

Logical, temporal and causal interpretations of conjunction. An experimental approach *

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1 Introduction

The aim of this paper is to study experimentally the role of the structure and the meaning in the treatment of sentences linked by connectives and, in particular, by the connective (or conjunction) *et* (*and*).

It is well known that the conjunction *et* can have various interpretations in natural language such as logical, temporal or causal ones. Assuming a structural uniformity among these different interpretations, semantic and pragmatic theories explain these interpretative differences by the general pragmatic principles of communication (Grice 1975, 1989, Posner 1980, Schmerling 1975, Carston 1993, Blakemore & Carston 1999, Blakemore & Carston 2005). However, quite recently, Bjorkman (2010) has put forth some arguments in favor of a structural division among these different interpretations. In brief, asymmetric interpretations (temporal and causal) in their syntactic structure involve a coordination of temporal phrases (TP), while symmetric interpretations (logical) imply a coordination of the complementizer phrases (CP).

** The present paper is dedicated to Anne Reboul in celebration of her 60th birthday. Her extraordinary work as well as her always supportive and gentle advice have not ceased to inspire and encourage the authors of this paper in their own research. Joyeux anniversaire très chère Anne!

This paper presents a pilot study whose aim is to examine which elements prevail in the on-line treatment of the sentences with the French connective *et*. If structural considerations prove to have a cost in the treatment of *et*, we can make the hypothesis of a clear difference in the treatment of asymmetric (temporal and causal) and symmetric (logical) interpretations. The latter should have a longer time of treatment because they are composed of larger syntactic structures (CP), whereas the former should have a shorter time of treatment because they have smaller syntactic structures (TP). On the contrary, if pragmatic principles play a dominant role in the treatment of sentences with *et* we can expect that the logical interpretation of *et* be treated most rapidly since it constitutes the basic semantics of *et*, whereas the two other types of interpretation should be treated less rapidly.

The determination of the “rapidity” of treatment between temporal and causal *et* is to be found in different pragmatic theories. For instance, for Levinson (1983, 2000), the temporal interpretation should precede the causal one. For the Relevance Theory (Sperber & Wilson 1986/1995) this is not necessarily the case. The speaker interprets utterances based on her encyclopedic knowledge which contains various mental schemes that allow getting the correct utterance interpretation. We will discuss both approaches in more details in section 2.1.

2 Background

According to traditional pragmatic theories, the semantics of *and* is rooted in the meaning of the logical operator of conjunction \wedge which is minimal in the sense that it takes into account only the truth-values of the conjoined propositions. So, a complex proposition containing conjunction is true just in case both propositions that compose it are true. Consequently, the logical conjunction has the property of symmetry, which means that $p \wedge q$ is equivalent to $q \wedge p$. Table 1 gives the truth-table for \wedge , where 1 = true and 0 = false.

Logical conjunction		
P	Q	$P \wedge Q$
1	1	1
1	0	0
0	1	0
0	0	0

Table 1. Truth-table for logical conjunction

However, it is well known that the spectrum of relations that can be expressed with *and* is very broad and the nature of some of these relations makes the property of symmetry unsuitable. Furthermore, in some cases, the inverse property, the one of asymmetry, is applicable as in the cases of temporal and causal interpretations.

- (1) It rains and it is windy. (logical interpretation)
- (2) John woke up and he took his shower. (temporal interpretation)
- (3) Mary pushed Max and he fell. (causal interpretation)

Standardly, it is assumed in pragmatics that the semantic nucleus of *and* is constituted by its logical meaning and all the other interpretations are explicable via pragmatic rules and principles.

2. 1. Pragmatic perspective

Grice (1989) forwarded the idea according to which there is no fundamental difference between the meaning of logical words in formal languages and the meaning of their counterparts in natural language. For instance, the connective *and* in the Gricean example below keeps its logical meaning and its temporal value corresponds to an implicature, that is, it is inferred thanks to general pragmatic principles which govern the communication.

- (4) John put off his boots and went to bed.

In particular, here the interlocutor supposes that the speaker obeys to the maxim of order according to which the eventualities are usually narrated in the order in which they happened.

However, the application of the maxim of order does not elucidate the problem of causal interpretations and Grice didn't bring the solution to this matter. But the post-gricean approaches have studied the subject.

First, Levinson (1983, 146) conceived an incremental algorithm designed for the calculation of the various interpretations of *and*, like in (5).

(5) Let be *P* and *Q*. Try to interpret it as:

- (i) "P and then Q"; if it is possible, try:
- (ii) "P and by consequence Q"; if it is possible, try:
- (iii) "P, and P is the cause of Q".

So, Levinson's theory predicts that after the logical interpretation comes temporal interpretation followed by the causal one.

The Relevance Theory proposes a different solution (Sperber & Wilson 1986/1995). First of all, contrary to Grice, temporal but also causal interpretations are not considered to be implicatures but they are aspects of *what is said* determined in an inferential manner (Carston 1988, 2002). More particularly, the interpretation depends on the degree of accessibility of contextual assumptions which activate different mental schemas, for instance of causal nature. The existence of such schemas among different encyclopedic knowledge of participants of the conversation ensures the adequate interpretation of a given conjoined utterance. For example, the correct assignment of the truth-conditions for a causal sentence as (6) is guaranteed by the interaction of the principle of relevance and some contextual assumptions.

(6) Mary dropped the vase on the tiles and it broke.

All the participants of the conversation have a causal schema saying that a vase which is dropped on the tiles breaks. These contextual assumptions are made accessible precisely due to the encyclopedic knowledge that interlocutors share on this type of eventualities. As long as the contextual assumptions provide interpretations in accordance with the principle of relevance, other possible interpretations are ruled out¹.

2. 2. *Syntactic perspective*

Bjorkman (2010) presents an approach based on an analysis of embedded clauses according to which there is a syntactic difference between symmetric and asymmetric coordination. The important point is that in the embedded contexts asymmetric interpretations are only available for the TP-level coordination while the symmetric interpretations are accessible for the CP-level coordination. Let's consider Bjorkman's example (2010).

- (7) a. The newspaper reported that a new mayor was elected and there was a riot.
 b. The newspaper reported that a new mayor was elected and that there was a riot.

The structural difference between the two examples is clear. In (7)a the complementizer *that* is present once, which suggests that the conjunction *and* relates two structures of the type TP. *That* appears twice in (7)b implying the presence of a structure larger than TP, the one of CP. (8) schematically illustrates the difference between the two structures following Bjorkman (2010).

- (8) a. ... reported [_{CP} that [_{TP}...]] and [_{TP}...]
 b. ... reported [_{CP} that ...] and [_{CP} that ...]

¹ The importance of causal schemas under the form of causal laws is also put forth by the Relevance Nomological Model (Blochowiak 2014a, 2014b).

This structural difference is reflected in an interpretative differentiation. When the TP-level coordination is involved, possible interpretations include the asymmetric interpretations while in the case of the CP-level coordination only the symmetric relations can appear. For instance, (7)a tends towards an interpretation in which the speaker observes a causal link between the two events described in the embedded clauses. According to this interpretation the riot was causally linked to the election of the mayor. On the contrary, (7)b does not suggest such an interpretation. The two events described by the embedded clauses are rather treated in the independent manner, with no causal relation between them.

Thus, the generalization proposed by Bjorkman (2010) is the following: the coordination of embedded clauses of type TP delivers interpretations with asymmetric relations (temporal or causal) whereas the coordination of CP structures gives symmetric interpretations (logical).

Assuming that the interpretation process is sensitive to the size of the language structures, Bjorkman's hypothesis predicts that symmetric interpretations, having larger structures, take longer time of treatment with respect to asymmetric interpretations whose structures are smaller.

2.3. An experimental study on and

Bjorkman's hypothesis has been tested experimentally by Thompson et al. (2011, 2012). The experiment has considered time of treatment of sentences as being semantically distinct: (i) logical, (ii) temporal and (iii) causal *vs* as being structurally distinct: (i) asymmetric and (ii) symmetric.

The experiment has been conducted with RSVP methodology (Rapid Serial Visual Presentation) (Foster 1970). This method consists in presenting to the participants sentences (word by word) in the center of a computer screen at a fixed rate. After the presentation of a sequence of words, participants have been required to read aloud

the sentence they have seen. Therefore, the measure of this experiment corresponds to the time of the production of presented sentences.

Their results seem to partially confirm the syntactic thesis formulated by Bjorkman (2010). Globally, the sentences implying the symmetric interpretations have been produced at slower rate than the ones with asymmetric interpretations. However, the difference between temporal interpretations does not reach statistical difference. Only the difference between logical and causal *and* is statistically significant.

Before going further, it is worth examining the protocol used by Thompson et al. First of all, the size of the subject group in their study is quite restricted because it counts only 8 participants. Moreover, one should ask whether the methodology used (RSVP), and more particularly the measure of the production time, is best adapted for the study concerning the interpretation of *and*.

Even more problematic are the stimuli used in the experiment. Indeed, the analysis of the stimuli reveals some problems in their construction. First, certain sequences cannot be judged as being purely temporal. Examples provided in (9) could be well interpreted as causal and they are classified in the set of temporal *and*.

- (9) a. The player scored and the team won the game.
- b. The man fell and the woman laughed.
- c. She won the lottery and they bought a yacht.

Moreover, the set containing stimuli with logical *and* is not uniform because it encloses episodic (10)a, habitual (10)b and generic (10)c sentences.

- (10) a. Gabriel ordered the pasta and Lily had some chicken.
- b. Sarah studies in the library and Connie works from home.
- c. Wolves hunt in packs and lions run in prides.

The lack of clarity in the temporal examples as well as the non-uniformity in the set of logical examples could have potentially impacted the times of production and by consequence the final results of the experiment conducted by Thompson et al. (2011, 2012).

In order to verify the results obtained by Thompson et al., we have conceived of a pilot experiment which takes into account the problematic points detected in the choice of stimuli and it also uses a different methodology. The pilot experiment that we will present in the next section has been conducted for the French conjunction *et*.

3 An experimental study on *et*

In sum, we can consider two types of approaches that aim at explaining different interpretations of *et*. The pragmatic approach would predict that the treatment of logical *et* is the least costly, followed by the temporal and causal *et* (according to Levinson 1983) or indistinctly by the causal and temporal *et* depending on the accessibility of contextual premises (according to Relevance Theory). According to the syntactic approach, on the contrary, the asymmetric structures (temporal and causal *et*) should be treated equally more rapidly than the symmetric structures that are heavier (logical *et*).

In order to provide some light on this question, we have considered the three types of *et*, as in the experiment carried out by Thompson et al., with the difference that our experiment was conducted on the French conjunction *et* and the employed method diverges from the one used for *and*.

3.1. A pilot study on *et*

3.1.1. Material and method

Participants

Thirty-two students (19 female, Mage = 24.23, SD = 4.44, [18-34 y.o.]) in Humanities at the University of Geneva have participated in the experiment. The majority were native speakers of French (n = 26) and the others had a very good level of French (n = 6).

Design

In this study we aimed at measuring the reading times of complex propositions *P et Q* depending on the three types of possible interpretations of *et* (logical, temporal and causal).

It is based on two complementary experiments, the 'control' and the 'test' experiment. The same propositions have been used in the two experiments, the difference being that in the control experiment the coma has been used to replace the conjunction *et*. In this manner, the proposition test (*P et Q*) *Il a neigé toute la nuit et les autoroutes sont impraticables* (It was snowing all the night long and the highways are impassable) corresponds to the proposition control (*P, Q*) *Il a neigé toute la nuit, les autoroutes sont impraticables*. The goal of the control experiment is to determine the mean reading time of *Q* without the presence of the conjunction. The test experiment serves to determine the effect of the conjunction on the mean reading time of *Q* as a function of the experimental condition (logical, causal, temporal).

To hide the aim of the experiment, the instruction given to participants was to judge whether the sequences of propositions are plausible or not. For example, the sequence *Marie a préparé les crêpes et Jean a passé l'aspirateur* (Marie made the pancakes and Jean used the vacuum cleaner) should be judged as plausible by participants, whereas the sequence *Pierre est parti à la montagne et il a vu des extraterrestres en pyjama* (Pierre went to the mountains and he saw extraterrestrials in pyjamas) as implausible. The participants were also asked to answer as fast and as accurately as possible.

The propositions have been constructed according to three criteria: a) all the propositions following the conjunction (*P et Q*) are in *passé composé*; b) all the propositions are made of frequent words; c) the number of syllables of the second proposition (*Q*) is of 9 for the logical condition, 12 for the temporal condition and 10 for the causal one. The Table 2 presents a sample of each category.

Condition	P	Q
Logical (n = 6)	<i>Jean a joué de la guitare</i> Jean played the guitar	<i>et Agnès a dansé le flamenco.</i> and Agnès danced flamenco.
Temporal (n = 6)	<i>L'avion a atterri</i> The plane landed	<i>et les passagers sont descendus sur le tarmac.</i> and the passengers got off on the runway.
Causal (n = 6)	<i>Des pluies torrentielles se sont abattues sur le Jura</i> The heavy rainfalls hit the Jura	<i>et l'électricité a été coupée.</i> and the electricity was cut off.
Implausible (n = 10)	<i>Les policiers ont attrapé le malfrat</i> The policemen caught the criminal	<i>et ils ont joué aux échecs avec lui.</i> and they played chess with him.

Table 2. Presentation of each type of propositions used.

Procedure

After the participants signed the consent, they have been invited to sit in front of the computer on which they would pass the experiment. The participants have been assigned randomly to one of the two experiments.

The experiment starts by reading instructions followed by a training phase (9 sequences) and by an experimental phase (28 sequences with 18 sequences-test). For each trial, a first proposition (*P*) appeared at the center of the computer screen and the participant had to press the SPACE button to pass to the next proposition (*et Q*). After reading the whole sequence (*P et Q*), the participant had to decide whether the whole sequence seemed plausible (button p) or implausible (button q) (the order of buttons was counterbalanced between the participants). Both experiments have been designed using of the software E-Prime 2.0 (Schneider, Eschman & Zuccolotto 2012). All the propositions have been presented randomly at the center of a computer screen (a PC) in white font (Times New Roman, size 18) on a black screen.

3. 1. 2. Results

The aim of this experiment is to isolate the mean reading time (RT) for each type of *et* in order to compare them and test the predictions presented before. To do so, we have measured the RT of the sequence composed of the conjunction and the second proposition (*et Q*) in the test experiment and of the second proposition alone (*Q*) in the control experiment. In order to obtain a mean RT for each type of *et*, we have subtracted the mean RT of each control proposition (*Q*) from the RT of the corresponding test propositions (*et Q*), that is: $RT_{et} = et\ Q - Q$. So, in the example *Marie a préparé les crêpes et Jean a passé l'aspirateur* (Marie made the pancakes and Jean used the vacuum cleaner), we measured the RT of the second proposition with the conjunction (*et Jean a passé l'aspirateur*) and subtracted the mean RT of the second proposition without conjunction (*Jean a passé l'aspirateur*).

Two participants have been excluded from the analysis because their accuracy was inferior to 75% ($M = .93$, $SD = .24$). So, the following analyses focus on the correct answers to the 18 plausible propositions of the experiment test ($n = 17$) and the experiment control ($n = 13$).

Experiment control

A first descriptive analysis allows us to determine the mean reading time of each proposition (*Q*) as well as the mean reading time for each condition: $M_{\text{Logical}} = 2260$, $SD = 1021$; $M_{\text{Temporal}} = 2225$, $SD = 757$; $M_{\text{Causal}} = 2092$, $SD = 1433$. In addition, an analysis of variance does not reveal any mean effect of the condition on the propositions RT, $F(2, 206) = 2.37$, $p = .096$. Tukey's post-hoc tests did not reveal any difference between the conditions.

Experiment test

A descriptive analysis presented in Table 3 and Figure 1 shows the RT of *et Q - Q* in each condition.

TL (<i>et Q - Q</i>)	N	Moyenne	Ecart-type
Logique	86	-284,50	766,19
Temporel	93	147,03	920,09
Causal	94	326,60	1070,22

Table 3. Mean RT of (*et Q - Q*) as a function of the experimental condition (logical, temporal or causal).

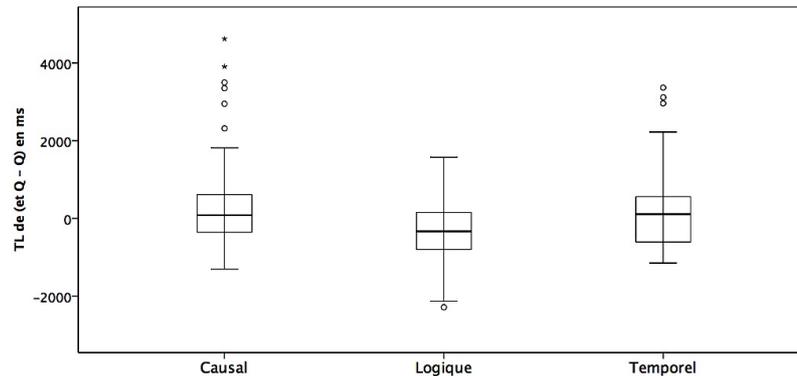


Figure 1. Box-plots of RT of *et Q - Q* according to the type of interpretation of the conjunction *et* (causal, logical and temporal). The black line indicates the median value. The boxes represent the half of the sample, between inferior and superior quartiles. The whiskers represent the most extreme values, outliers excluded (circles and asterisks).

In addition, a paired-sample Wilcoxon signed-rank test shows that the RT of (*et Q - Q*) of the logical condition ($Mdn = -200$) is significantly smaller than the causal condition ($Mdn = -.33$, $Z = -3.01$, $p < .01$, $r = .35$) and the temporal condition ($Mdn = 132$, $Z = -3.19$, $p < .001$, $r = .59$). The same test reveals no difference between the RT of the causal condition and temporal one ($Z = -.35$, $p = .72$). Moreover, a paired-sample Wilcoxon signed-rank test shows that symmetrical propositions ($Mdn = -200$) are read faster than the asymmetric propositions ($Mdn = 293$), $Z = 2.63$, $p < .01$, $r = .32$.

In sum, the results obtained seem to indicate that symmetric propositions are treated faster than the asymmetric ones. In addition, the logical interpretation of *et* is treated faster than causal and temporal interpretations. However, it was not possible

to reveal a difference in reading time between causal and temporal interpretation of *et*.

3. 2. Discussion

The results obtained in the experiment on French support predictions of pragmatic theories concerning conjunction. Logical interpretations (symmetric) have been treated the most rapidly, followed by causal and temporal interpretations (asymmetric). Thus, the results of our experiment are in opposition to the ones obtained by Thompson et al. (2011, 2012) and the considerations about structural differences brought forward by Bjorkman (2010).

What are the elements that could explain these differences?

Beyond the problem of stimuli that we have pointed out in the section 2.3, the experiment conducted by Thompson et al. presents a major methodological difference as well. Indeed, they have used the *Rapid Serial Visual Presentation* paradigm and the analysis of the production time whereas we took the option of *Self Paced Reading* task. The former is more widely used in the research on the lexicon, semantics and semantic treatment (Rayner & Sereno 1994). The latter is more appropriate to studies on the discourse comprehension (Garrod 2006). Anyway, one has to point out a lack of precision in the description of the procedure and of the analyses of Thompson et al.'s paper.

Finally, it is important to underline that the small number of participants (eight) constitute a weak point of their protocol and no statistical tests has been reported in the paper by Thompson et al. (2011, 2012), and this casts doubts on the interpretation of the conclusions of their study.

4 Conclusions

This paper presented a pilot experiment that aimed at verifying empirically the predictions of syntactic and pragmatic theories concerning conjunction. On one hand, according to one syntactic proposal (Bjorkman 2010) there is a structural difference between the symmetric uses (including logical interpretations) that imply bigger structures (CP) and asymmetric uses (including temporal and causal interpretations) that are composed of smaller structures (TP). On the other hand, pragmatic theories claim that the meaning of the conjunction in natural languages is based on the meaning of logical conjunction that is symmetric. Other types of interpretations, such as temporal or causal, are inferred by the interlocutors via general principles of pragmatics. Therefore, the predictions of these two approaches are clear: logical interpretations should be less costly for the pragmatic approach and vice versa for the syntactic approach.

We have reported the experiment conducted on *and* (Thompson et al. 2011, 2012) whose results point towards a partial confirmation of the syntactic theory. However, these results do not seem to be easily usable (or generalizable) given the problems of the construction of the stimuli that we have reported and the small number of participants.

We have conducted an experiment on French avoiding the problems with the stimuli observed in the Thompson et al.'s experiment and with different methodology, and we have obtained the results which are the opposite to the ones obtained for English. Logical interpretations have been treated the most rapidly, followed by temporal and causal interpretations with a statistically significant difference between the logical and causal interpretations as well as logical and temporal interpretations. A future experiment with a bigger number of participants

will be conducted soon in order to confirm the first results obtained in our pilot experiment.

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