reaction).
- "co-reactions" also are well-defined. The second speaker utters them to show that (s)he is at least *as much* troubled (or made happy) by the mentioned fact or event, thus emphasizing the modality.
- clarification reactions are also logically determined. They make another version of the saturated clause explicit.
- "empty" reactions, i.e. reactions with no specific content, are not taken into account in the model (except agreements). For example, reactions like "I don't think you are right" cannot replace an invalidation, they do not play any logical role, and they are lost during logical translation without any damage for the representation of logical argumentation.
- all these admissible logical reactions leave room for a wide range of "logically neutral" reactions, i.e. any "non empty" statement having no effect on the logical context. But **the model rules them out**, or rather predicts that such logically neutral reactions will be understood as indications of misunderstanding and will encourage the first speaker to make the context more explicit (e.g. [ex_channel, p.20] A4 from C's point of view).

In other words, according to our model, a reply must have an effect in relation to the logical context: either a positive effect by strengthening the modality (co-reactions) or making the logical context more explicit (clarifications), or a "destructive" effect. We can make a principle from this :

Second principle of logical relevance :

Every reply aims at strengthen the problematics, or conversely at diminishing or destroying it.

Elaboration and information exchange, which are often considered as a defining feature of conversations at the sociological level, must emerge from these few logical actions, mainly from the "destructive" ones.

The most surprising thing here is that the first speaker does expect destructive replies. They are a kind of energy that conversations need to progress, as is illustrated, for example, by the fact that many conversations stop after one or two instances of "co-reactions" or agreements. This dynamic effect due to destructive replies comes from the possibility they offer for further destruction, as we will see in the next section.

Summary: Our model is as restrictive for replies as it was for the first utterance. A logically relevant reply must perform a logical action on the logical context: invalidation, banalization, antagonistic action. These reactions have a "destructive" effect on the logical context underlying the first utterance. Other possibilities are: co-reactions, agreement, clarification. This excludes logically neutral replies, and puts strong constraints on the second utterance. Banalization has been described with greater detail: we showed how a locutor can lower the information brought by a first utterance in the improbable mode.

8.Conversations in progress

8.1.Reply linking

To see how replies can logically affect each other, let us consider a longer excerpt:

[ex_doors]
context: A is repainting doors in his home, and he decided to remove old paint first, which proves to be a hard work.
A1- Ben moi, j'en bave actuellement parce qu'il faut que je refasse mes portes, la peinture. Alors j'ai décapé à la chaleur. Ca part bien. Mais pas partout. C'est un travail dingue, hein?
[...]
B2- Quelle chaleur? La lampe à souder?
A3- Ouais, avec un truc spécial.
B3- Faut une brosse, dure, une brosse métallique.
A4- Oui, mais j'attaque le bois.
B4- T'attaques le bois.
[pause 5 secondes]
A5- Enfin je sais pas. C'est un boulot dingue, hein? C'est plus de boulot que de racheter une porte, hein?
B5- Oh, c'est pour ça qu'il vaut mieux laiss... il vaut mieux simplement poncer, repeindre par dessus
A6- Ben oui, mais si on est les quinzièmes à se dire ça
B6- Ah oui.
A7- Y a déjà trois couches de peinture, hein, dessus.
B7- Remarque, si elle tient bien, la peinture, là où elle est écaillée, on peut enduire. De l'enduit à l'eau, ou
A8- Oui, mais l'état de surface est pas joli, quoi, ça fait laque, tu sais, ça fait vieille porte.

A1- I have to repaint my doors. I've burned off the old paint. It worked OK, but not everywhere. It's really tough work!
[...]
B2- How are you burning them? Are you using a blowtorch?
A3- Yes, with a special thing
B3- You have to use a wire brush
A4- Yes, but that wrecks the wood
B4- It wrecks the wood...
[pause 5 seconds]

A5- It's crazy! It's more trouble than buying a new door.
B5- Maybe you'd do better just sanding and repainting them.
A6- Yes, but if we are the fifteenth ones to think of that
B6- Oh, yeah...
A7- there are already three layers of paint
B7- if the old remaining paint sticks well, you can fill in the peeled spots with filler compound
A8- Yeah, but the surface won't look great. It'll look like an old door.

A1 is an introduction in the undesirable mode. B2 no doubts is intended as a suggestion (which is a form of indirect invalidation, see p. 32): B had apparently in mind less efficient heating devices using hot air, in which case a blowtorch is a good suggestion. The suggestion B3 acts actually as an indirect invalidation:

repainting_is_tough_work $\Rightarrow$ **UND**
[*old_paint_is_burnt_off* **&** **not** *wire_brush* **&** **not** *repainting_is_tough_work*] $\Rightarrow$ **F**

B3 denies the supposedly forgotten hypothesis [**not** *wire_brush*]. Notice how the wire brush is presented as *necessary* in B3 ("you *have to...*"). This can be explained by rewriting the last clause:

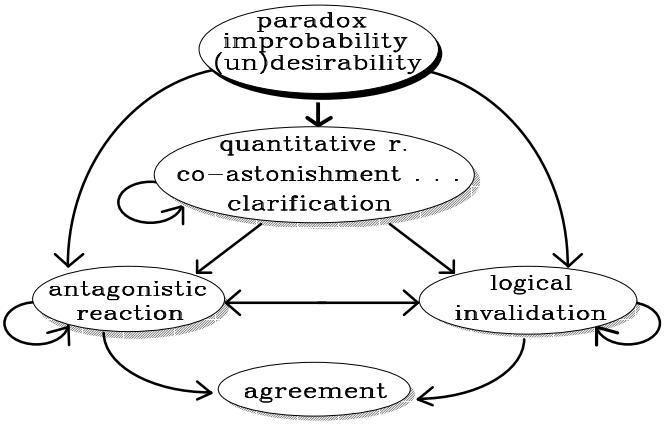
[*old_paint_is_burnt_off* **&** **not** *repainting_is_tough_work*] $\Rightarrow$ *wire_brush*

Then A4 appears as a typical antagonistic reaction against B3. The use of a wire brush indeed destroys the reasoning leading to [*tough_work*], and thus inherits high desirability value. A4 does not dispute the desirability of a wire brush as making things easier, but shows that it has undesirable side-effects, namely that it damages the wood.

wood-is-wrecked $\Rightarrow$ **UND**
[*wire-brush* **&** *wood-is-soft* **&** **not** *wood-is-wrecked*] $\Rightarrow$ **F**

We observe here how an antagonistic reaction can be opposed to an invalidation. We have the same sequence with the suggestion B5 and the antagonistic reaction A6-A7, and one more time with the suggestion B7 and the antagonistic reaction A8. Note the "Yes but" which often starts antagonistic reactions.

[ex_chicken, p.22] B1, A2, B2 offered a succession of invalidations characteristic of paradoxical mode: each reply invalidates the preceding one. The diagram of figure 6 shows all the possibilities of linking between replies.



---------- figure 6: reply transition diagram ----------

We describe these transitions more precisely below by means of a context-free grammar (figure 7).

CONV	-->	SUBJ	CONV	
CONV	-->	.		
SUBJ	-->	PAR | IMP | UND | DES		
PAR	-->	LUT	PAR	
PAR	-->	inv	agree	
LUT	-->	aston	LUT	
LUT	-->	inv	inv	LUT
IMP	-->	LUT	IMP	
IMP	-->	derar	IMP	
IMP	-->	inv	agree	
IMP	-->	.		
DES	-->	rej	DES	
DES	-->	dedram	DES	
DES	-->	anta	UND	DES
DES	-->	LUT	DES	
DES	-->	inv	accord	
DES	-->	.		
UND	-->	lam	UND	
UND	-->	dedram	UND	
UND	-->	anta	DES	UND
UND	-->	LUT	UND	
UND	-->	inv	agree	
UND	-->	.		

legend:

CONV	conversation
SUBJ	subject of conversation
LUT	invalidation contest
PAR	paradox
IMP	improbability
UND	undesirability
DES	desirability
agree	agreement
inv	invalidation
aston	(co)-astonishment
derar	banalization in the improbable mode
rej	(co)-rejoycing
lam	(co)-disappointment
dedram	banalization in the (un)desirable mode
anta	antagonistic reaction

---------- figure 7: conversational grammar ----------

Here banalizations, "co-reactions" and clarifications are presented as transitory reactions. Invalidations and antagonistic reactions may follow each other or may loop on themselves. Eventually an acceptance may close the subject, but this is far from being systematic.

Antagonistic loops occur frequently when several solutions compete:

[ex_trailer]
context: B and C want to by a station wagon. A makes another suggestion, since station wagons were presented as expensive and difficult to park in a previous conversation.
[...]
A1- Maintenant... il y a une solution pour économiser le break, c'est la remorque [...]
B1- Ouais, mais il faut voir aussi
A2- et on met dessus, quand on enlève la caisse, on y met [des tas de choses]
B2- Oui, mais le break, c'est pas mal aussi!
C1- Faut un garage [pour la remorque]
A3- Oui, mais si on l'utilise deux fois par an, ballader un break!
C2- La remorque, moi, je peux pas la stocker.
B3- C'est pas plus gros qu'une voiture normale, un break.

A1- Now... There is a solution to avoid buying a station wagon: a trailer [...]
B1- Yes, but you must also see...
A2- and when you remove the bodywork, you can put [plenty of things] *on it*
B2- Yes, but a station wagon isn't bad either.
C1- You need a garage [to store the trailer]
A3- Yes, but to have to drive a station wagon when you really need it twice a year!
C2- I can't store a trailer
B3- A station wagon isn't bigger than a normal car

Here the trailer is presented in A1 as a suggestion against the previously discussed high cost of a station wagon. A2 anticipates B1 as an antagonistic reaction: according to B, but not to A, a station wagon has more room. Then B2, C1, A3 and perhaps C2 can be understood as antagonistic reactions. The question with C2 is to know if the storing problem is a definitive one, in which case C2 would appear as an invalidation. The direct invalidation B3 closes the excerpt.

To understand how logical relevance is at work here, we have to consider that trailer and station wagon are exclusive and locally form an exhaustive set of solutions:

[*trailer* **&** *station_wagon*] $\Rightarrow$ **F**
[**not** *trailer* **&** **not** *station_wagon*] $\Rightarrow$ **F**

A2 explains that a trailer is desirable because it has a lot of room. B replies in B2 that the trailer's negation (i.e. the station wagon) is equally desirable. With C1, the trailer appears this time as undesirable, but its negation is also undesirable in A3. Thus B and A made use here of two of the four different ways that are predicted by the model in order to form their antagonistic reply (see p.33).

Arrows in figure 6 should not be taken too literally as indicating moves in the conversational game, as will be shown now.

8.2.Reply dynamics

We have to consider first that speakers may reply to themselves, as in the following excerpt:

[ex_station-wagon]
context: B and C want to by a station wagon. A points out that such vehicles are expensive.
A1- Mais, heu, quand je disais une voiture spacieuse,... Ah oui, break. Evidemment, il y a de la place dans un break. Seulement les breaks sont rares et chers, je crois, ils sont recherchés.
B1- Non, non, ou ils sont
C1- Non, j'en ai vu une à vendre, mais il [B] *a pas voulu acheter.*
A2- et ensuite, ils ont des kilométrages impressionnants. Ils ont 200.000 bornes quand tu les...

A1- But when I spoke about a spacious car... Oh yes, a station wagon. Yes indeed, there is much space in a station wagon. But these are rare and expensive, I think, they are much sought-after.
B1- No, no, they are either...
C1- No, I saw one for sale, but he [B] *didn't want to buy.*
A2- and then, they have got a lot of mileage. They have over 200,000 km when you...

A1 begins with a repetition of an utterance he gave in a previous conversation, were he learned that B and C wanted to buy a really big car: not a spacious one, but a station wagon. But A suddenly remembers he already got an answer, and finds a new antagonistic argument: station wagons are expensive. Yet another antagonistic argument comes in A2, as if B1 and C1 had not been uttered. We see that people are able to converse alone, and transitions in the diagram of figure 6 are to be understood as indicating logical replies, regardless of who uttered them (see note **Erreur! Signet non défini.** p.3).

But this diagram gives a feeling of endless forward progression, each reply being destroyed by the following one. We could observe this kind of progression with [ex_trailer] A1-A2 --> B2, C1 --> A3 --> C2. But replies do not link systematically this way. [ex_doors, p.41] A5 or [ex_ping-pong, p.36] A5, for instance, showed how speakers often backtrack on a previous utterance. This backtrack may be very short, or very distant as in [ex_station-wagon] A1. Let us illustrate the case of backtracks of short length:

[ex_wheels] (from [Maynard 1991:206])
context: "then the parties systematically introduced and pursued talk regarding cars, experiences with working on them, and also what kinds of cars the participants would ideally like, what they could afford, and other matters".
A1 - Have you ever heard anything about wire wheels?
B1 - They can be a real pain. They, you know, they go out of [??] and
A2 - Yeah - The if you get a flat you have to take it to a special place to get the flat repaired
B2 - why is that?
A3 - because they're really easy to break. I mean to bend and damage
B3 - Oh really?
A4 - And most people won't touch them unless they have the special, you know, equipment or they they have the know how
B4 - They're like about two hundred bucks a piece or something too
A5 - Yeah they and they're real expensive to have aligned
B5 - Yeah, you get them just chromed and that's the only way to have them just about too, you know
A6 - Yeah

In this excerpt, the two participants compete to find the best antagonistic reaction. The context of A1 includes the fact that wire wheels are very much appreciated by sport car buyers. Thus B1, A2, B4, A5, B5 which mention drawbacks of such wheels appear as antagonistic reactions. They are at the same level, because they are all directed against the context of A1. We may represent the dynamic hierarchy of this excerpt this way (which reminds of A.Trognon's [1990] hierarchical diagrams):

```
context of A1
-----  B1
-----  A2
-----  -----  B2
-----  -----  -----  A3
-----  -----  -----  -----  B3
-----  -----  -----  A4
-----  B4
-----  A5
-----  B5
```

This schema shows clearly the backtracking phenomenon. We can also notice that A4 performs a backtracking, since it is like A3 an explanation (i.e. an invalidation) of the context of B2[14]. Such short-range backtracks do conflict with the predictions of the conversational grammar of figure 7. But formal grammars are known to be unable to represent such backtracking phenomena [Sabah 1988]. We can see the actual conversation as the trace (with only terminal symbols) of grammar rule applications.

Some backtracks are made necessary because sometimes whole conversations play the role of a single reply. We had an example of this with story rounds, where each story plays the role of a banalization, and also in [ex_ping-pong, p.36] B2 through C2 in which relevance of A2 is at stake (see note 12 p. 36), and which is followed by the backtrack A5.

Many far backtrackings are also to be observed in longer conversations, so that some replies may attack distant previous interventions. In the corpus, a 355 replies conversation upon conceiving a gastronomic meal stretches over half an hour. The conversation started with a question: "What are we going to eat when Bill comes?", which indicates the undesirable fact of having yet no idea of the menu that will be offered to the invited person. The fact that Bill is a foreign visitor makes the problem non trivial. During the conversation, this fact will be periodically invalidated:

[*invited*(Bill) **& not** *known*(menu)] $\Rightarrow$ **UND**
[*known*(menu) **& not** *known*(main_course)] $\Rightarrow$ **F**
[*known*(menu) **& not** *known*(hors_d'oeuvre)] $\Rightarrow$ **F**
[*known*(menu) **& not** *known*(cheese)] $\Rightarrow$ **F**
. . .

As we will see below, suggesting here a main course is a way to invalidate a possible reasoning leading to **UND**:

not *known*(main_course) $\Rightarrow$ **not** *known*(menu)
[*invited*(bill) **& not** *known*(menu)] $\Rightarrow$ **UND**

But [**not** *known*(main_course)] inherits by the way the undesirable attribute, and a whole conversation may ensue around the problem of finding a suitable main course. Then interlocutors may backtrack on invalidating another reasoning:

[14] We interpret B2 this way: B has some reason to think that wheel's types are unrelated to problems concerning tires. A2 contradicts this. B is amazed at this paradox, and expresses his surprise by asking B2.

not *known*(hors_d'oeuvre) ⇒ **not** *known*(menu)
[*invited*(bill) **&** **not** *known*(menu)] ⇒ **UND**

and so on until nobody can find a way to prove [**not** *known*(menu)].

The linking of replies as it is predicted by the model, was statically depicted in the diagram of figure 6. We just gave some indications upon its dynamics. This model shows that heavy constraints limit the range of admissible logical actions each reply may perform when it is produced. But we gave so far few indications of how replies are actually conceived and how such constraints may be helpful, precisely, to detect and understand relevance. Next section aims at indicating ways of studying such aspects.

Summary: We showed in this section that whole conversations consist of invalidations, antagonistic reactions, etc. (and nothing else!) and that many combinations are possible. But the contraint of logical relevance applies throughout the conversation: each reply must have a logical effect on the context. However, this context is not necessarily the context underlying the preceding utterance: replies may backtrack on previous contexts.

9.Simulating conversation

The conversational model as we described it consists of a set of constraints that seem to limit the range of possibilities that are accessible to an interlocutor at a given stage of a conversation. Is this set of constraints complete enough allow us to explain why and how (s)he picked this argument at this moment, and did not utter some other valid fact? We cannot hope of course that this set of constraints allows a synthesis of argumentation "from nothing". However, if we take the relevant logical knowledge of participants into account, then the model may allow to fill the gap between logical representation and argumentation[15] . In other words, it must be possible to design a computer program which would reproduce the linking of replies when we give to it the interlocutors' knowledge as input. That is what we tried with the PARADISE program [Dessalles 1990b].

Here are two examples of reconstruction performed by PARADISE. The program is able to play both parts, but we give only one example for each excerpt.

[reconstitution of ex_chicken (p.22)]
PARADISE *(A1')- It's surprising that people buy because they see "farm-raised", since the "farm-raised" mention is not guaranteed*
human *(b1')- a-seal is a seal and a-seal goes with the "farm-raised" mention*
PAR.*(A1'')- But maybe a-seal is not guaranteed*
hum.*(b1'')- a-seal is guaranteed*
PAR.*(A2')- It is possible that a-seal is not guaranteed . One has only to consider that a-seal is not guaranteed by somebody*
hum.*(b2')- a-seal is guaranteed by a-producers'-association*

We give below the knowledge used by PARADISE to generate this reconstruction. Notice that the distance between this logical knowledge and the output lies in the ability to pick the right argument at every moment in the conversation.

[15] This formulation may remind of the way Sperber and Wilson describe the main purpose of Pragmatics: a way to fill the gap between semantic representation and propositional form [Sperber & Wilson 1986:281].

common knowledge

[*purchase_caused_by*(**Mention**) **& not** *guaranteed*(**Mention**)] ⇒ **F**
[*seal*(**L**) **&** *goes_with*(**L**,**Mention**) **&** *guaranteed*(**L**) **& not** *guaranteed*(**Mention**)] ⇒ **F**
[*guarantees*(**X**,**LM**) **& not** *guaranteed*(**LM**)] ⇒ **F**
not *purchase_caused_by*(farm_raised_mention) ⇒ **F**

A's specific knowledge

guaranteed(farm_raised_mention) ⇒ **F**

B's specific knowledge

not *seal*(a_seal) ⇒ **F**
not *goes_with*(a_seal, farm_raised_mention) ⇒ **F**
not *guarantees*(a_producers'_association, a_seal) ⇒ **F**

The next excerpt shows that PARADISE can also deal with the modality **UND**:

[reconstitution of ex_doors (p.41)]
human *(a1')- old paint is burnt off and repainting is tough work*
PARADISE *(B3')- One can avoid that repainting is tough work . One has only to consider that one uses a wire brush.*
hum.*(a4')- it wrecks the wood*
PAR.*(B3'')- But maybe the wood is not soft*
hum.*(a4'')- the wood is soft*
PAR.*(B4'-B5')- Yes indeed, if the wood is soft then one does not use a wire brush or else it wrecks the wood. One can avoid that old paint is burnt off and repainting is tough work. One has only to consider that doors are sanded.*
hum.*(a7')- there are several layers*
PAR.*(B7')- But maybe one can apply filler compound.*
hum.*(a8')- the surface looks not great*
PAR.*(B7'')- Yes you're right. Old paint is burnt off or else surface looks not great, since there are several layers. Yes you're right. Repainting is tough work, since old paint is burnt off and one does not use a wire brush.*

We see again that PARADISE allows to explain the whole conversation (considered as a list of arguments) by a slight difference between A and B's knowledge:

common knowledge

repainting_is_tough_work ⇒ **UND**
wood_is_wrecked ⇒ **UND**
not *surface_looks_correct* ⇒ **UND**
not *surface_looks_great* ⇒ **UND**

[*old_paint_is_burnt_off* **&** **not** *surface_looks_great*] ⇒ **F**
[*surface_looks_correct* **&** **not** *old_paint_is_burnt_off*
& **not** *doors_are_sanded* **&** **not** *filler_compound_is_applied*] ⇒ **F**
[**not** *old_paint_is_burnt_off* **&** *several_layers*
& **not** *filler_compound_is_applied* **&** *surface_looks_correct*] ⇒ **F**
[*doors_are_sanded* **&** **not** *several_layers* **&** **not** *surface_looks_correct*] ⇒ **F**
[*old_paint_is_burnt_off* **&** **not** *wire_brush* **&** **not** *repainting_is_tough_work*] ⇒ **F**
[*old_paint_is_burnt_off* **&** *wire_brush* **&** *repainting_is_tough_work*] ⇒ **F**
[*wire_brush* **&** *wood_is_soft* **&** **not** *wood_is_wrecked*] ⇒ **F**
[**not** *old_paint_is_burnt_off* **&** *several_layers* **&** *surface_looks_great*] ⇒ **F**
[*surface_looks_great* **&** **not** *surface_looks_correct*] ⇒ **F**

A's specific knowledge

not *wood_is_soft* ⇒ **F**
not *several_layers* ⇒ **F**

PARADISE is thus able to fill the gap between the static logical knowledge extracted from contextual information and the dynamic linking of utterances which can be observed in real conversation. To achieve this, it was necessary to make it able to understand why a given reply is logically relevant, and to give it definite strategies to make logically relevant utterances [dessalles 1990].

We also better understand how a slight difference between the logical contexts that speakers have in mind may induce a whole conversation. For instance, PARADISE allows us to explain [ex_doors, p.41] by merely attributing the additional information 'the wood is soft' and 'there are already several layers' to A. The remainder is shared knowledge.

PARADISE was designed to recognize logical relevance and to form relevant replies using only a small group of fixed strategies. This makes the similarity between its utterances and human ones more striking. It also indicates that logical relevance is not so complicated and mysterious, since it can be captured by artificial devices.

10.Cognitive implications

Logical analysis of conversation contributes to natural language analysis at its own level, as shown in figure 8.

There are several reasons why we should distinguish different levels in language, but the most obvious is that linguistic productions may be perceived as correct at one level and incorrect at the other. For instance "The garden of the door eats the sky" is syntactically correct, but seems meaningless. The sentence "there are people in the world who are older than twelve" is semantically fully acceptable, but there are contexts in which it cannot receive any pragmatic relevance. In order to illustrate the necessity of integrating logic into pragmatics, we need only to notice that there may

sociology
. . .
argumentation strategy
logical pragmatics
semantics
syntax
morphology
phonology

-------- figure 8: levels of language analysis ---------

be utterances that merely associated with the context, but that perform no logical action, and are thus logically irrelevant (e.g. [ex_channel, p.20] A4).

Some laws described at a given linguistic level are sometimes considered as general or even universal. To what extent could the logical constraints outlined here be universal? Are they limited to western culture? Both possible answers to this last question would be of the greatest interest. Many studies show that logic plays an important role during discourse in unrelated cultures (cf. [Hutchins 1980:67], [I. Taylor 1989:277]), but specific studies on spontaneous conversation are still necessary. And among people sharing the same culture, are there groups or individuals who do not care about logical relevance? An easy answer is to consider that this fact, if true, would be well known.

It is actually well known, but for a special kind of people who are said to show "conversational disorders". Here is a conversation with an ill person, recorded by A. Trognon [Trognon 1988]:

[ex_singing]
context: this conversation was recorded by the investigator when speaking to a mentally ill woman.
A1- Vous ne chantez plus, là?
B1- Je chante mais c'est faux.
A2- C'est faux?
B2- C'est faux.
A3- Oh faut peut-être continuer un peu, non?
B3- Oh mais j'ai été à l'école, moi!
A4- Ouais?
B4- A l'école, on m'a appris à connaître la vie hein... connaître les gens quoi... tout ça les décès les mariages
A5- Oui
B5- soit c'est des décès, soit c'est des mariages... mais c'est pas bien les décès par exemple... vaut mieux pas décéder.

A1- You don't sing anymore?
B1- I'm singing, but out of tune
A2- Out of tune?
B2- Out of tune.
A3- You should keep on, shouldn't you?
B3- Oh but I went to school!
A4- Yes?
B4- At school, I learned to know life... to know people... all this stuff, deaths, weddings
A5- yes
B5- It's either deaths, or weddings... but deaths are bad things, for instance... it's better not to be deceased.

It seems uneasy to communicate with ill persons. Here, not only logical constraints are transgressed: B3 is an abrupt topic change, taking no care of transition rules. But it is also a bad topic introduction. We cannot find any likely context that can make B3+B4 paradoxical or improbable or (un)desirable. Eventually B comes on an undesirable proposition at the end of B5, but no interesting context makes it relevant.

Logical analysis may allow to give scientific definition and diagnosis of what conversational disorder is. Some of these disorders have been shown indeed to be related to logic [Watzlawick & al.

1977], [Bateson & al. 1956]. But ill persons are not the only ones who utter replies which are not logically appropriate. Young children are often disconcerting with their wrong reasonings, their strange justifications, etc. However, McTear excerpts [McTear 1985] show that children under six are sometimes able to discuss together according to a precise logical frame. They seem to be sensitive to the three modalities (paradox, improbability, (un)desirability), but logical contexts seem to be very simple.

It becomes clear now that conversation is not a social interaction without any logical structure, or with a more or less random logical structure depending on external circumstances. Conversations do have an intrinsic logical structure which no doubts contributes to make this social means of communication possible.

But it may be also interesting to notice that the logical constraints that protagonists impose on each other's replies are cognitively justified. For example, discussing paradoxes will give them opportunities to repair inconsistencies which corrupt their knowledge. This must be very valuable, if we remember how insistent first speakers were in [ex_Goffman, p.6], in [ex_ping-pong, p.36] or in [ex_Christmas-tree, p.37] on obtaining adequate invalidations. When discussing about improbable events, they will perform a reappraisal of the probability coefficients they assign to each event. This is essential when we think that each decision in everyday life requires several probabilistic estimations. When conversing in the (un)desirable mode, they take advantage of each other's experience, they think up and test together plans of action which will spare them undesirable experiences, or which will bring them closer to beneficial situations.

We did not speak here of other kinds of constraints that limit interlocutor's freedom, because they are not strictly "logical", and therefore lie out of the scope of this paper. But such constraints, as for example topic transition rules, have also many cognitive implications.

Being aware of the importance of logical constraints in conversation, we can think of several applications in areas like A.I., Computer Aided Learning, speech understanding, expertise transfer, etc.

11.Technical applications of logical conversation analysis

The design of PARADISE program revealed how limited the range of admissible replies is. People working on speech understanding may take advantage of these limitations to anticipate possible answers of their system's user, thus changing the difficult problem of understanding a mere sentence into the problem of recognizing known predicates in a reply (this is one of the strategies used in [Andry 1992] where speech recognition is assisted by an anticipation of the intention underlying the next utterance).

Conversely human/machine interaction should also gain in quality if all the machine's replies are logically relevant, in the precise sense we gave to this word. This is exactly what led us to implement conversational logic in the specific context of teaching aids.

Computer tutorial dialogues usually bear little resemblance to relaxed conversation. Most of the time, the student is tested by a succession of logically unrelated questions. In teaching contexts, dialogues are often considered as exercises. Their purpose is to train the student until her/his performance (i.e. percentage of good answers) reaches a given threshold that indicates that the skill has been acquired. But this is not our approach to teaching. We make a fundamental distinction between conceptual and procedural knowledge. Performance and thresholds are irrelevant when it

goes about conceptual knowledge transmission [Dessalles 1990a]. Concepts are entities that we represent logically, and as it turns out, conversation appears to be very well suited to concept teaching.

There are very few attempts, even in Intelligent Tutoring Systems design, to use conversation as a way to teach conceptual knowledge (a famous exception is the WHY system [Collins 1976]). Therefore we decided to develop a conversational module for our C.A.L. system SAVANT3 which tries to manage a "free" conversation with the student, uttering and expecting only relevant replies.

[interaction with SAVANT3]
context: this dialogue is proposed as an introduction to a digital communication course. Some concepts like digital symbols were presented, and then a printed page is displayed. Here is an example of dialogue between the system (S) and a student (E).
S1- Can we consider a printed text as a digital message ?
E1- sure
S2- According to what I understood: this typed page can be considered as a digital message. We have to consider symbols allowing a complete description of the page
E2- characters
S3- yes... mmm... According to what I understood: the points (pixels) in the page are not taken as symbols. What else in the page could we code, if we except printed characters?
E3- you mean if there are drawings?
S4- According to you, one wants to code for figures (schemas, photos, signature). It's surprising, if we admit that the points (pixels) in the page are not taken as symbols !
E4- but this is a printed page
S5- yes... According to what I understood: one chooses a TELETEXT-like coding. Printed characters are not the only thing to be coded...
E5- no
S6- Could you say more?...
E6- margins, paragraphs
S7- yes... mmm... But wait... According to what you said: one wants to code for positions (paragraphs, etc.). I must say I'm confused !
E7- you use special codes
S8- well, well!... Okay...

SAVANT3 makes use of a different knowledge base for each topic: typically 15 clauses represented in paradoxical form. During interaction, new facts learned from the student are added to this knowledge. The strategy used to converse with the student is quite simple, and reminds of the entrapment strategy used in WHY [Stevens & al. 1979]. The knowledge given to SAVANT3 on a specific subject consists of a set of incompatibilities:

$$[\, p_{11} \,\&\, p_{12} \,\&\, \ldots \,\&\, p_{1n} \,] \Rightarrow \mathbf{F}$$
$$[\, p_{21} \,\&\, p_{22} \,\&\, \ldots \,\&\, p_{2m} \,] \Rightarrow \mathbf{F}$$
$$\ldots$$

Some of these clauses may be invalid at a given point of the conversation with the student (when at least one term is false). SAVANT3 looks for an valid clause (e.g. clause j if all p_{ji} are known to be true or are still unknown). When a sufficient number of terms in this saturated clause are known, it utters known terms and pretends to be surprised, thus performing an utterance in the paradoxical mode. The student's utterance is then analysed in order to see if it denies a mentioned term (direct

invalidation, as in E4) or an unmentioned one (indirect invalidation, as in E7). The possibility of indirect invalidation comes thus from intentionally forgotten premises when the program utters surprise.

The valid clause chosen by the system to utter surprise is selected according to the ratio of known terms in it. When the best clause in this respect still contains too many unknown terms, showing surprise would be premature. So SAVANT3 tries to bring the student to determine the truth value of the next undetermined term (the simplest way to achieve this is to utter a pat sentence associated with this term by the author). The functioning of SAVANT3 is described in greater detail in [Dessalles 1990a].

One of the main objectives of SAVANT3 is to make each utterance logically relevant. Our hope is that its utterances will be perceived as relevant by the student, and it will be the case if the student is aware of the incompatibility which motivated the system's move. The system is always able to justify the relevance of its utterances by displaying other terms of the current paradox and by keeping on feigning surprise (as in S4). Conversely, the student is continuously invited to make relevant replies and to observe their logical effect.

The conversation that ensues from SAVANT3's entrapment strategy is a way to negotiate conceptual knowledge with the student. We hope it to appear as natural and pleasant. A student's utterance is not *a priori* considered false or right. It might be sound or stupid, the program always does its best to invalidate it by situating it into an incompatibility and by giving further arguments if there are some left. The conversation stops when no paradox remains valid.

According to our view, the relevance requirement has much pedagogical value. During everyday conversation, we carefully recall and assemble relevant contextual knowledge into what our model represents as logical formulas, upon which successive replies will act. Each new item appears thus only in a logical context. Interlocutors are not asked to memorize logically unmotivated items, unlike what is required from students during traditional courses. Logical relevance makes the management of our knowledge much easier. That is why we hope that students will learn better when conversing with SAVANT 3. They should better understand, because understanding a concept means updating its logical connections with other concepts, and better memorize, thanks to these connections and to the problematic context that brings out the importance of each new concept.

We may think of this kind of logical negotiation as one of the most natural way for students to maintain their conceptual knowledge. But the same could be said of knowledge in expert systems. Knowledge acquisition and knowledge maintenance could be handled in part through conversations, i.e. dialogues in which both participants take great care of being logically relevant. For example any declaration, made by a human expert in a given situation, that does not match the system's conclusions gives, an opportunity for the latter to utter its surprise (paradoxical mode). The human expert may then produce some indirect invalidation of the system's arguments which will correct and improve its knowledge base. And arguing this way may well be more pleasant from the expert point of view than having to debug a set of rules out of context. (S)he will even be surprised when the system, having detected an inconsistency in its database, utters a sound paradox spontaneously.

In some descriptions of expertise [Dreyfus & Dreyfus 1986:23] logic is presented as useful only at intermediary stages. Human experts would not care about logic. But logic is actually the only way for humans to communicate their expertise. It is of course not always possible, and sometimes competence can only be acquired after long and painful practice. But whenever expertise can be conceptualized, it can be transmitted through logical negotiation, i.e. conversation. This is why we

should try to implement interfaces making use of conversational laws, and not mere dialogue capabilities, in expert systems (see [dessalles 1992b]).

12.Conclusion

Depicting conversational behavior as an information exchange is making a very weak and vague observation. Conversations are the main device used by humans to exchange logically relevant knowledge. Conversational constraints compel anyone who wishes to initiate a conversational social interaction to recall and elaborate logically relevant knowledge and to utter part of it in a very codified form. When we want to express some thought, we make use of our language competence to code this thought into words. We take great care of using existing words and acceptable syntax, and we manage to utter meaningful sentences that will be correctly understood. But this encoding of thoughts is not completed if we do not place them in a context where they obviously play a logical role.

If we ignore the logical dimension of conversations, we miss their fundamental function. Our brains need to exchange not only facts, but also logical conceptual relations. They can construct such relations by themselves when confronted with experience. But the fastest and most efficient way to achieve this is no doubts to take advantage of inter-conceptual relations constructed by others. How could we wonder that the transfer of a knowledge, which may be complex, requires precise rules to be respected?

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Annex: some logical rewriting rules

The reader needs only a basic knowledge of formal logic in order to understand the meaning of the formulas used to express the content of conversations. We mention here some rewriting rules that are used to syntactically transform these formulas.

Basic symbols:

$p \Rightarrow q$	logical implication	(if p, then q)
not p	negation	(the contrary of p is true)
p **&** q	conjunction	(p and q are simultaneously true)
p **or** q	disjunction	(of p and q, one at least is true)

Symbols p, q, etc. represent logical propositions. They may be replaced by any syntactically correct formula that links logical propositions. This allows to apply successively several rewriting rules.

Some rewriting rules:

not (p **&** q)	can be rewritten as	**not** p **or not** q
not (p **or** q)	can be rewritten as	**not** p **& not** q
$p \Rightarrow q$	can be rewritten as	**not** q $\Rightarrow$ **not** p
$p \Rightarrow q$	can be rewritten as	**not** p **or** q
not ($p \Rightarrow q$)	can be rewritten as	p **& not** q
$p \Rightarrow$ (q **or** r)	can be rewritten as	(p **& not** q) $\Rightarrow$ r
$p \Rightarrow$ (q **&** r)	can be rewritten as	($p \Rightarrow q$) **&** ($p \Rightarrow r$)
(p **or** q) $\Rightarrow$ r	can be rewritten as	($p \Rightarrow r$) **&** ($q \Rightarrow r$)

Modalities used in the representation of contextual knowledge in conversations:

$p \Rightarrow$ **F**	falsity	(p is false)
T $\Rightarrow$ p	truth	(p is true)
$p \Rightarrow$ **IMPR**	improbability	(p is highly improbable)
PROB $\Rightarrow$ p	probability	(p is highly probable)
$p \Rightarrow$ **UND**	undesirability	(p is sufficient to make me unhappy)
UND $\Rightarrow$ p	undesirability	(if I am unhappy, then necessarily p)
$p \Rightarrow$ **DES**	desirability	(p is sufficient to make me unhappy)
DES $\Rightarrow$ p	desirability	(if I am happy, then necessarily p)

These modalities are designed so that they can be used as propositions in rewriting rules, with the following conventions:

not F	is rewritten as	**T**
not IMPR	is rewritten as	**PROB**
not UND	is rewritten as	**DES**

Any syntactically correct formula of propositional logic can be rewritten as a conjunction of *paradoxical clauses* (negative clauses):

$$[\ p_1\ \mathbf{\&}\ p_2\ \mathbf{\&}\ \ldots\ \mathbf{\&}\ p_n\ ]\ \Rightarrow\ \mathbf{F}$$

The meaning of such a clause is that p_1 , p_2 , ... p_n are incompatible: they cannot be all simultaneously true. With these modalities, we will obtain clauses like:

$$[\ p_1\ \mathbf{\&}\ p_2\ \mathbf{\&}\ \ldots\ \mathbf{\&}\ p_n\ ]\ \Rightarrow\ \mathbf{IMPR}$$

$$[\ p_1\ \mathbf{\&}\ p_2\ \mathbf{\&}\ \ldots\ \mathbf{\&}\ p_n\ ]\ \Rightarrow\ \mathbf{UND}$$

$$[\ p_1\ \mathbf{\&}\ p_2\ \mathbf{\&}\ \ldots\ \mathbf{\&}\ p_n\ ]\ \Rightarrow\ \mathbf{DES}$$

Predicate calculus makes use of variables on which two quantifiers may operate:

$\forall\ \mathbf{x} \in X;\ p(\mathbf{x})$	universal quantifier	(property p() is true for all elements in X)
$\exists\ \mathbf{x_0} \in X;\ p(\mathbf{x_0})$	existential quantifier	(property p() is true for at least one element in X)

Rewriting rules are identical, with this additional rule:

not ($\forall\ \mathbf{x} \in X;\ p(\mathbf{x})$) can be rewritten as $\exists\ \mathbf{x} \in X;$ **not** $p(\mathbf{x})$

All rules indicated here can also be used from right to left and can be combined together.

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