Chapter 7

How logical is natural language conjunction? An experimental investigation of the French conjunction *et* *†

Joanna Blochowiak & Thomas Castelain

Abstract The aim of this paper is to study experimentally the role of structure and meaning in the processing of sentences linked by the conjunction *and*. Traditionally, different interpretations of conjunction in natural language are explained from a pragmatic perspective as the result of the interaction between its logical meaning and pragmatic principles governing the discourse. According to Grice and many of his followers, the semantics of *and* is equivalent to its logical, truth-functional definition, and the additional (e.g. temporal) connotations are pragmatically derived as implicatures. Quite recently, an alternative explanation has emerged from a syntactic perspective, according to which there is a structural ambiguity between the symmetrical (logical)

*The present paper is dedicated to Anne Reboul in celebration of her 60th birthday. Her extraordinary work, as well as her ever-supportive and gentle advice, has never ceased to inspire and encourage the authors of this paper in their own research.

†The present study was a part of Project Nº 100012_146093: "LogPrag: the semantics and pragmatics of logical words (negation, connectives, quantifiers)" carried out at the University of Geneva (2014-2017) and funded by the Swiss National Science Foundation. The first author is grateful to this institution for its generous financial and administrative support. The two authors wish to express their gratitude to Jacques Moeschler for his valuable collaboration on an earlier version of this paper.

and asymmetrical (temporal and causal) uses of conjunction. These approaches make different predictions in terms of the processing cost involved in interpreting utterances with *and*. This paper presents a reading time experiment conducted on the French conjunction *et* (and), which aims to test these predictions. In general, our results showed that the reading times of logical, temporal and causal interpretations increased in that order. In particular, we found that the difference between logical and causal interpretations was statistically significant, while the difference between logical and temporal was not. In the discussion, we examine the hypothesis that this lack of difference may be due to the difficulty in differentiating between logical and temporal interpretations inherent to natural language.

Keywords Logical words · Conjunction · Relevance Theory · Reading time experiment

1 Introduction

It is well known that the conjunction *and* can have various interpretations in natural language, such as logical, temporal or causal interpretations. Assuming 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 favour of a structural division between 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 complementizer phrases (CP).

This paper presents an experimental study aiming to examine which elements prevail in the on-line processing of sentences with the French conjunction *et*. If structural considerations prove to have a cost in the processing of *et*, we could hypothesize a clear difference between the processing of asymmetric (temporal and causal) and symmetric (logical) interpretations. The latter should have shorter processing times, because they are composed of smaller syntactic structures (TP), whereas the former should exhibit longer processing times, because they are composed of larger syntactic structures (CP). In contrast, if pragmatic principles play a dominant role in the processing of sentences with *et*, we can expect the logical interpretation of *et* to be processed faster, since it constitutes the basic semantics of *et*, whereas the two other

types of interpretation should be processed at a slower rate.[1] The determination of the "rapidity" of processing between temporal and causal *et* is to be found in different pragmatic theories. For instance, for Levinson (1983, 2000), the temporal interpretation should be quicker to process than the causal; however, this is not necessarily the case for Relevance Theory (Sperber & Wilson 1986/1995). The speaker interprets utterances based on her encyclopedic knowledge, which contains various mental schemes that allow the correct utterance interpretation to be reached. We will discuss both approaches in more detail in section 2.1.

2 Background

According to traditional pragmatic theories, the semantics of *and* is rooted in the meaning of the operator of the conjunction $\wedge$ from propositional logic, which is minimal, in the sense that it takes into account only the truth-values of the conjoined propositions. Hence, the resulting complex proposition ($p \wedge q$) is true only if both the propositions (p, q) that compose it are true. Consequently, the logical operator of conjunction has the property of symmetry, which means that the result of its application is independent of the order of its arguments, i.e. $p \wedge q$ is equivalent to $q \wedge p$. Table 7.1 gives the truth-table for $\wedge$, where 1 = true and 0 = false.

p	q	$p \wedge q$
1	1	1
1	0	0
0	1	0
0	0	0

Table 7.1: Truth-table for logical conjunction

Strictly speaking, the conjunction *and* in logic is a binary operator inducing the logical relation of conjunction, in the sense that any two-place operation defines a binary relation when the value of the result of this operation is fixed (for logical operators, the value is fixed to 1). Here, if we assume that the complex conjunctive proposition is true, we arrive at a relation between the two conjuncts which holds if and only if both are true. Hence, this is a purely logical relation which applies to every conjunctive statement.

[1] However, we should emphasize that this traditional view has recently been questioned. Some studies on the topic of implicatures suggest that only scalar implicatures with lexical replacement can incur a processing cost. For more detail, see Tiel & Schaeken 2017.

However, it is well known that the spectrum of relations which can be expressed by *and* in natural language is very broad, and the nature of some of these relations makes the property of symmetry unsuitable. Furthermore, in some situations, the inverse property—asymmetry—is applicable, as is true for many temporal and causal interpretations.

The standard assumption within pragmatics is that the semantic nucleus of *and* is constituted by its logical meaning, and the hearer arrives at all the other interpretations via the pragmatic type of inference, with the help of pragmatic rules and principles of conversation. So, as far as the logical form is concerned, examples (1)-(3) are symmetric, and other layers of meaning come from some sort of pragmatic inference (basically implicature or explicature, depending on the pragmatic theory, which we will detail in the next section).

(1) It is raining and it is windy. (logical interpretation)

(2) John woke up and he took his shower. (temporal interpretation)

(3) Mary pushed Max and he fell down. (causal interpretation)

In the remainder of this section, we will present in more detail three pragmatic accounts (section 2.1) and a syntactic approach to conjunction (section 2.2).

2.1 Pragmatic perspective

Grice's original proposal was formulated in reaction to ordinary-language philosophers of his time, for whom there was a fundamental gap between the meaning of logical words—i.e. operators, connectives and quantifiers from propositional calculus—and their natural language counterparts:

> It is a commonplace of philosophical logic that there are, or appear to be, divergences in meaning between, on the one hand, at least some of what I shall call the FORMAL devices—$\neg, \wedge, \vee, \supset, (x), \exists(x), \imath x$ (when these are given a standard two-valued interpretation)—and, on the other, what are taken to be their analogues or counterparts in natural language—such expressions as not, and, or, if, all, some (or at least one), the.
>
> [...]
>
> I wish, rather, to maintain that the common assumption of the contestants that the divergences do in fact exist is (broadly speaking) a common mistake, and that the mistake arises from an inadequate

> attention to the nature and importance of the conditions governing conversation. (Grice 1975: 41–43)

In other words, according to a traditional philosophical view, a word such as *and* and its logical counterpart $\wedge$ have two distinct meanings, with rather few links between them. For Grice (1975), this view was mistaken, because it didn't take into account the rules and principles guiding natural language conversation. For instance, in the Gricean example (4), below, *and* keeps its logical meaning, and its temporal value corresponds to an implicature—that is, it is inferred by way of general pragmatic principles which govern communication.

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

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

However, the application of the maxim of orderliness does not elucidate the issue of causal interpretations, and Grice provided no solution to this matter. Nonetheless, post- and neo-Gricean approaches have offered some explanations for this phenomenon. We will focus on the approaches of Levinson and Relevance Theory, in that order, as they allow for the formulation of experimentally testable predictions.

Initially, Levinson (1983: 146) came up with an incremental algorithm, reproduced in (5), which was designed to calculate the various interpretations of *and*.

(5) Given *P* and *Q*, try to interpreting it as:
   a. "P and then Q"; if successful try:
   b. "P and therefore Q"; if successful try also:
   c. "P, and P is the cause of Q".

So, Levinson's 1983 proposal predicts that after the logical interpretation comes the temporal interpretation, followed by the causal interpretation.

A later development of Levinson's theory (Levinson 2000) shifted the focus onto the default type of interpretations. He proposed a theory of I-implicatures, which are generalized conversational implicatures triggered and guided by stereotypical information associated with the situations described by utterances. I-implicatures, which are pragmatically enriched meanings, automatically arise by default unless some specific contextual information prevails over them. In contrast, particularized implicatures are not automatic, and

are triggered in specific contexts. Temporal and causal interpretations of *and* are typical examples of I-implicatures; temporal interpretation in particular is claimed to be the default one. When two past-tense event descriptions are conjoined with *and*, temporal sequential interpretation is the first to arise (6). However, since I-implicatures are pragmatic types of inference, they can be cancelled by the meaning of temporal adverbs (7), our knowledge of the world (8), or explicitly (9).

(6) Max went to the railway station and bought a ticket.
(Implicature: Max went to the railway station and then he bought a ticket.)

(7) Max went to the railway station and he bought his ticket before.
(The temporal implicature is cancelled by the interpretation of the adverb *before*.)

(8) Max went to the railway station and he bought his ticket online at home.
(The temporal implicature is cancelled by our world knowledge.)

(9) Max went to the railway station and he bought his ticket, but not in this order.
(The temporal implicature is cancelled by explicit denial.)

As far as cognitive processing is concerned, the updated version of Levinson's theory—and the theories defending default interpretations in general—predict that pragmatic enriched meanings come first by default, while semantic readings need a second stage to cancel default interpretations. The second stage is effortful and time-consuming, and semantic interpretations will therefore take longer to process than pragmatic ones. As such, in the case of the conjunction, the default type of theory predicts that temporal and causal readings of *and* (i.e. pragmatic interpretations) will be processed faster than symmetric/logical ones (i.e. semantic interpretations). We think that Levinson's 2000 proposal can deliver an even finer-grained prediction, which is that a temporal sequential interpretation (i.e. two conjoined past-tense event descriptions) will arise first, by default, followed by a causal one, if at all plausible; finally, a semantic/logical interpretation will appear whenever none of the pragmatic interpretations (temporal or causal) can be derived by the hearer.

Relevance Theory proposes a different solution (Sperber & Wilson 1986/1995). First of all, contrary to Grice and neo-Griceans like Levinson, neither temporal nor causal interpretations are considered to be implicatures, but are instead aspects of *what is said*, determined in an inferential manner (Carston 1988, 2002). In relevance theoretical terms, they are explicatures.

This account is motivated by many authors' observation (Carston 1988, 2002, Wilson & Sperber 1993, Moeschler 2000, 2010) that temporal and causal interpretations are elements of the meaning which contribute to the proposition expressed by utterances of *and*-sentences, as the classic examples borrowed from Carston (2002: 227) illustrate.

(10) a. Either he left her and she took to the bottle or she took to the bottle and he left her.
b. He didn't go to a bank and steal some money; he stole some money and went to the bank.

As Carston points out, the embedding of the *and*-conjunction under the scope of logical operators, such as disjunction (10a) or negation (10b), demonstrates that the causal and temporal relations have to be part of the proposition expressed by the utterance of an *and*-sentence, as (10a) would otherwise be a mere redundant repetition of the form 'Either P or P', and (10b) would be a contradiction in the form 'Not P; P'. In other words, the temporal and causal relations need to be inferred by the hearer in order to arrive at the full propositional form evaluable in terms of truth and falsity. The point made by the relevance-theoretic account is that temporal and causal inferences, although pragmatic in nature, serve to enrich the propositional form of the utterance of an *and*-sentence.

How do these inferences come about? In the relevance-theoretic framework, the temporal and causal interpretations depend on the degree of accessibility of contextual assumptions that activate different mental schemas—for instance, of temporal or causal nature. The existence of such cognitive scripts or schemas, among other aspects of interlocutors' encyclopedic knowledge, ensures the adequate interpretation of a given utterance of an *and*-sentence. Such schemas capture types of causal or temporal situations which refer to frequently encountered sequences of particular events, actions or processes. For example, the correct assignment of the truth-conditions for a causal sentence, as in (11), is guaranteed by the interaction of the principle of relevance and some contextual assumption stored within a mental script concerning a type of described causal scenario.

(11) Mary dropped the vase on the tiles.

In this case, all the participants in the conversation have in their background knowledge a causal schema saying that a vase dropped on tiles will break. These contextual assumptions are made accessible precisely because of the encyclopedic knowledge that interlocutors share about this type of event.

As long as the contextual assumptions provide interpretations in accordance with the principle of relevance, other possible interpretations are ruled out.[2]

2.2 Syntactic perspective

Bjorkman (2010) presents an approach based on the 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 coordination of temporal phrases (TP), while the symmetric interpretations are accessible for the coordination of complementizer phrases (CP). Consider the following example, from Bjorkman (2010).

(12) 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 (12a), the complementizer *that* is present once, which suggests that the conjunction *and* relates two structures of the type TP. *That* appears twice in (12b), implying the presence of a structure larger than TP, the CP structure. (13) illustrates the difference between the two structures schematically (Bjorkman 2010).

(13) a. ... *reported* $[_{CP}$ *that* $[_{TP}$*...] and* $[_{TP}$*...]]*
b. ... *reported* $[_{CP}$ *that ...] and* $[_{CP}$ *that ...]*

This structural difference is reflected in interpretative differentiation. When the TP-level coordination is involved, asymmetric interpretations are among those possible, while only the symmetric relations can appear in the case of the CP-level coordination. For instance, (12a) 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. (12b), on the other hand, suggests no such interpretation; the two events described by the embedded clauses are instead processed in an independent manner, with no causal relation between them.

As such, the generalization proposed by Bjorkman (2010) is the following: the coordination of embedded clauses of the TP type provides interpretations with asymmetric relations (temporal or causal), whereas the coordi-

[2]The importance of causal schemas under the form of causal laws is also put forward in the Relevance Nomological Model (Blochowiak 2014, 2016).

nation 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, have longer processing times than asymmetric interpretations whose structures are smaller.

Below, we will look at previous experimental studies which aimed to test the predictions of different theories concerning the processing of logical words in general (Section 3.1), including the conjunction *and*. In Section 3.2, we will describe in more detail a study specifically designed to verify pragmatic and syntactic predictions regarding the conjunction *and* in English (Thompson et al. 2011, 2012). Finally, we will present our study on the French conjunction *et*, which was designed to verify the results obtained for English by Thompson et al. (2011, 2012).

3 Experimental investigation of logical words

The interpretation of logical words in natural language—and the particular question of how much logic there is in the natural language usage of logical words—has been under theoretical debate for a long time. Are we really sensitive to the logical interpretations as they are defined in classical logic? Or are these definitions purely theoretical artefacts with no cognitive reality whatsoever, implying that all we capture in our interpretation of the natural language expressions is their pragmatics? With the advent of experimental investigation of this subject, many answers to these issues have been found.

3.1 Logical words in children and adults cross-linguistically

In general, it seems that people are sensitive to the purely logical meanings of logical words. Numerous psycholinguistic studies have shown that children tend to interpret logical words as they are defined in classical logic (Noveck 2001; Papafragou & Musolino 2003; Guasti et al. 2005; Pouscoulous et al. 2007). These findings have been reported for several languages, such as French, English, Greek, Italian and German. A recent study on the acquisition of logical connectives in Chinese children confirms that the logical senses are the first to be acquired (Su 2014).

By now, it is well established (see Noveck & Reboul 2008 for an overview) that the 'non-enriched' semantic readings also require less effort to be processed by adults; this has been measured with various techniques, such as

sentence processing tasks (for instance, Breheny et al. 2006 for *or*) or electroencephalography (for example, Nieuwland et al. 2010 for quantifiers).

Regarding quantifiers, there is abundant literature aiming to determine how the meaning of words such as *some* is understood (Horn 1972, Levinson 2000). Typically, it is assumed that *some* is a scalar term which is semantically compatible with *all,* but pragmatically enriched to *some but not all*. According to Levinson's (2000) approach, *some*—like *and*—has a default interpretation, *some but not all*. However, the experimental investigation does not confirm the predictions following from the default type of accounts, according to which semantic reading should take longer as a result of the stage cancelling the pragmatic default interpretation. For instance, in a sentence evaluation study, Bott and Noveck (2004) found that participants responded equally quickly to true underinformative sentences (semantic readings), such as *Some goats are mammals,* as they did to control items which were true or false statements, such as *Some mammals are goats* and *All goats are insects*. However, the participants took significantly longer to evaluate underinformative sentences which received false responses.

The tendency for rapid cognitive processing of non-enriched semantic readings has also been confirmed for disjunction and conjunction. The semantic meaning of disjunction is usually equated with the inclusive definition of disjunction in logic (that is, *one or both*) while the pragmatic enriched meaning is narrowed down to its exclusive interpretation (i.e. *or but not both*). In a sentence processing experiment, Breheny et al. (2006) presented participants with two types of contexts in which the same disjunctive sentences could be best interpreted as pragmatically enriched (upper-bound context, as in (14)) or not so (lower-bound context, as in (15)). During the self-paced reading task, the participants had to read the sentences chunk by chunk, by hitting the space bar (indicated by a slash in the examples below).

(14) Upper-bound context
While Mary and John were out shopping, /it started raining./John would get wet./Even though she did not have a lot of money,/she offered to buy him/an umbrella or a coat./

(15) Lower-bound context
It was highly probable that it would rain./Mary advised John/to dress accordingly./To avoid getting wet,/she suggested to him/to take with him/an umbrella or a coat./

The results are in accordance with previous findings showing that the participants took significantly less time to read the phrases containing *or* under the

non-enriched semantic interpretation (lower-bound context) than the phrases with pragmatically enriched *or* (upper-bound context).

As we have seen earlier, the semantic non-enriched meaning of *and* in natural language is usually equated with the logical definition of conjunction, while the pragmatically enriched readings—i.e. temporal and causal interpretations—are derived via certain pragmatic mechanisms. Depending on the theory, these pragmatic inferences are claimed to be implicatures (Grice 1989, Levinson 2000) or explicatures—that is, the pragmatically inferred aspects of *what is said* (Carston 1993, 2002). The pragmatic meaning is usually claimed to arise later (in development or processing), except by default accounts such as Levinson's, in which pragmatic readings come first. Here again, default approaches do not receive experimental confirmation. For instance, Noveck et al. (2009) provided experimental evidence that pragmatic enrichments are cognitively costlier, and thus acquired later. In their experiment, participants first saw a small cartoon presenting two events in a certain order. They were then asked to answer questions formulated with the conjunction *and*, where the two events were presented in the reverse order. For instance, one question asked "Did Guillaume eat dinner at a friend's and pick up a cat into his arms?", while the cartoon presented the events in the reverse order. Children answered *yes* to such questions more frequently than adults, demonstrating once more their 'preference' for the semantic and logical interpretations of logical terms.

In the next section, we will present a reading time experiment on conjunction in English which seems to question these results. This study took into account predictions from not only pragmatic theories but also the syntactic account of conjunction reported in Section 2.2.

3.2 An experimental study on *and*

Bjorkman's hypothesis has been tested experimentally by Thompson et al. (2011, 2012). The experiment considered the processing time of sentences interpreted as semantically distinct (logical, temporal and causal) versus sentences interpreted as structurally distinct (asymmetric and symmetric).

The experiment was conducted with RSVP methodology (Rapid Serial Visual Presentation) (Forster 1970). This method presents the participants with sentences (word by word), in the centre of a computer screen, at a fixed rate. After the presentation of a sequence of words, participants are required to read aloud the sentence they have seen. Therefore, the measure of this experiment corresponds to the total production time of the sentences presented.

Their results seem partially to confirm the syntactic thesis formulated by Bjorkman (2010). Globally, the sentences implying symmetric interpretations were produced at a slower rate than those with asymmetric interpretations. However, the difference between logical and temporal interpretations is not statistically significant: it is only the difference between the logical and the causal *and* which meets this threshold.

Before going further, it is worth examining the protocol used by Thompson et al. (2011, 2012). First of all, the size of the subject group in their study was quite restricted, as it contained only eight participants. In addition, one should ask whether the RSVP methodology used—and, in particular, the measure of the production time—is best adapted for a study concerning the interpretation of *and*.

Even more problematic are the stimuli used in the experiment. First, certain sequences cannot be judged as purely temporal. The examples provided in (16) could very well be interpreted as causal *and*, but are classified as temporal *and*.

(16) 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 includes episodic (17a), habitual (17b) and generic (17c) sentences.

(17) 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, might have affected the production times, and as a 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. (2011, 2012), we developed a pilot experiment on the French conjunction *et*, which takes into account the problematic points detected in the choice of stimuli, and relies on a different methodology (Blochowiak et al. 2015). In the study presented in this contribution, we used the same procedure, but with a significantly larger number of participants, and included only native French speakers.

4 An experimental investigation of *et*

Outlined above were two types of approach which aim to explain different interpretations of *et*. The pragmatic approach predicts that the processing of the logical *et* is the least costly, followed by the temporal and the causal *et* (Levinson 1983), or by the causal and temporal *et* ordered according to the accessibility of contextual premises (Relevance Theory). In contrast, according to the syntactic approach, the asymmetric structures (temporal and causal *et*) should both be processed faster than the heavier symmetric structures (logical *et*).

To shed light on this question, we considered the three types of *et*, as in the experiment carried out by Thompson et al. (2011, 2012), trying to avoid problematic stimuli as much as we could. In particular, in the construction of our examples, we were careful to keep the verbal tense used in the sentences constant, in order to construct a stimuli dataset as uniform as possible. We used the French past tense *passé composé* across the three conditions, as it has one particular characteristic: unlike another French past tense, the *passé simple*, the *passé composé* does not impose a temporal sequential reading on sequences of sentences. For instance, the events described in (18) are understood to take place one after another because of the *passé simple* (PS), while in (19) the order is not imposed by the instructions related to the *passé composé* (PC).

(18) Marie prépara le café. Les enfants vinrent à la maison.
Marie prepared.PS coffee. Children came.PS home.

(19) Marie a préparé le café. Les enfants sont venus à la maison.
Marie prepared.PC coffee. Children came.PC home.

If hearers arrive at a temporal sequential reading of (19), it is instead due to Grice's maxim of orderliness (see Moeschler 2002, de Saussure 2003, Grisot 2015 for more detail on the French verbal system, and Grisot & Blochowiak (under revision) for experimental investigation of the interplay between French PS and PC, lexical aspect and temporal connectives).

4.1 A self-paced reading experiment on *et*

4.1.1 Material and method

Participants Sixty-six native French speakers (45 females, *M*age = 23.27, *SD* = 5.09, [18-46 y.o.]), students in Humanities at the University of Geneva, participated in the experiment. The participants were randomly assigned to

one of the two experiments (45 to the Experimental condition and 21 to the Control condition).

Design In this study, we aimed to measure the reading times of complex sentences *P et Q*, depending on the three types of possible interpretations of *et*: logical, temporal and causal.

The study is based on two complementary experiments: the 'control' and 'test' experiments. The same sentences were used in the two experiments, the difference being that the comma was used in the control experiment to replace the conjunction *et*. Thus, the 'test' complex sentence (*P et Q*) *Il a neigé toute la nuit et les autoroutes sont impraticables* (It was snowing all night long and the highways are impassable) corresponds to the 'control' sentences *(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 *et*. The test experiment serves to determine the effect of the conjunction *et* 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 sentences were plausible or not. For example, the sequence *Marie a préparé les crêpes et Jean a passé l'aspirateur* (Marie made the pancakes and Jean did the vacuuming) 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 sentences were constructed according to three criteria: a) all the sentences following the conjunction (*P et Q*) are in the *passé composé*; b) all the sentences are made up of common words; c) the number of syllables of the second sentence (*Q*) is between nine and twelve. Table 7.2 presents a sample of each category.

Procedure The experiment began with reading instructions, followed by a training phase (9 sequences) and an experimental phase (28 sequences with 18 test-sequences / 18 control-sequences). For each trial, a first sentence (*P*) appeared in the centre of the computer screen, and the participant had to press the space bar to move to the next sentence (*et Q / Q*). After reading the whole sequence (*P et Q* or *P, Q*), the participant had to decide whether the whole sequence seemed plausible (key p) or implausible (key q) (the ordering of the keys was counterbalanced between the participants). Both experiments were

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

Table 7.2: Presentation of each type of sentence read

designed using the E-Prime 2.0 software (Schneider, Eschman & Zuccolotto 2002). All the sentences were presented in a random order, at the centre of a black computer screen in white text (Times New Roman font, size 18).

4.1.2 Results

The aim of this experiment was to try to isolate the mean reading time (RT) for each type of *et*, in order to compare them and test the predictions presented above. To do so, we measured the RT of the sequence composed of the conjunction *et* and the second sentence (*Q*) in the 'test' experiment, and of the second sentence alone (*Q*) in the 'control' experiment. In order to obtain a mean RT for each type of *et*, we subtracted the mean RT of each 'control' sentence (*Q*) from the RT of the corresponding 'test' sentences (*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 did the vacuuming), we measured the RT of the second sentence with the conjunction (*et Jean a passé l'aspirateur*) and subtracted the mean RT of the second sentence without the conjunction (*Jean a passé l'aspirateur*) obtained by the participants from the 'control' experiment.

'Control' experiment An initial descriptive analysis allowed us to determine the mean reading time for each sentence (Q) in order to compute the *et* $Q - Q$ for each sentence: MLogical = 2374, SD = 1062; MTemporal = 2354, SD = 928; MCausal = 2016, SD = 796. In addition, a median test revealed no difference between the three conditions, $\chi^2 = 5.45$, $p = .065$.

'Test' experiment A Jonckheere-Terpstra test for ordered alternatives (Logical < Temporal < Causal) revealed a significant trend in the data, $T_{JT} = 111$, $z = 4.84$, $p < .001$ (see Table 7.3 and Figure 7.1). Associated post-hoc tests showed that the RT of (*et* $Q - Q$) of the logical condition was significantly smaller than the causal condition ($Z = 5.02$, $p < .001$), but not the temporal condition ($Z = .920$, $p = .54$). The same test revealed also a significant difference between the causal and temporal conditions ($Z = 3.97$, $p < .001$).

In addition, a Mann-Withney test showed a significant difference between symmetrical sentences (i.e. logical condition, Mdn = -440) and asymmetric sentences (i.e. causal and temporal conditions together, Mdn = -284), $Z = 3.36$, $p < .01$.

Condition	N	Mean	SD
Logical	267	-315.91	950.05
Temporal	258	-214.98	1024.46
Causal	230	123.04	1019.37

Table 7.3: Mean RT of (*et* $Q - Q$) as a function of the experimental condition (logical, temporal or causal).

4.2 Discussion

In short, the results obtained seem to indicate that symmetric propositions are processed faster than asymmetric ones. In particular, the logical interpretation of *et* is processed faster than the causal interpretation, and the temporal interpretation is also processed faster than the causal one.

The first observation is that the results of our experiment contrast with those obtained by Thompson et al. (2011, 2012). Since our study was carried out to verify reported findings in Thompson et al. (2011, 2012), and was thus designed to test a similar type of stimuli, we need to look more closely at the elements which could explain our results' differences.

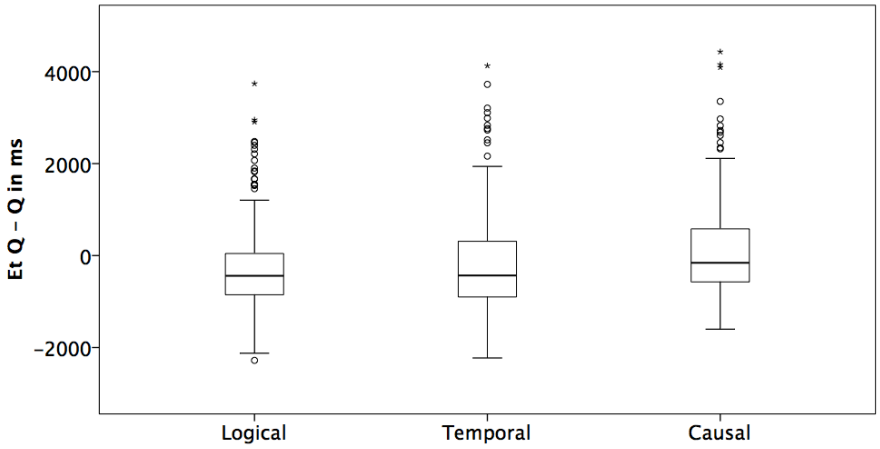

Figure 7.1: Box-plots of RT of *et Q – Q* according to the type of interpretation of the conjunction *et* (causal, logical and temporal). The black line indicates the median value. The boxes represent half of the sample, between the highest and lowest quartiles. The whiskers represent the most extreme values, excluding outliers (circles and asterisks).

Beyond the problem of stimuli, which we pointed out in section 2.3, the experiment conducted by Thompson et al. (2011, 2012) presents a major methodological difference from ours, insofar as they used the *Rapid Serial Visual Presentation* paradigm and analysis of the production time, whereas we took the option of a *Self-Paced Reading* task. The former is more widely used in the research on lexical processing (Rayner & Sereno 1994), while the latter is more appropriate for studies on discourse comprehension (Garrod 2006). Aside from this, it should be pointed out that Thompson et al. (2011, 2012) do not provide statistical tests of their results. It is also important to emphasize that the small number of participants (eight) constitutes a weak point of their study.

The second observation is that the results obtained in the experiment on French partially support the predictions of pragmatic theories concerning the conjunction *and* (although see the discussion below). Logical interpretations (symmetric) were processed the most rapidly, followed by temporal and causal interpretations (asymmetric). Thus, our findings seem to be consistent with a series of experiments conducted on various logical terms presented in section 3.1 (see Noveck & Reboul 2008 for a summary). However, we did not observe a statistically significant difference between logical and temporal interpreta-

tions, despite pragmatic approaches' prediction that this difference should exist. So, why did we not find this? In the remainder of this section, we will try to explore possible reasons for this lack of difference in our results. The discussion will pinpoint some inherent difficulties in the definition of the logical interpretation of the conjunction *and* in natural language.

In contrast with the unambiguous vision we presented earlier, it turns out that logical and temporal interpretations are not so easy to tease apart in their natural language uses. In fact, the problem lies in the definition of the logical meaning of the conjunction *and* itself. As we explained in section 2, the logical meaning of conjunction is defined by its truth-table, from which it inherits the property of symmetry. Therefore, for a conjoined sentence to be classified as having a logical interpretation in practice, it is usually assumed that it must have the property of symmetry. However, our claim is that this criterion gives rise to a classification that is too coarse-grained. This is due to the fact that a speaker, when uttering a conjunctive statement, affirms in the vast majority of cases two things: i) that both conjoined propositions are true; and ii) that the denotations of these propositions (i.e. the corresponding states of affairs) are somehow related (some exceptions are dealt with below). This pragmatic use of conjunction takes into account two complementary aspects of the conjunction *and*: its logical function as a propositional operator; and its purely pragmatic ability to convey some relation between denotations of the conjuncts.

In its logical function, there is only one relation involved: the logical conjunctive relation[3], which has the property of symmetry. For instance, (20) is a typical example one might find in a logic textbook, but not really in everyday discourse.

(20) Bern is a capital of Switzerland and 7 is a prime number.

The only two important points here are that both conjuncts are true, which makes the whole sentence true, and that it is possible to switch the order of conjuncts without any changes in the meaning. Besides this, there is no other relationship one could think of between the two conjuncts. This is therefore the logical relation of conjunction in its "pure" form, which uniquely determines the property of symmetry. We can also find more natural examples of the pure logical meaning of *and* in embedded clauses of the type discussed in section 2.2. The relevant example, with its syntactic analysis, is repeated below in (21).

[3] As we said in section 2, the conjunction *and* in logic is—strictly speaking—a binary operator which induces the logical relation of conjunction.

(21) a. The newspaper reported that a new mayor was elected and that there was a riot.
b. ... reported [CP that ...] and [CP that ...]

In its pragmatic, everyday use, more relations are involved. Consider (22), where it is possible to reverse the conjuncts without changing the meaning of the whole *and*-sentence. The property of symmetry is conserved but, importantly, it is not uniquely determined by the logical relation of conjunction.

(22) John is playing basketball outside and Veronica is listening to music in her room.

What is crucial to note is that (22) conveys a temporal relation, that of simultaneity, which is also symmetric. In this case, the property of symmetry does not just pertain to the logical relation of conjunction, but is also attached to the real world relation of temporal simultaneity. Note that the same comment applies to example (1).

It is also important to observe that there are other types of relations which can be further conveyed with *and*, such as additive (23) or contrastive relations (24).

(23) John is tall and Veronica is tall.

(24) John is tall and Veronica is short.

Interestingly, there are languages which clearly distinguish between these two kinds of interpretations, using different conjunctions for them. In Polish, for instance, *i* serves—notwithstanding other nuances—to express additive relations (25), where *a* is employed for relations of contrast (26) (Wajszczuk 1984; see Sax 2014 for an analysis of Polish *a* in a Relevance Theory framework; see also Blakemore and Carston 1999, Blakemore 2002, Umbach 2004, Sawicki 2008 for different kinds of contrastive relations). Other languages, like Russian and Romanian, also make similar distinctions.

(25) a. Jan jest wysoki i Weronika jest wysoka.
b. #Jan jest wysoki a Weronika jest wysoka.
'John is tall and Veronica is tall.'

(26) a. Jan jest wysoki a Weronika jest niska.
b. #Jan jest wysoki i Weronika jest niska.
'John is tall and Veronica is short.'

It is worth asking what the relationship is between the purely logical re-

lations which hold between the propositions and the relations between states of affairs that are denoted by these propositions, although we will not pursue such an investigation here. We will only observe that the property of symmetry, related to the logical conjunctive relation, may or may not coincide with the properties of relations conveyed by natural language interpretations of *and*. As it happens, some world relations are symmetric where others are not; thus, the properties of both logical and world relations are similar (i.e. symmetric) in some cases, while in others they are not. In the latter instance, the property of the given world relation prevails in the interpretation. It would be interesting to provide some formal answer to the question of why this is so. The answer to this question is beyond the scope of this contribution, and will thus be left for further investigation. Our attention will instead turn to a different question.

How can these observations explain our experimental results? Before answering this, we should note that the examples in our logical category conveyed a contrastive and/or simultaneous temporal relation, which is to say that they were not relation-free (other than a purely logical relation). If there is some conjunctive relation between the two conjuncts which is other than logical, we can suppose that a comprehender will grasp this relation in just the same manner as with temporal sequences of events or causal relations—that is, by inferring it. In this way, the comprehender enriches the meaning of the conjunction, just as in sequential temporal and causal interpretations. If this is correct, we should not be surprised that, despite the symmetry, we observe extra time in the processing of our logical condition.

In the light of this complementary explanation, the only certain conclusion we can draw from our experiment is that causal interpretations of *and* are processed at a slower rate than temporal (sequential and simultaneous) interpretations. Why is this so? In the remaining part of this discussion, we will propose an explanation according to the relevance-theoretic framework.

As we observed earlier, various relations that the utterances of *and*-sentences convey are the contributions to the explicit content of these utterances—that is, explicatures. The two relevant questions are the following: what is the difference between the two types of explicature; and what is the relationship between the two explicatures in causal *and*-conjoined sentences? As we said above, there are causal schemas which are invoked in causal interpretations of utterances of *and*-sentences (Carston 2002, Blochowiak 2014, 2016). There are also many temporal schemas which involve stereotypical sequences of events. Some of the temporal relations do not form stereotypical schemas, and the hearer can only recover a temporal relation on the basis of verbal tenses, aspectual classes and general world knowledge indicating how the two given

eventualities can, a priori, follow one another or be parallel.

In the case of temporal explicatures, the procedure seems to be quite obvious: temporal relations appear in the presence of certain temporal schemas, if these exist, or merely on the basis of verbal tenses and aspectual classes in the absence of temporal schemas. Similarly, one could say that causal relations in *and*-conjoined sentences emerge in accordance with certain causal schemas. The crucial question is to know how temporal and causal explicatures interact or are related to one another in causal *and*-sentences.

Broadly speaking, we can think about two options: (i) the causal interpretation comes first, bypassing the temporal interpretation, which is to say that the hearer realizes right away that he is dealing with a causal interpretation of *and*; (ii) the temporal interpretation of *and* comes first, and the causal one at a second stage. The first option parallels the *causality-by-default* hypothesis (Sanders 2005), according to which comprehenders have a very strong cognitive drive to interpret—and often over-interpret—eventualities as causally related, which makes them very quick at detecting causality in the real world (Michotte 1963, Bechlivanidis & Lagnado 2016, Moors et al. 2017, *inter alia*), as well as at judging various descriptions of eventualities in language to refer to causal scenarios, independently of the presence of linguistic markers such as causal connectives (see, for instance, Sanders & Noordman 2000, Kuperberg et al. 2011, Mak & Sanders 2013). The second option echoes the *temporality-by-default* hypothesis proposed for *and* by Levinson (2000), which we described earlier: recall his argument that there is a cross-linguistically attested tendency to interpret two conjoined past-tense event descriptions as temporally successive by default (see also Lascarides & Asher 1993), and, if at all possible, as causally related.

From the processing point of view, the first option would predict shorter processing for causal interpretations of *and*, whereas the second option would predict shorter processing for temporal interpretations. Interestingly enough, our results seem to go against the *causality-by-default* hypothesis, as far as the causal interpretation of the conjunction *and* is concerned. This result is remarkable in itself, and will certainly need further experimental investigation. It seems that there is something in the meaning of *and* which prevents the causal interpretation from coming about immediately. Indeed, our findings seem to support the temporality-by-default hypothesis. A note of caution should nevertheless be sounded here: Levinson (2000: 123) talks specifically about temporal sequences of events described in the past tense, whereas in our experimental dataset we deal with temporal simultaneity (the logical condition) as well. In other words, in the case of Levinson's work, we should talk

about the *temporal sequence* as the default interpretation of *and*. In that sense, Levinsons's hypothesis finds partial confirmation in our results—that is, temporal sequential relations (temporal condition) are processed faster than causal relations (causal condition).

However, in order to provide a fuller explanation for our findings, we would like to propose an extension of the relevance-theoretic proposal concerning the conjunction *and*. Recall that temporal and causal interpretations of *and* are treated as explicatures in Relevance Theory, and arise in accordance with temporal or causal schemas whenever they are available, guaranteeing the requirement of optimal relevance. Our aim here is to specify how these two pragmatic inferences interact one with another. The prediction we formulated according to Carston's original proposal was that the temporal or causal interpretations can arise from the start, depending on the type of schema (temporal or causal respectively) available for a given *and*-conjoined sentence. However, for the causal interpretation of *and* to appear, we will argue below that the temporal inference—be it sequential or simultaneous—must have been the first to be drawn by the hearer. To illustrate this point, consider the following example, borrowed from Carston (2002: 236):

(27) a. She screamed and he hit her.
b. He hit her and she screamed.

In (27a), the interpretation is that he hit her as the causal result of her screaming, whereas in (27b), the opposite causal relation—that she screamed as a causal result of his hitting her—is recovered. This case is particularly interesting in the discussion of the possible interrelations between temporal and causal explicatures. Here, two possible causal schemas are available to us: (i) one can scream as a result of being hit by someone; or (ii) one can hit someone because he or she screamed. The crucial point we are making is that the choice of one causal schema over another is based on the temporal order of the events described in the conjuncts. In (27a), the hearer understands that first she screamed and then he hit her, and the presence of the relevant causal schema (in which the first event corresponds to the cause and the second to the causal consequence) ensures the causal interpretation in accordance with it. The opposite procedure applies in (27b), in which the hearer—according to the temporal order of the events, which is the converse of the previous order—selects the second causal schema. So, before concluding that temporal order plays a crucial role in establishing the causal relation in *and*-conjoined sentences, we need to ask the following question: what is the source of the inference of temporal sequence? The presence of the conjunction *and*, or maybe just past

verbal tenses? An answer may come from the two following examples from Carston (2002: 236), which present exactly the same sentences as (27), but without the conjunction *and*.

(28) a. She screamed. He hit her.
b. He hit her. She screamed.

As Carston notes, the causal interpretations are not as clear-cut as in (27). As such, in the presence of conflicting causal schemas, the simple alignment of events in juxtaposed sentences is not enough to impose the temporal sequencing of events. Therefore, we can conclude that it is indeed the conjunction *and* which 'forces' the temporal order of events described in the conjuncts.

What are the implications for our initial question about the interaction between the two explicatures—the temporal and the causal—in causal interpretations of *and*-sentences? Our proposal is that the temporal explicature in the case of *and*-conjoined sentences is derived first, and this stage is necessary for the drawing of the causal explicature. In other words, a temporal inference in the form of an explicature is the starting point, and a plausible causal explicature is calculated on the basis of the temporal one, given that a relevant causal schema is available to the hearer. From the processing point of view, this proposal predicts that temporal interpretations of *and* will take less time, as there is only one explicature for the hearer to recover, while causal interpretations of *and* will be costlier, since the hearer needs to draw two pragmatic inferences (a temporal explicature and a causal explicature).

What about simultaneous cases? In our experimental dataset, the stimuli from the logical condition refer for the most part to simultaneous temporal relations, or at least to temporal inclusion, and, as we saw, do not differ statistically from the temporal sequences (temporal condition). Thus, it seems that the two types of temporal relations behave similarly as far as the cognitive processing of *and*-conjoined sentences is concerned, which would be consistent with our hypothesis that any type of temporal relation has to be recovered by a pragmatic inference, which is a cognitively costly process.

And what of the causal relations based on simultaneous temporal relations? Even in the case of simultaneity, it seems that an order has to be recovered for the causal relation to arise. For instance, the causal relation is present in (29a) but absent in (29b), where the two conjuncts are flipped around.

(29) a. The atmospheric pressure is low and I have a headache.
b. I have a headache and the atmospheric pressure is low.

This example suggests that, even in the case of causality with states, the or-

der in which each state began must be recovered to arrive at a causal interpretation—that is, the state in which the atmospheric pressure is low (or the event in which it dropped) started before the state in which I started to have a headache, even if they continue in parallel for some period of time and support one another causally (cf. Blochowiak 2009 for more detail). While we did not verify causal relations based on simultaneous temporal relations in the experiment presented here, the prediction would be similar to causal relations based on temporal sequences. In both types of situation, the hearer has first to establish the temporal coordinates of the eventualities described in the conjuncts, and she can search for a causal link afterwards.

4.3 Conclusions

This paper presented a self-paced reading experiment which aimed to verify experimentally the predictions of syntactic and pragmatic theories concerning the conjunction *and*. On the one hand, according to a syntactic proposal (Bjorkman 2010), there is a structural difference between the symmetric uses (including logical interpretations) implying bigger syntactic structures (CP) and asymmetric uses (including temporal and causal interpretations) composed of smaller syntactic structures (TP). Thus, the syntactic approach predicts shorter processing for asymmetric interpretations (temporal and causal) and longer processing for symmetric ones (logical). On the other hand, pragmatic theories claim that the meaning of the conjunction *and* in natural language is based on the meaning of the logical conjunctive operator $\wedge$, which is symmetric. Hearers pragmatically infer other types of interpretation, such as temporal or causal ones, by general principles of pragmatics. In accordance with this general pragmatic comprehension procedure, a relevance-theoretic account predicts that semantic/logical interpretations should be processed faster than pragmatic ones (temporal and causal). A different position is held by Levinson (2000), for whom pragmatic interpretations come first by default, and in the particular case of *and*, the temporal relation is claimed to be the first recovered by the hearer.

The results of the experiment conducted by Thompson et al. (2011, 2012) on the English conjunction *and* point towards a partial confirmation of the syntactic theory. However, these results do not seem to be easily generalizable, given the problems regarding the construction of the stimuli and the small number of participants in the sample size (cf. Section 3.2).

The results of the experiment we conducted on the French conjunction *et* were the opposite of those obtained for English by Thompson et al. (2011, 2012). Logical and temporal interpretations were processed the fastest, fol-

lowed by causal interpretations, with a statistically significant difference between the logical and causal interpretations but no statistically significant difference observed between logical and temporal conditions.

The fact that we could not find a statistically significant difference between logical and temporal *and* is interesting, as it highlights a theoretical problem of the definition of the logical interpretations of the conjunction *and* in natural language. As it turns out, the property of symmetry—usually taken as the criterion for classifying sentences with *and* as logical—is problematic, as some relations which *and* can convey in natural language (such as temporal simultaneity or inclusion) have the property of symmetry independently of the property of symmetry coming from logic. In other words, the stimuli from our logical condition could in fact be interpreted as instances of temporal simultaneous relations.

In the light of this finer-grained analysis of the data from the logical condition, we can reinterpret our findings as follows: we observed a statistically significant difference between causal interpretations on the one hand and temporal interpretations (sequential and simultaneous) on the other. How does this new restatement fit the predictions? First, we should observe that neither the syntactic account nor the relevance theoretic approach differentiates between the temporal and causal types of interpretation. The only prediction to have been partially verified is Levinson's 2000 proposal, which put forward the temporality-as-default hypothesis. However, Levinson talked about the default interpretation for two conjoined past-tense event descriptions as temporally successive. Yet, in our experimental dataset, we also have simultaneous or overlapping temporal relations (i.e. logical condition) which seem to pattern with sequential ones. This observation has led us to formulate a new hypothesis, which is a refinement of the relevance theoretical account for conjunction. Nevertheless, it should be stressed that our hypothesis is tentative. It is open to further empirical verification, and holds only for as long as the results we obtained can be confirmed.

We followed a relevance-based analysis of *and*, which argues that its temporal and causal interpretations arise as explicatures—that is, they are pragmatically inferred contributions to the explicit content of utterances of *and*-sentences. Our proposal is that these explicatures are not independent as far as the causal interpretations of *and* are concerned. In particular, for a hearer to derive a causal interpretation, he has first to infer the temporal ordering of the events described in the conjuncts. Consequently, in the case of temporal interpretations of *and*, only one explicature is to be drawn by the hearer (i.e. the temporal explicature, be it sequential or simultaneous), whereas in the case of

the causal interpretation of *and*, two explicatures are computed (i.e. the temporal explicature augmented by the causal explicature), provided that the relevant causal schema is accessible to the hearer. Our hypothesis is based on the observation that when two causal schemas are available (the event described in the first conjunct could have caused the event described in the second conjunct or *vice versa*), it is the temporal order of eventualities which imposes the choice of one schema over another (cf. example (27) and subsequent discussion). From the point of view of processing, our proposal's prediction is clear. Temporal interpretations of *and* should be processed faster than causal interpretations, as the hearer has to infer one explicature when only temporality is involved, where in the case of causal *and*, the hearer has to recover the causal explicature according to the temporal explicature. It is important to note another prediction which follows from our proposal: since it is the conjunction *and* which 'forces' the initial temporal interpretation, in juxtaposed sentences (cf. example (28)), we do not expect the temporal interpretation to arise before the causal interpretation. In summary, we predict that causal interpretations will be processed faster than temporal interpretations in the case of juxtaposed sentences. We will leave this prediction for our future investigations.

References

Bechlivanidis C. & Lagnado D. (2016). "Time reordered: Causal perception guides the interpretation of temporal order". *Cognition* 146: 58–66.

Bjorkman B.M. (2010). "A syntactic correlate of semantic asymmetries in clausal coordination". *Proceedings of NELS* 41.

Blakemore D. & Carston R. (1999). "The pragmatics of *and*-conjunctions: The non-narrative cases". *UCL Working Papers in Linguistics* 11: 1–20.

Blakemore D. & Carston R. (2005). "The pragmatics of sentential coordination with *and*". *Lingua* 115(4): 569–589.

Blochowiak J., Castelain T. and Moeschler J. (2015), "Les interprétations logiques, temporelles et causales de la conjonction. Une perspective expérimentale." *Nouveaux cahiers de linguistique française* 32: 71–83.

Blochowiak, J. (2009). "La relation causale, ses relata et la négation". *Nouveaux cahiers de linguistique française* 29: 153–175.

Blochowiak J. (2014). *A theoretical approach to the quest for understanding. Semantics and pragmatics of whys and becauses*. PhD thesis, Department of Linguistics, University of Geneva.

Blochowiak J. (2016). "A presuppositional account of causal and temporal interpretations of *and*". *Topoi* 35: 93–107.

Bott L. & I. Noveck. (2004). "Some utterances are underinformative: The onset and time course of scalar inferences". *Journal of Memory and Language* 51(3): 437–457.

Breheny R., N. Katsos & J. Williams. (2006). "Are generalised scalar implicatures generated by default? An on-line investigation into the role of context in generating pragmatic inferences". *Cognition* 100(3): 434–463.

Carston R. (1988). "Implicature, explicature, and truth-theoretic semantics". In R.M. Kempson (ed). *Mental representations: the interface between language and reality*. Cambridge: Cambridge University Press. 155–181.

Carston R. (1993). "Conjunction, explanation and relevance". *Lingua* 90(1-2): 27–49.

Carston R. (2002). *Utterances and Thoughts. The Pragmatics of Explicit Communication*. Oxford: Blackwell.

Forster K. (1970). "Visual perception of rapidly presented word sequences of varying complexity". *Perception & Psychophysics* 8(4): 215–221.

Garrod S. (2006). "Psycholinguistic research methods". In M. Traxler & M.A. Gernsbacher (eds), *Handbook of psycholinguistics*. San Diego: Academic Press. 455–503.

Grice H. P. (1975). "Logic and conversation". In P. Cole & J.L. Morgan (eds) *Syntax and semantics, 3: Speech acts*. Amsterdam: Elsevier. 41–58.

Grice H. P. (1989). *Studies in the Way of Words*. Cambridge MA: Harvard University Press.

Grisot C. & Blochowiak J. (under revision). Temporal connectives and verbal tenses as processing instructions: evidence from French. *Cognitive Pragmatics*. De Gruyter.

Grisot C. (2015). *Temporal reference: empirical and theoretical perspectives. Converging evidence from English and Romance.*, PhD thesis, Department of Linguistics, University of Geneva.

Guasti M.T., G. Chierchia, S. Crain, F. Foppolo, A. Gualmi & L. Meroni (2005). "Why children and adults sometimes (but not always) compute implicatures". *Language and cognitive Processes* 20(5): 667–696.

Horn L. (1972). *On the semantic properties of the logical operators in English.* Doctoral dissertation, University of California, Los Angeles.

Kuperberg G. R., M. Paczynski, & T. Ditman (2011). "Establishing causal coherence across sentences: An ERP study". *Journal of Cognitive Neuroscience* 23: 1230–1246.

Lascarides A. & N. Asher (1993). "Temporal interpretation, discourse relations and commonsense entailment". *Linguistics and philosophy*, 16(5):

437–493.

Levinson S. C. (1983). *Pragmatics*. Cambridge: Cambridge University Press.

Levinson S. C. (2000). *Presumptive meanings: The theory of generalized conversational implicature*. Cambridge, MA: MIT press.

Mak, W. M. & Ted J. M. Sanders, T. J. M. (2013). "The role of causality in discourse processing: Effects of expectation and coherence relations". *Language and Cognitive Processes* 28(9): 1414–1437.

Michotte A. (1963). *The Perception of Causality.* Andover: Methuen.

Moeschler J. (2000). "Le Modèle des Inférences Directionnelles". *Cahiers de linguistique française* 22: 57–100.

Moeschler J. (2002). "Economy and Pragmatic Optimality: the Case of Directional Inferences". *Generative Grammar in Geneva* 3: 1–20.

Moeschler J. (2010). "Negation, scope and the descriptive/metalinguistic distinction". *Generative Grammar in Geneva* 6: 29–48.

Moors P., J. Wagemans, & L. de Wit (2017). "Causal events enter awareness faster than non-causal events". *PeerJ* 5:e2932.

Nieuwland M., T. Ditman & G. Kuperberg. (2010). "On the incrementality of pragmatic processing: An ERP investigation of informativeness and pragmatic abilities". *Journal of Memory and Language* 63(3): 324–346.

Noveck I. (2001). "When children are more logical than adults: Experimental investigations of scalar implicature". *Cognition* 78(2): 165–188.

Noveck I. & Reboul A. (2008). "Experimental pragmatics: A Gricean turn in the study of language". *Trends in Cognitive Sciences* 12(11): 425–431.

Noveck I., C. Chevallier, F. Chevaux, J. Musolino & L. Bott. (2009). "Children's enrichments of conjunctive sentences in context". In P. De Brabanter & M. Khissine. *Utterance Interpretation and Cognitive Models. Current Research in the Semantics/pragmatics Interface* (20). Bingley: Emerald. 211–234.

Papafragou A. & J. Musolino (2003). "Scalar implicatures: experiments at the semantics–pragmatics interface", *Cognition* 86(3): 253–282.

Pouscoulous N., I. Noveck, G. Politzer & A. Bastide (2007). "A developmental investigation of processing costs in implicature production". *Language acquisition* 14(4): 347–375.

Posner R. (1980). "Semantics and pragmatics of sentence connectives in natural language". In J. Searle, F. Kiefer & M. Bierwisch (eds). *Speech act theory and pragmatics*. Dordrecht: Reidel. 169–203.

Rayner K. & S.C. Sereno (1994). "Eye movements in reading". In M.A. Gernsbacher (ed). *Handbook of psycholinguistics*. San Diego: Academic Press. 57–81.

Sanders T. (2005). "Coherence, causality and cognitive complexity in discourse". In *Proceedings of the First International Symposium on the exploration and modelling of meaning* (SEM-05). 105–114.

Sanders T. J. M. & L. G. M. Noordman (2000). "The role of coherence relations and their linguistic markers in text processing". *Discourse Processes* 29: 37–60.

Saussure L. de (2003). *Temps et pertinence: éléments de pragmatique cognitive du temps*. Bruxelles: De Boeck Duculot.

Sawicki L. (2008). *Toward a Narrative Grammar of Polish*. Warszawa: Warsaw University Press.

Sax D. (2014). "Osobliwy przypadek polskiego spójnika *a*: analiza z perspektywy teorii relewancji Sperbera i Wilson", Talk given at Instytut Jzyka Polskiego, Warsaw University on May 22, 2014.

Schmerling S. (1975). "Asymmetric conjunction and rules of conversation". *Syntax and semantics* 3: 211–231.

Schneider W., A. Eschman & A. Zuccolotto (2002). *E-Prime user's guide*. Pittsburgh: Psychology Software Tools Inc.

Sperber D. & D. Wilson (1986/1995). *Relevance: Communication and Cognition*. Oxford: Blackwell/Cambridge, MA: Harvard University Press. 2nd edition.

Su Y. E. (2014). "The Acquisition of Logical Connectives in Child Mandarin". *Language Acquisition* 21(2): 119–155.

Thompson E., J. Collado, M. Omana, A. Yousuf-Litle (2011). "The processing of asymmetric and symmetric sentential conjunction". *Proceedings of the 4th ISCA workshop ExLing 2011*, Paris, France. 131–134.

Thompson E., J. Collado-Isasi, M. Omana, & A. Yousuf (2012). "The processing of asymmetric and symmetric sentential conjunction." *International Journal of Language Studies* 6(4): 25–40.

Tiel B., & Schaeken W. (2017). "Processing conversational implicatures: alternatives and counterfactual reasoning." *Cognitive science* 41(S5): 1119–1154.

Umbach C. (2004). "On the Notion of Contrast in Information Structure and Discourse Structure". *Journal of Semantics* 21(2): 1–21.

Wajszczuk J. (1984). "Metatekstowe *szwy* tesktu. Casus: polski spójnik *a*". In L. Lönngren (ed). *Polish Text Linguistics: the third Polish-Swedish Conference held at the University of Uppsala, 30 May4 June 1983*. Uppsala: Slaviska institutionen vid Uppsala universitet. 53–75.

Wilson D. & D. Sperber (1993). "Linguistic form and relevance". *Lingua* 90: 1–25.