

Temporal connectives and verbal tenses as processing instructions: evidence from French

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Abstract

In this paper³, we aim to enhance our understanding about the processing of implicit and explicit temporal chronological relations by investigating the roles of temporal connectives and verbal tenses, separately and in interaction. In particular, we investigate how two temporal connectives (*ensuite* and *puis*, both meaning “then”) and two verbal tenses expressing past time (the simple and compound past) act as processing instructions for chronological relations in French. Theoretical studies have suggested that the simple past encodes the instruction to relate events sequentially, unlike the more flexible compound past, which does not. Using an online experiment with a self-paced reading task, we show that these temporal connectives facilitate the processing of chronological relations when they are expressed with both verbal tenses, and that no significant difference is found between the two verbal tenses, nor between the two connectives. By means of an offline experiment with an evaluation task, we find, contrary to previous studies, that comprehenders prefer chronological relations to be overtly marked rather than implicitly expressed, and prefer to use the connective *puis* in particular. Furthermore, comprehenders prefer it when these relations are expressed using the compound past, rather than the simple past. Instead of using the *continuity* hypothesis (Segal et al. 1991; Murray 1997) to explain the processing of temporal relations, we conclude that a more accurate explanation considers a cluster of factors including linguistic knowledge (connectives, tenses, grammatical and lexical aspect) and world knowledge.

1 Introduction

Successful language processing requires, among many other things, an understanding of discourse relations, i.e. the relationships that are inferred to hold between situations described by sentences in a discourse. These relations can be expressed explicitly with the help of various discourse connectives (1), or they can remain implicit (2).

(1) John took off his boots, *then* he went to bed.

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(2) John took off his boots. He went to bed.

In French, the past events given in (1)-(2) can be expressed using either the French *Passé Simple* (a simple past form, henceforth termed PS), as in (3), or the *Passé Composé* (a compound past form, henceforth termed PC), as in (4). Additionally, the sequential temporal relation holding between these two events can remain implicit, as in (3) and (4), or be rendered explicit by overtly marking it with one of the two sequential temporal connectives *ensuite* and *puis* ‘then’, both of which can occur with the PS, as in (5), and the PC, as in (6).

(3) Jean *enleva* ses chaussures, il *alla* au lit.

(4) Jean *a enlevé* ses chaussures, il *est allé* au lit.

(5) Jean *enleva* ses chaussures, *puis/ensuite* il *alla* au lit.

(6) Jean *a enlevé* ses chaussures, *puis/ensuite* il *est allé* au lit.

These two verbal tenses are both described as perfective, and as locating eventualities (events, activities and states) in the past, i.e. before the moment of speech. However, the PS views the eventuality from a past time reference point, whereas the PC views it from a present time reference point, and can express a resultative state that holds at the moment of speech. As for the two temporal connectives, they encode similar but not identical procedural meanings (in the sense of encoded instructions which constrain the inferential phase of the comprehension process; Blakemore 1987, 2002). Unlike *puis*, when *ensuite* is used, the hearer may understand that there is a gap between the final boundary of the first event and the initial boundary of the second event. Taking into account these semantic differences between the PC and the PS, as well as between *ensuite* and *puis*, our first two research questions are: *what is the exact role of these two verbal tenses in processing chronological temporal relations; and is there an interaction between them and the temporal connectives considered?*

Finally, our third research question refers to the implicit vs. explicit status of sequential temporal relations. Previous experimental studies on connectives as processing instructions — for example, for causal relations (Millis & Just 1994, Cozijn et al. 2011) and contrastive relations (ever since Haberlandt 1982) — have shown that connectives produce a speeding-up effect at the beginning of clauses and a processing slowdown at the end, because readers wait until the end of the sentence to determine the relation between the two clauses. In the last twenty years, studies have shown that the effect of connectives is primarily on the immediately following segment, and that they facilitate the integration of the unfolding clause because readers build the coherence relation incrementally (Sanders & Noordman 2000, Mak & Sanders 2013, Canestrelli et al. 2013, Zufferey 2014, van Silfhout et al. 2015). Far fewer studies have

investigated the role of temporal connectives for processing coherence relations (Segal et al. 1991, van Silfhout 2015). So, our third research question is: *do these two temporal connectives encode similar processing instructions, resulting in an integration effect?*

This paper is organized as follows. In section 2, we will discuss the status of connectives as processing instructions and consider fine-grained semantic and pragmatic distinctions between *ensuite* and *puis*, which are expected to result in dissimilar processing effects. We will then discuss in section 3 the semantics and pragmatics of the PS and PC, regarding their capacity to locate events in time with respect to one another, as well as their repercussions for processing chronological relations. Section 4 is dedicated to the experimental side of this paper: in section 4.1, we will put forward a series of predictions on the possible main effects and interaction effects of the two variables tested in the experiments; section 4.2 deals with the online processing experiment; and section 4.3, with the offline evaluation experiment. A discussion of the results is included in section 5, which also concludes this paper.

2 Connectives as processing instructions

In the relevance-theoretic pragmatic framework (Sperber & Wilson 1986; Wilson & Sperber 2004, 2012), it is assumed that the linguistic expressions underdetermine the content that a speaker communicates explicitly and implicitly. The hearer must therefore recover the speaker's intended meaning inferentially, and the interpretative process is guided by the expectation of relevance and the quest for cognitive effects. Regarding temporal relations, Carston (1988) and Wilson & Sperber (1998) convincingly argued that they should be treated as pragmatically determined aspects of 'what is said'. In other words, they are explicatures: enriched forms of the truth-functional propositional content. More specifically, linguistic expressions encode information which is conceptual and procedural (i.e. instructions for manipulating conceptual representations), contributing to and constraining the interpretative process respectively. For example, some discourse connectives introduce premises (*after all, moreover*) and conclusions (*therefore*), where others point to implications (*so*), or instruct the hearer to abandon existing assumptions (*but, however*) or to consider the content of the immediately following segment to be given information (*after all*, or the French *puisque* "given that") (Blakemore 1987, 1988; Zufferey 2014).

The role played by connectives has been investigated in numerous other studies in linguistics and pragmatics, all of which have attempted to identify the meaning of temporal connectives (for instance, Fretheim (2006) for *then*, Kozłowska (1996), Gosselin (2007) and

Le Draoulec & Bras (2006) for French adverbials such as *puis*, *ensuite* ‘then’, *aussitôt*, *soudain* ‘suddenly’ and *alors* ‘then, so’). As noted above, the meaning of connectives was formulated in terms of procedures that guide the hearer in the comprehension process. For example, the role of the connectives *because*, *then*, *ensuite* and *puis* in examples (7), (8) and (9) is to mark the relation between the preceding and the subsequent segment(s) explicitly: a causal (cause-consequence) relation in (7), and chronological relations in (8) and (9).

(7) She slipped (*because*) the road was icy.

(8) John entered the bar, he ordered a coffee, (*then*) he went to sit in the back of the room.

(9) Jean entra dans le bar, il commanda un café, (*ensuite/puis*) il alla s’asseoir au fond de la salle.

Defining temporal connectives has proven to be a rather difficult task in the literature; consequently, there is no agreement on which linguistic markers should be included in this category. Gosselin (2007) proposed that a linguistic marker could be included in the category of temporal connectives when it conveys a specific temporal relation with the situation(s) from previous sentence. According to Gosselin, French markers such as *et* ‘and’, *puis* ‘then’, *alors* ‘then, so’, *ensuite* ‘then’, *après* ‘after’, *plus tard* ‘later’, *aussitôt* ‘as soon as’ and *dès cet instant* ‘from this moment’ should be grouped under the label of *temporal connectives*. In the absence of a temporal connective, and based only on the verbal tense of an utterance, he argued that two types of temporal relations may be established by default: (i) chronological sequencing for the perfective/aoristic aspect (that is, the PC and the PS); and (ii) synchronicity for the imperfective/unaccomplished aspect (that is, the Imparfait ‘imperfect’). Hence, when a temporal connective is used, its encoded instructions constrain or specify the default temporal relation (provided by the verbal tense).

Ensuite and *puis* are described as conveying chronological sequential temporal relations, and exclude synchronous temporal relations (unlike *et*). In particular, *ensuite* instructs the hearer to relate the final boundary of the first eventuality e_1 to the initial boundary of the second eventuality e_2 in terms of *precedence but not immediate vicinity*. In other words, there is a linguistically relevant interval between the end of e_1 and the beginning of e_2 , as shown in examples (10) and (11). Gosselin points out that this is the fundamental difference between *puis* and *ensuite*, since *puis* instructs for a relation of the *optional immediate precedence* type (i.e. the initial boundary of e_2 can coincide with the final boundary of e_1).

(10) Le vase est tombé. **Ensuite* il s’est brisé.

‘The vase fell. ?Then it broke.’

(11) La fenêtre s’est ouverte. *Ensuite*, le courant d’air s’est engouffré.

‘The window opened. Then [afterwards but not immediately] the draught rushed in.’

(12) Le vase est tombé. *Puis* il s’est brisé.

‘The vase fell. Then it broke.’

De Saussure (2007, 2011) also argues in favour of a procedural account of *ensuite*. However, he does not follow Gosselin in his analysis that *ensuite* is a *temporal* connective, and instead argues that *ensuite* should be considered as a procedural *serial* connective. For him, the basic semantic meaning of *ensuite*, just like *d’abord* ‘firstly’ and *enfin* ‘finally’, is to order various types of elements. By way of pragmatic enrichment, the ordering of these elements can be specified to *temporal* order, as in (13), *argumentative* order, as in (14), and *discursive* order, as in (15).

(13) Paul s’est rendu à Paris en décembre 1997. *Ensuite*, il y a habité pendant plus d’une année. (de Saussure 2011)

‘Paul went to Paris in December 1997. Then he lived there for more than a year.’

(14) Je ne sortirai pas. D’abord je suis fatigué, *ensuite* aller au restaurant est la dernière chose qui me ferait plaisir. Enfin, il y a un match à la télé ce soir. (de Saussure 2007)

‘I’m not going out. First, I am tired, and going to a restaurant is the last thing that would make me happy. Also, there is a game on the TV tonight.’

(15) Il y a plein de cas où tu dois faire une sauvegarde supplémentaire. D’abord, si tu ouvres un fichier reçu par email. *Ensuite*, si tu dois transférer le fichier à un collègue qui utilise une autre plate-forme. Et puis surtout, chaque fois que tu fais une modification sur le fichier original. (de Saussure 2007)

‘There are plenty of cases where you have to do an extra back-up. First, if you open a file that you received by email. Then, if you have to transfer the file to a colleague who uses a different platform. And most of all especially, every time you make a modification to the original file.’

In contrast to de Saussure’s treatment of *ensuite*, Kozłowska (1996) points out that this adverb is used to link bounded telic and atelic eventualities, thus excluding states. Following Dowty (1986) — who observed that bounded eventualities are usually interpreted sequentially while unbounded ones are usually interpreted to be temporally simultaneous — Kozłowska makes the hypothesis that *ensuite* is a formal means of overtly marking chronological sequential relations. For her, “*ensuite* is directly linked to the temporal sequencing phenomenon, i.e. to forward temporal progression (*e1* takes place before *e2*). Consequently, *ensuite* is compatible with utterances presenting temporal progression and it is not compatible with utterances presenting other types of temporal relations, such as: causal inversion, simultaneity, temporal indeterminacy.” (1996, 255)

So scholars are split between accepting or rejecting *ensuite* as a member of the category of temporal connectives. A similar state of affairs is observed for *puis*. *Puis* is also described in classical grammars as indicating *temporal succession* (Grevisse 1980; Robert 2016; cf. Bras et al. 2001), as in (16), from Robert (2016). In this usage, *puis* corresponds to English *then* or *afterwards*. Succession can also be understood with respect to a spatio-temporal dimension, thus expressing it from the *view of an observer* (Robert 2016), as in (17).

(16) Dieu nous prête un moment les prés et les fontaines [...] *Puis* il nous les retire. Il souffle notre flamme. (V. Hugo, *Les rayons et les Ombres*)

‘God lends us for a moment the meadows and the fountains [...] Then he takes them back. He blows out our flame.’

(17) En bas, des fleurs rouges, jaunes [...] *puis* c'étaient les jasmins, les glycines. Puis voici une lande. La forêt... et puis un damier de plaines.

‘Below, red, yellow flowers [...] then there were the jasmines, the wisteria. Then here is a moor. The forest [...] and then a tartan of fields.’

According to Grevisse (1980), the notion of temporal succession can disappear, and be replaced by the meaning of *logical succession*. In this case, the meaning of *puis* corresponds to the English *besides* or *moreover*, as in (18).

(18) On trouvait à Yonville qu'il avait des manières comme il faut. Il écoutait raisonner les gens mûrs [...] *Puis* il possédait des talents. (Flaubert, *Madame Bovary*)

‘People from Yonville thought that he had manners as he ought. He used to listen to mature people reasoning [...] Besides, he was talented.’

Certain scholars, such as Hansen (1995) and Reyle (1998), have suggested that the meaning and the discursive function of *puis* have evolved from the basic temporal value to the enumerative and argumentative value, and that the temporal ordering is inferred by default in narrative contexts (cf. discussion in Bras et al. 2001). Bras et al. (2001) argue against this proposal, pointing to the fact that when *puis* links to past events expressed with the PS, other temporal interpretations (such as simultaneity or temporal regression) are not possible. For them, *puis* is an adverbial marking temporal succession, which acts, syntactically speaking, as a conjunction. Others, such as Gosselin (2007) and de Saussure (2007), also consider *puis*, semantically speaking, as a temporal connective that marks the temporal succession of eventualities described by series of utterances.

3 Verbal tenses as processing instructions

The link between verbal tenses and temporal relations holding between eventualities has been pointed out by formal semantic discursive theories, according to which a verbal tense should be interpreted as temporally related to the preceding sentences (Kamp 1979, Hinrichs 1986; Kamp & Rohrer 1983, Partee 1973). In *Discourse Representation Theory* (Kamp & Reyle 1993), the discursive contribution of verbal tenses consists of introducing temporal discourse referents (eventualities) and temporal relations which the discourse referents have with the surrounding context. This is done by making use of Reichenbach's coordinates: reference point R, event moment E and speech moment S (Reichenbach 1947). In example (19), the arrival occurs at some indefinite time on a specific day in the past, and Mary's entering the house is linked to the time of the arrival.

(19) Mary arrived during the day. She let herself into the house.

The interpretation of (19) involves establishing a discourse referent for the arrival event, and linking it to a reference time that indicates an interval just after the time of arrival. The second sentence introduces an event that is constrained to be included in the reference time interval, and has the property of shifting the reference time from *just after the time of arrival* to *just after the time of entering the house*.

In the same framework, if a text contains a succession of sentences whose main verbs are in the PS, the order of the sentences corresponds to the order of the events in the world. Hence, Kamp and Rohrer (1983) suggested that the PS encodes the temporal sequencing of eventualities, as in (20).

(20) Un homme *entra* dans le bar. Bill lui *servit* une bière.

'A man entered the bar. Bill served him a beer.'

Adopting a relevance-theoretic approach, scholars (Nicolle 1998; Moeschler 2000a, 2002; Saussure 2003, 2011; Aménos-Pons 2011) have proposed that verbal tenses, which encode procedural information, impose constraints on the determination of temporal reference. Within this framework, Moeschler (2000a, 2002) proposed a model of temporal interpretation of discourse, called the *Model of Directional Inferences*, which is based on inferences that the hearer has to make about the temporal location of eventualities in relation to each other. Moeschler's proposal is that, during the comprehension process, the hearer makes inferences about the temporal sequencing of eventualities. These are not default inferences, but are driven by both the meaning of the linguistic expressions (verbal tenses and connectives such as *because, and, and then, then*) and by non-linguistic information (contextual hypotheses and

encyclopedic knowledge). Example (21) shows the incompatibility of the PS, conveying a forward relation, with the connective *parce que*, which imposes a backward relation. This incompatibility disappears in (22), where the backward relation is maintained by the conceptual relation between the verbs.

(21) ?Marie *poussa* Jean *parce qu'*il *tomba*.

?‘Mary pushed John because he fell.’

(22) Jean *tomba* *parce que* Marie le *poussa*.

‘John fell because Mary pushed him.’

As Moeschler argues, the PC allows both forward and backward temporal inferences (that is, chronological and anti-chronological sequencing relations), whereas the PS conveys only a forward temporal direction (Moeschler et al. 1998; Moeschler 2000a, 2000b, 2002). In other words, since the PC is not directional (i.e. it does not impose a temporal direction), hearers must make use of other types of information in order to decide the type of temporal relation holding between the segments they process, such as world knowledge (if the relation remains implicit) or temporal connectives (if the relation is explicit), as in examples (23), (24) and (25).

(23) Marie *a poussé* Jean. Il *est tombé*.

‘Mary pushed John. He fell.’

(24) Jean *est tombé*. Marie l’*a poussé*.

‘John fell. Mary pushed him.’

(25) Marie *a poussé* Jean *parce qu'*il *est tombé*.

‘Mary pushed John because he fell.’

More recently, Grisot (2015, 2018) has proposed a relevance-theoretic pragmatic model of verbal tenses, according to which verbal tenses’ contribution to the expression of temporal relations (chronological, anti-chronological or synchronous) should be linked to the procedural information encoded by the grammatical category of tense. According to this model, in order to identify the meaning of a verbal tense, which is a generic notion referring to grammatical aspect and tense as applied to lexical aspect, one should distinguish between the contributions of these three underlying categories. Verbal tenses are therefore underdetermined linguistic categories whose meanings and discursive functions are specified contextually by determining the input provided by tense, grammatical aspect and lexical aspect.

Consequently, differences between verbal tenses — in terms of their meaning and their influence on the processing of discourse relations — come from semantic and pragmatic features linked to tense, grammatical aspect and lexical aspect. In particular, the contribution

of the category of tense is determined contextually at two levels. The first is the localisation of events and states with respect to the moment of speech — that is, in the past ($E < S$), present ($E = S$) or future ($E > S$). The second is the localisation of events and states with respect to one another, making use of the reference point R, information referred to in Grisot (2015, 2018) as the binominal [\pm narrativity] feature. The [+narrative] value corresponds to sequential temporal relations (chronological when R increases incrementally, and anti-chronological when R decreases incrementally), whereas the [-narrative] value corresponds to synchronous temporal relations (when R remains constant).

Grammatical aspect encodes procedural information constraining the interpretative process by imposing the speaker’s viewpoint on the eventuality. To be more precise, the perfective aspect constrains the hearer to build a completed representation of the eventuality denoted by the verb — in other words, a single whole with highlighted boundaries. This proposal has been confirmed experimentally. For example, Magliano & Schleich (2000) tested the influence of grammatical aspect on the interpretation of a series of situations: English native speakers read stories in which the target eventuality was expressed with the progressive, such as *was changing a tire* or, with the perfective, *changed a tire*. This target eventuality was followed by three other eventualities, which could be understood as taking place either during or after the target situation. The results indicated that eventualities expressed by the imperfective aspect are understood as ongoing at the moment of speech, whereas eventualities expressed by the perfective aspect are understood as completed. Furthermore, Mozuraitis et al. (2013) used a series of eye-tracking experiments with reading tasks to compare sentences such as *Mrs. Adams was knitting/knitted a new sweater ... She wore her new garment*; they showed that readers have greater difficulty processing the second event (she wore...) if it followed an imperfective verb (was knitting) rather than a perfective verb (knitted). Finally, lexical aspect encodes conceptual representations of states, activities and events. In these terms, the simple and the compound past receive almost identical descriptions, where the differences lie in the position of the R point, as shown in Table 3-1.

Table 3-1 : The description of the meaning of simple and compound past

Verbal tense	Tense		Grammatical aspect	Lexical aspect
French PC	$E < R = S$	\pm narrative	perfective	events and states

French PS	E=R<S	±narrative	perfective	events and states
English SP	E=R<S	±narrative	perfective	events and states

The localisation of the R point as simultaneous with S is linked to the interpretation of the PC as expressing a past time eventuality that has a resultative state holding at S. This interpretation occurs in the usages known as the *resultative* PC and the *accomplishment* PC (Brunot 1922), as in example (26). In contrast, the PS presents the past time eventuality as disconnected from the present time.

- (26) Policier: Votre permis de conduire, s'il vous plait? Chauffeur : Je l'*ai oublié* à la maison.
 'Policeman: You driving license, please? Driver: I left/have left it at home.'

The English sentences in (27) (expressing a chronological relation) and (28) (expressing a synchronous relation), both of which use a Simple Past, may be translated into French using a PC, as in (29) and (30), or a PS, as in (31) and (32).

- (27) Mary *arrived* late in the evening. She *entered* the house.
 (28) Mary *arrived* late in the evening. Her sister *waited* for her.
 (29) Marie *est arrivée* tard le soir. Elle *est entrée* dans la maison.
 (30) Marie *est arrivée* tard le soir. Sa sœur l'*a attendue*.
 (31) Marie *arriva* tard le soir. Elle *entra* dans la maison.
 (32) Marie *arriva* tard le soir. Sa soeur l'*attendit*.

Unlike previous proposals (either the semantic position adopted by Kamp & Rohrer, or the inferential approach adopted by Moeschler), this model argues that neither the PC nor the PS is expected to inform the reader about the coherence temporal relation more than the other does. These verbal tenses instruct the hearer to build a completed representation of the eventuality denoted by the verb, to locate it before the moment of speech, and to relate it to the following eventuality, sequentially or synchronously. The construction of a sequential or synchronous coherence relation is in accordance with the linguistic elements at the reader's disposal, and his search for relevance, which is weighed in terms of cognitive effects and processing efforts.

The PC and the PS do present dissimilarities which are linked not to their meaning but to their frequency of usage. This phenomenon is known as the *aoristic drift* of the PC (Squartini & Bertinetto 2000), and has also been observed in other Romance languages such as Italian and Romanian, although not Spanish (Aménos-Pons 2011). Grisot (2015, 2018) reports the results of a corpus study carried out on a total of 1031 tensed predicative verbal forms, identified in

603 sentences randomly chosen from texts written in French belonging to four stylistic registers (literature, newspaper articles, parliamentary discussions and legislation). In this corpus, 72% of PS occurrences identified were in literature, 19% in newspaper articles, 8% in parliamentary discussions and 0% in legislation. Unlike the PS, the PC does not present such a skewed distribution. In the same corpus, 15% of PC occurrences identified were in literature, 5% in newspaper articles, 51% in parliamentary discussions and 28% in legislation.

4 Experimental investigation

The experimental work discussed in this section consists of two experiments. In the first, an online self-paced reading experiment (section 4.2), participants read sentences in which two events were narrated in a chronological manner. The verbal tense of these sentences was either the PC or the PS. The chronological relation was either overtly marked using one of two connectives, or expressed implicitly. In the second experiment, an offline acceptability experiment (section 4.3), participants consciously had to evaluate all the variants of the same experimental items, corresponding to experimental conditions, on a five-point Likert scale.

4.1 Hypotheses and predictions

The theoretical analyses of verbal tenses and of the connectives *ensuite* and *puis* presented in sections 2 and 3 give rise to a series of hypotheses, and their subsequent predictions for online and offline experimental testing. Table 4-1 shows the three variables under consideration: the Verbal Tense (PC or PS), the Connective (*ensuite* or *puis*) and the Implicitness status of the temporal relation (explicit, using one of the two connectives, or implicit).

Table 4-1 : Summary of hypotheses and predictions in terms of mean reading times (RT)

Variable	Theoretical hypotheses	Predictions
Verbal tense	1. PS and PC encode different meanings	A main effect of VT: PS<PC
	2. PC and PS have similar contextually determined meanings	No main effect of VT: PS=PC
	3. PS is less frequent than PC	A main effect of VT: PS>PC
Implicitness	4. <i>ensuite</i> and <i>puis</i> are (temporal) processing instructions	A main effect of Implicitness: explicit<implicit
	5. <i>ensuite</i> and <i>puis</i> are not (temporal) processing instructions	No main effect of Implicitness: explicit=implicit
Connective	6. <i>ensuite</i> and <i>puis</i> encode different meanings	A main effect of Connective: <i>puis</i> ≠ <i>ensuite</i>

	7. <i>ensuite</i> and <i>puis</i> encode similar meanings	No main effect of Connective: <i>puis=ensuite</i>
Verbal Tense and Connective	8. PC and PS are not equally compatible with both <i>ensuite</i> and <i>puis</i>	Interaction effects: <i>PCensuite</i> < <i>PCpuis</i> <i>PSensuite</i> > <i>PSpuis</i> <i>PCensuite</i> < <i>PSensuite</i> <i>PCpuis</i> < <i>PSpuis</i>
	9. PC and PS are equally compatible with both <i>ensuite</i> and <i>puis</i>	No interaction effect: <i>PCensuite</i> = <i>PCpuis</i> <i>PSpuis</i> = <i>PSpuis</i>

The first set of hypotheses and predictions concerns the meanings of the verbal tenses tested, and their roles in the expression of temporal relations. Firstly, the PC and PS encode different procedural content regarding sequential relations: the PC is undetermined with respect to sequential relations, whereas the PS instructs the hearer to establish a default sequential relation (Kamp & Rohrer 1983; de Saussure 2003). This hypothesis leads to the prediction that when comprehenders need to handle a series of past events which should be understood sequentially, we would expect a main effect for the Verbal Tense variable. Shorter reading times should be measured when the events are expressed with the PS than when they are expressed with the PC. Secondly, the PC and PS are both perfective verbal tenses, and their meanings are contextually determined (Moeschler 2000b, 2002; Grisot & Moeschler 2014; Grisot 2015, 2018). Consequently, when comprehenders need to handle a series of past events that should be understood sequentially, we would expect no main effect for the Verbal Tense variable.

The second set of hypotheses and predictions regards the implicit vs. explicit expression of chronological relations. If *ensuite* and *puis* are indeed temporal sequential connectives — that is, their encoded semantic meaning is temporal sequencing — we would expect that the processing of a temporal relation is facilitated by the connective, unlike when the temporal relation is implicit, and processed only according to the information provided by the perfective verbal tense. As such, we would expect a main effect of the explicit/implicit status of the temporal relation to take the form of shorter reading times and higher acceptability rates when the temporal relation is overtly marked, compared to when it is implicit. This would be the case both for undetermined and sequential temporal relations.

The third set of hypotheses and predictions regards the roles of *ensuite* and *puis*, taken separately, in the overt marking of sequential temporal relations. Firstly, these two connectives have been described as having different meanings, at the level of a fine-grained semantic

analysis: precedence but not immediate vicinity (i.e., there is a gap between the final boundary of the first event and the initial boundary of the second event) for *ensuite*; and optional immediate precedence (the final boundary of the first event might be the same as the initial boundary of the second event) for *puis* (Kozłowska 1998; de Saussure 2003). If these fine-grained semantic differences impact on processing, then we expect a main effect of the connective variable. The second hypothesis is that *ensuite* and *puis* are both sequential temporal connectives with similar meanings, which result in similar effects for the cognitive processing of sequential temporal relations. In this case, we would not expect a main effect of the connective.

The fourth set of hypotheses concerns the co-occurrence of verbal tenses and temporal connectives. As noted above, the two connectives have been described as having dissimilar fine-grained semantic meanings; consequently, we expect interaction effects between the independent variables of Verbal Tense and Connective. If, due to these fine-grained meaning distinctions, the PC and PS are not equally compatible with both *ensuite* and *puis*, we would expect to find a high degree of compatibility between the PC and *ensuite*, and between the PS and *puis*. This compatibility would trigger shorter reading times and higher acceptability scores. The second interaction effect is linked to the hypothesis advanced by the discourse-semantic approaches to verbal tenses, which is that the PS instructs the reader that a sequential relation will follow, whereas the PC does not. In this case, we would expect that connectives only facilitate processing in combination with the PC. In contrast, one can assume that the PC and PS are equally compatible with both *ensuite* and *puis*; in this case, we would expect no effect of interaction between the independent variables of Verbal Tense and Connective. In other words, we do not expect to find either of the two verbal tenses behaving differently when combined with *ensuite* than when combined with *puis*.

4.2 Online processing experiment with self-paced reading task

4.2.1 Participants

Participants in this experiment were 54 second- and third-year students from the University of Neuchâtel (45 females, mean age: 21.59, range 18-26). All participants were native speakers of French studying language sciences or speech therapy. Their participation in the experiment was part of their activity for one class in linguistics, and they were not paid for their participation.

4.2.2 Materials and procedure

In this experiment, we used a 2x3 within-group design, in which we made use of two variables: the *Implicitness* variable, with three levels (*ensuite*, *puis* and *implicit*); and the Verbal Tense variable (hereafter, VT), with two levels (PC and PS). The six experimental conditions can be seen in Table 4-2, and are illustrated in examples (33)-(36). Reading times were measured for four regions:

- the **pre-critical** region (number 2, just before the connective in the explicit condition)
- the region of the **connective** (number 3 in the explicit condition)
- the region of the **subject-verb** of the second sentence (region 4 immediately following the connective in the explicit condition, and number 3 in the implicit condition)
- the region of the **object** of the second sentence (region 5 in the explicit condition, and region 4 in the implicit condition).

Examples (33) and (34) illustrate the explicit condition, and examples (35) and (36) the implicit condition. As can be seen, the regions considered were identical in the two experimental conditions.

(33) [Lucie est partie]¹ [dans la forêt]², [CONNECTIVE]³ [elle a nettoyé]⁴ [sa voiture]⁵ [avec un aspirateur de bonne qualité.]⁶

‘Lucie went to the forest, then she vacuumed her car with a good quality vacuum cleaner.’

(34) [Lucie partit]¹ [dans la forêt]², [CONNECTIVE]³ [elle nettoya]⁴ [sa voiture]⁵ [avec un aspirateur de bonne qualité.]⁶

(35) [Lucie est partie]¹ [dans la forêt]², [elle a nettoyé]³ [sa voiture]⁴ [avec un aspirateur]⁵ [de bonne qualité.]⁶

‘Lucie went to the forest, she vacuumed her car with a good quality vacuum cleaner.’

(36) [Lucie partit]¹ [dans la forêt]², [elle nettoya]³ [sa voiture]⁴ [avec un aspirateur]⁵ [de bonne qualité.]⁶

‘Lucie went to the forest, she vacuumed her car with a good quality vacuum cleaner.’

Table 4-2: The 2x3 experimental design

	Implicitness		
Verbal tense	Explicit/Connective		Implicit
	PC <i>ensuite</i>	PC <i>puis</i>	PC <i>implicit</i>
	PS <i>ensuite</i>	PS <i>puis</i>	PS <i>implicit</i>

The 42 experimental items had a variant in each experimental condition, resulting in 252

variants of the experimental items. 18 fillers, having the same structure, were also used in the experiment, and each of them was also iterated in 6 variants corresponding to the 6 experimental conditions. The total of 360 sentences (252 variants of experimental items and 108 variants of fillers) were distributed in 6 lists. Each participant saw only one list consisting of 60 sentences, and read experimental items from all the 6 conditions. A total of 10 yes/no comprehension questions appeared randomly within each list. Participants could answer by pressing a key for *yes* or for *no*, according to their choice. For example, the experimental item from (33)-(36) was followed by this comprehension question, and required a *yes* answer:

(37) La voiture de Lucie, était-elle sale?
'Lucy's car, was it dirty?'

On pressing the space bar, the different regions appeared consecutively on the screen, and disappeared from the screen as the readers went on to the next region. This design allowed the participants to read each region individually, and prevented them from pressing the space bar in order to see all the regions before starting to read.

Experiments were designed with the E-prime software (Schneider et al. 2012), and participants were tested individually. Each session began with written instructions displayed on the screen, followed by a training phase, in which the participants saw 4 sentences similar to the items and 5 sentences similar to the fillers. At the end of the training phase, the participants were given the opportunity to ask questions of the experiment's coordinator before the actual experiment started. Each series of regions began with a fixation cross in the middle of the screen for 1000ms. Participants read each region, and pressed the space bar in order to display the following region. There was no time constraint imposed for the task, and each participant completed the experiment within approximately 15 minutes. A list of all experimental items is provided in the Appendix.

4.2.3 Analysis and results

All answers to the comprehension question were checked. Two participants answered only 50% of the questions correctly, so they were deleted from the data set. The general level of success in the comprehension questions was 88%. Before conducting the analysis, the data were cleaned in two phases. In the first phase, extreme values were removed by deleting observations under 50ms. and over 4500 ms. measured for the first critical region (segment 4 in the explicit condition, and segment 3 in the implicit condition), as these reading times are not considered in the literature to represent normal reading times for short segments, such as those used in our

experiment (cf. Zufferey 2014). This corresponds to 6 observations (0.27% of the data). Furthermore, outliers were removed from the data by deleting all observations above and below 2.5SD from the subject's and item's mean values. This corresponded to a total of 176 observations (8.15% of the data). The mean reading times (standard errors between parentheses) for the target regions (as illustrated above in examples (33)-(36)) in each of the six experimental conditions are reported in Table 4-3.

Table 4-3 : Mean reading times and standard errors (ms.) for the target regions

Condition	Region			
	pre-critical <i>dans la foret</i>	connective <i>ensuite/puis/∅</i>	subject-verb <i>elle nettoya</i>	object <i>sa voiture</i>
ensuitePC	865.35 (26.78)	723.35 (15.82)	735.17 (16.31)	818.52 (23.47)
ensuitePS	955.76 (33.47)	772.70 (19.59)	718.10 (14.90)	851.49 (26.35)
puisPC	873.78 (23.45)	744.55 (17.60)	748.52 (16.81)	860.30 (26.95)
puisPS	975.08 (30.84)	728.66 (15.26)	749.88 (15.60)	885.93 (30.61)
implicitPC	884.35 (25.74)	∅	798.82 (17.92)	910.42 (31.60)
implicitPS	929.29 (34.55)	∅	816.08 (17.71)	891.21 (27.23)

A Kolmogorov test applied to the data showed that they were not normally distributed ($p < .05$). In order to normalise reading time data, we transformed the actual mean values into the reciprocal values (1/the original value; cf. Field 2009, Chapter 5). This transformation results in a normal distribution of the data.

A dependent-samples ANOVA was run on the normalized data for each target segment (pre-critical, connective, subject-verb and object), in order to verify whether the two independent variables separately or jointly affect the processing of the regions for which reading times were measured.

In the pre-critical region, a significant effect of the Verbal Tense variable was found ($F(1,51) = 8.23, p < .05$, partial Eta Squared .140), according to which the mean reading times of the PS were longer ($M = 968.25, SE = 48.30$) than those of the PC ($M = 881.38, SE = 30.25$). No significant effect was found for the Implicitness variable ($F(2,50) = .092, p > .05$), nor for the interaction between the two variables ($F(2,50) = .507, p > .05$, partial Eta Squared .020).

In the connective region in the explicit condition, no significant main effect was found, either for the Verbal Tense variable ($F(1,51) = 1.822, p > .05$) or for the Connective variable ($F(1,51) = .272, p > .05$).

In the subject-verb region of the second sentence, a significant main effect was found for the Implicitness variable ($F(1,50)= 19.98, p<.05$, partial Eta Squared .444), according to which reading times for this region vary with respect to the three levels of the Implicitness variable. Pairwise post hoc comparisons using the Bonferroni test showed that reading times in the implicit condition ($M=819.93, SE=29.39$) are significantly longer than in the explicit condition with *ensuite* ($M=730.13, SE=25.88$) and with *puis* ($M=757.36, SE=27.98$). Additionally, the difference between *ensuite* and *puis* is not statistically significant ($p>0.5$).

In the object region of the second sentence, the same effect was found Implicitness variable ($F(1,50)= 4.191, p<.05$, partial Eta Squared .144). As in the previous region, pairwise post hoc comparisons using the Bonferroni test showed that reading times in the implicit condition ($M=919.85, SE=39.50$) are significantly longer than in the explicit condition with *ensuite* ($M=840.34, SE=34.57$) and with *puis* ($M=877.12, SE=35.0$). Additionally, the difference between *ensuite* and *puis* is not statistically significant ($p>0.5$).

4.2.4 Discussion

Three results can be established from the data analysis. The first is a main effect of the Verbal tense variable, measured only for the pre-critical region; the second is a main effect of the Implicitness variable, measured for the subject-verb and object regions of the second sentence; and the third is a lack of interaction effect between Verbal Tense and Implicitness.

The first result is linked to hypotheses 1 and 3 from Table 4-1. According to hypothesis 1, and contrary to hypothesis 2, the PS and the PC encode different meanings regarding their capacity to inform the hearer about the localization of eventualities with respect to one another. Consequently, shorter reading times were expected for the PS than for the PC. The results of the experiment showed similar reading times for the PS and the PC in three target segments. This result does not manifest the expected difference in meaning between the two verbal tenses, as the PC was read as quickly as the PS was. In contrast, these results can be explained by the fact the both the PC and the PS are perfective verbal tenses. This information provided by grammatical aspect instructs the comprehender to build a mental representation of a completed eventuality, which facilitates the integration of a subsequent mental representation (Magliano & Schleich 2000; Mozuraitis et al. 2013).

However, in the pre-critical segment, the opposite effect is observed: that is, longer reading times for the PS than the PC. This result might be due to the low frequency of the PS in contemporary, daily-usage French, as discussed in section 3 and predicted by hypothesis 3. We assume these longer reading times for the PS in the pre-critical region are due to the surprise

effect when encountering this verbal tense, rather than a semantic difference between the PC and the PS. This assumption is supported by the fact that this difference between the two verbal tenses disappears in the three other subsequent target regions. We therefore interpret this result as supporting hypothesis 2, put forward by Grisot (2015, 2018), according to which the meaning of the PC and the PS, in terms of their capacity to express temporal relations, is contextually determined. In the case of our experiment, the two verbal tenses equally informed readers in terms of the chronological relation to be established between the two events.

The second result is linked to hypotheses 4-7, regarding the semantics of *ensuite* and *puis* and their status as temporal connectives. Scholars advancing hypothesis 4, rather than 5, treat *ensuite* and *puis* as having a temporal sequential semantic meaning, which is to say that they encode a processing instruction according to which the two events they connect should be understood in a chronological order. Consequently, this instruction facilitates processing and helps the reader to integrate the second event (consisting of subject, verb and object) into the mental representation that he is building. This facilitation effect is indicated by shorter reading times in the explicit condition than in the implicit condition. Our results provide supplementary evidence in favour of the incremental integration effect of connectives, as previously shown by Canestrelli et al. (2013) and van Silfhout (2015), and contrary to Millis & Just (2004) and Cozijn et al. (2011).

As such, our experiment provides evidence that both *ensuite* and *puis* facilitate access to the chronological interpretation of the two segments that they link. Our experiment does not allow us to pinpoint the source of this facilitation effect — that is, whether it comes from their semantic encoded temporal meaning, or from their pragmatically enriched temporal meaning. Further experimental work should be carried out in order to distinguish between and to measure the reading times for the possible pragmatically determined usages of *ensuite*, compared to the basic semantic meaning. The same is necessary for *puis*, for which Bras et al. (2001) proposed that the temporal sequential meaning was replaced by the *logical succession* meaning.

Furthermore, hypothesis 6, unlike 7, predicts that the fine-grained difference in meaning between *ensuite* (that is, precedence but not immediate vicinity) and *puis* (that is, optional immediate precedence) is relevant for processing chronological relations at the cognitive level. Our experiment did not provide evidence in favour of this prediction. On the contrary, for three of the four target regions (connective, subject-verb of the second sentence, and object of the second sentence), the reading times for *ensuite* and *puis* were similar.

The third result is linked to hypotheses 8 and 9 regarding possible incompatibilities between

the two connectives and the two verbal tenses. Hypothesis 8, unlike 9, puts forward the idea that the PC and the PS are not equally compatible with both *ensuite* and *puis*. Due to the fine-grained semantic features of *ensuite* and the PC (such as the gap between the final boundary of the first event and the initial boundary of the second event, and the state resulting from the event expressed for the PC), we would expect the PC to be more compatible with *ensuite* than with *puis*. Conversely, we would expect PS to be more compatible with *puis* than with *ensuite*, because the former connective allows immediate vicinity, and the PS does not impose a state resulting from the event expressed. Moreover, an interaction effect would have been expected on the basis of the hypothesis that the PS already encodes an instruction to relate events chronologically where the PC does not. Consequently, a facilitation effect of the connective should only have been found for the PC, and not for the PS. Our experiment did not show statistically significant interactions between the two connectives and the two verbal tenses. This means that the two verbal tenses are similarly compatible with the two connectives. This finding was observed in all of the four target regions.

The hypotheses discussed above, in the light on the online processing data, were also tested by directly appealing to subjects' judgments on the acceptability of the variants of the experimental items in the six conditions. If differences between the PC and the PS or between *ensuite* and *puis* were not detected by the online experimental method, they should still be reflected in acceptability scores. Additionally, the difference between the explicit and implicit conditions should be confirmed by the acceptability scores.

4.3 Offline evaluation experiment with acceptability scores

4.3.1 Participants

Participants in this experiment were 40 second- and third-year students from the University of Neuchâtel (31 females, mean age: 21.57, range 18-25). They also participated in the online experiment discussed in section 4.2. Their participation in the experiment was part of their activity for one class in linguistics, and they were not paid for their participation.

4.3.2 Materials and Procedure

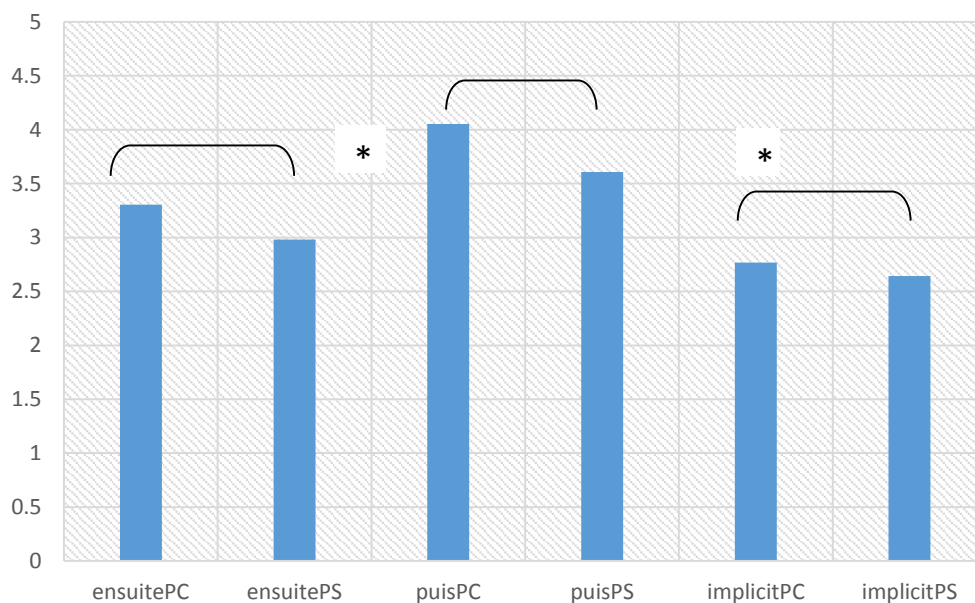
28 of the 42 experimental items used in the online experiment were used in the offline experiment. There were no fillers used in this experiment. Participants were told that they would participate in a second experiment, in which they would see a selection of sentences from the previous experiment, and that each sentence would occur in six variants. The six variants correspond to the 2x3 design used in the online experiment, as shown in Table 4-2.

The 28 groups of four variants (corresponding to the 28 items from the online experiment) were distributed into two lists. Each list contained 14 groups of sentences. Each participant received one of the two lists on a sheet of paper. Participants were asked to rate the acceptability of each variant on a five-point Likert scale. They were allowed to give the same Likert scale score to more than one variant from each group if they wanted to.

4.3.3 Analysis and results

The median value for each variant was calculated across all the participants who saw that variant. Median values were organized according to condition, resulting in 28 for each condition. The results are visualized in the bar chart given in Figure 4-1.

Figure 4-1 : Mean median values in the six conditions



A dependent-samples ANOVA was run on the median values for each experimental item in each of the six conditions. A statistically significant main effect of the Implicitness variable was found ($F(2, 26)=24.051, p<.05$, partial Eta Squared .649), according to which acceptability scores vary with respect to the three levels of the Implicitness variable. Pairwise post hoc comparisons showed that acceptability scores in the *puis* condition ($M=3.83, SE=.113$) are higher than those in the *implicit* condition ($M=2.70, SE=.179$). In contrast, acceptability scores in the *ensuite* condition are not significantly different from those in the *implicit* condition ($p>.05$). Furthermore, acceptability scores in the *puis* condition ($M=3.83, SE=.113$) are higher than those in the *ensuite* condition ($M=3.14, SE=.125$).

There was also a second main effect found in the Verbal Tense variable ($F(1, 27)=6.574$, $p<.05$, partial Eta Squared .196), according to which variants of the experimental items in the PC received higher acceptability scores ($M=3.37$, $SE=.063$) than variants in the PS ($M=3.07$, $SE=.084$).

Finally, the interaction effect between the Implicitness and Verbal Tense variables was not statistically significant ($F(2, 26)=1.642$, $p>.05$), indicating that the acceptability scores given to the *ensuite*, *puis* and implicit variants do not vary according to the verbal tense used.

4.3.4 Discussion

Three results can be established from the analysis of the acceptability data: a main effect of the Implicitness variable; a main effect of the Verbal Tense variable; and no interaction between the two variables.

The first result reveals a difference between *ensuite* and *puis* which did not appear in the processing data from the online experiment: when participants consciously have to evaluate the suitability of one of the two connectives to mark chronological relations overtly, they prefer *puis*. This indicates that this connective's fine-grained semantic meaning of *optional immediate vicinity* makes it more acceptable than *ensuite* to mark chronological relations overtly. Additionally, this preference is also manifested when comparing overtly marked chronological relations using *puis* to implicit relations. In contrast, when *ensuite* is compared to the cases when the relation is expressed implicitly, no preference is shown. We make the assumption that *puis* is the best of a number of grammatically possible options which comprehenders have to express chronological relations. In our view, the difference between the online and offline results is due to the fact that processing is based on the semantics of the two connectives, whereas offline evaluation is influenced by the way that speakers use these two connectives, or are taught to use them (for example, at school or in grammar books).

The second result confirms the difference between the PC and the PS found in the pre-critical region, but not in the other three target regions. Participants read segments in the PS slower than those in the PC, and gave lower scores to the former than to the latter. As we mentioned in the discussion of the online data, we assume that this difference comes from the fact that the PS is typically used less frequently than the PC. It seems that comprehenders are particularly sensitive to their own usage of a certain linguistic expression or grammatical category, and the frequency of their usage.

The third result confirms the findings from the processing data regarding the lack of interaction between the two verbal tenses and the two connectives. It seems to indicate that at

the conscious and processing levels alike, the PC and the PS are equally compatible with both *ensuite* and *puis*.

5 General discussion

5.1 Are chronological relations expected or unexpected discourse relations?

Studies in psychology and psycholinguistics have suggested that *comprehenders have expectations* about the relations holding between segments when reading a text, which bias their inferential decisions during comprehension. According to the literature, it seems that there are two types of expectations: those based on cognitive biases, such as the *continuity* hypothesis (Segal et al. 1991; Murray 1997) or the *causality-by-default* hypothesis (Sanders 2005); and those triggered by linguistic elements, such as implicit causality verbs (Rohde et al. 2011) or grammatical aspect (Ferretti et al. 2009; Mozuraitis et al. 2013).

Below, we will discuss the *continuity* hypothesis, as initially put forward by Segal et al. (1991), and subsequently mentioned in other studies in which it was treated as a *cognitive bias* for processing temporal relations. Based on this *bias*, certain scholars have closely linked the continuous/discontinuous status of a discourse relation to its degree of implicitness/explicitness using a connective (Asr & Demberg 2012; Hoek et al. 2017). In our view, the over-generalisation of Segal et al.'s continuity principle has resulted in problematic conclusions, specifically with respect to sequential temporal connectives and chronological relations. Our proposal is that a more accurate way to explain the processing of temporal relations is to take into consideration a cluster of factors, including world knowledge and linguistic knowledge (section 5.2).

For Segal et al. (1991), the *continuity* principle applies in a narrative text with respect to the frame of reference set in the narrative (times, objects and events), and holds that:

“A new sentence in the text is interpreted in terms of an ongoing construction of an integrated component of the narrative’s meaning. Unless specifically marked, the new meaning is incorporated into, and regarded as continuous with, the current ongoing construction. Readers presume, by default, that continuity is maintained. Only if there is a textual cue that the new text is discontinuous with the old, or if attempts at continuous integration cannot be maintained, does the reader interpret new information as discontinuous.” (Segal et al. 1991:32)

Segal and colleagues investigate the role of additive (*and*), temporal (*then*), causal (*so* and *because*) and adversative (*but*) connectives in structuring short narratives produced by five-year-old children. They found that additive and temporal connectives are directly linked to

marking narrative continuity and discontinuity respectively, whereas the roles of causal and adversative connectives were less clear-cut. In particular, among causal connectives, *so* marks continuity with respect to events (cause-consequence), whereas *because* marks discontinuity. *But*, on the other hand, maintains temporal, character and goal-related continuity.

Segal et al.'s proposal about the continuity principle seems to be in conflict with their findings. For example, they write that:

“We find evidence in our frequency data for the continuity principle that continuity is the preferred or unmarked condition. *And* the purest marker of continuity was by far the most frequent connective used and was often used for successive clauses. By contrast, *then* the complement of *and* in that it is the purest marker of discontinuity, was both less frequent than *and* and only infrequently used for successive clauses.” (1991:50)

In other words, continuity (that is, the unmarked condition) is marked by *and*, which is the most frequent connective used in the short narratives. By contrast, discontinuity (that is, the marked condition) is marked by *then*, which is much less frequent in their material. This interpretation of the results would mean that continuous relations should more frequently be explicitly marked by a connective than discontinuous relations. However, this contradicts the very principle of continuity, according to which comprehenders assume by default that continuity is assumed, and that discontinuous relations should be indicated by textual cues. Moreover, we are not convinced by the idea that *then* and chronological temporal relations should be considered discontinuous, since the connective *and* — like *then* — can be used to express the temporal sequencing of events in a narrative, as shown by the pair of examples (38)-(39).

(38) John took off his boots, *then* he went to bed.

(39) John took off his boots, *and* he went to bed.

Later, Murray (1997) uses presumably the same principle of continuity to refer to the interpretation of sentences in a narrative as “following one another in a continuous manner. As readers progress through a narrative, they assume that the events will follow in a linear fashion.” (Murray 1997:228). In other words, for Murray, interpreting events in a chronological order is the same as interpreting them in a continuous manner. In contrast, interpreting events in an anti-chronological order — that is, temporally backwards — is the same as interpreting them in a discontinuous manner. So, Murray's view is demonstrably the opposite of Segal et al.'s proposal.

Furthermore, Murray makes and tests the hypothesis that connectives impact on online

processing, to the extent that they signal an event that represents a departure from the continuity of the events stated in the text. He proposes that connectives affect processing insofar as they mark continuity or discontinuity: they serve as explicit markers of continuity and discontinuity in a discourse, and differently facilitate online processing in that they inform the reader about upcoming continuity and discontinuity. Contrary to Segal et al.'s findings, Murray finds that contrastive connectives mark discontinuity, and facilitate processing more than causal connectives, which mark continuity. As for additive connectives, both Segal et al. and Murray treat them as marking continuous relations. This result should be taken with caution: as Murray himself points it out, the effects of specific connectives, rather than types of connectives, should be investigated.

More recently, Asr & Dember (2012) have taken the findings of these previous studies to indicate strongly the

“implicitness of the discourse connector as a sign of expectation of the discourse relations: if readers have a default preference to infer a specific relation in the text, this type of relation should tend to appear without explicit markers.” (Asr & Dember 2012:2671)

In their analysis of the Penn Discourse Tree Bank (PDTB, Prasad et al. 2008), they use the continuous vs. discontinuous status of discourse relations to predict their implicit vs. explicit marking using discourse connectives. In the PDTB, temporal relations are of two types: asynchronous (sequential relations) and synchronous (simultaneous relations). Asynchronous relations are further classified as relations of precedence (chronological) and succession (anti-chronological), as illustrated in (40) and (41) respectively, borrowed from Asr & Dember (2012:2674).

(40) He believes [that \$55 a share is the most you can pay for Georgia Gulf], before [it becomes a bad acquisition].

(41) [The fields were developed], after [the Australian government decided in 1987 to make the first 30 million barrels from the new fields free of excise tax].

Asr & Dember follow Segal et al.'s understanding of the continuity principle in their classification of both types of asynchronous relations — that is, chronological and anti-chronological — as discontinuous relations. Additionally, they note that synchronous relations are harder to classify as they sometimes introduce new events, so they should also be classified as discontinuous. In other words, all three types of temporal relation are highly unexpected relations, because they are not predicted by the continuity bias. This assumption is in contrast

with Murray's proposal, who predicts that chronological relations are highly expected relations because they follow the continuity hypothesis. Furthermore, based on the *Uniform Information Density* hypothesis (UID, Frank & Jaeger 2008; Jaeger 2010), according to which humans tend to spread information evenly across an utterance or a series of utterances, Asr & Demberg predict that highly expected relations may be left implicit because comprehenders prefer passages with the connective omitted rather than included.

In their analysis of the PDTB, they find general evidence supporting both the discontinuous and continuous status of asynchronous relations. In particular, they find that asynchronous relations are expressed explicitly (that is, overtly marked using a temporal discourse marker) more often than implicitly. However, in a finer-grained analysis of cases involving temporal continuity, such as cause/result, concession/contra-expectation and the chronological order of events, they find that discourse connectives are dropped when the relation between events conforms to linearity in time.

This discussion raises three principal issues. The first is that scholars have used the continuity principle/hypothesis in different ways, which has led to both contradictory results and confusion regarding the status of temporal relations. The second is that the continuity hypothesis, understood as a cognitive bias, has resulted in confusing and misleading predictions when investigating the processing of temporal connectives and temporal relations. The third is that we currently lack evidence that humans interpret a series of situations in a chronological manner because of a cognitive bias, rather than because of a cluster of linguistic cues. In contrast, the existing results seem to suggest that processing is biased by linguistic information, such as that provided by grammatical aspect or implicit causality verbs. To verify properly whether there can be a cognitive bias for interpreting situations chronologically without it interacting with linguistic biases, experiments should be carried out using non-linguistic stimuli, such as pictures.

Moreover, as pointed out by Hoek et al. (2017), the predictions about the marking of (temporal) coherence relations which can be formulated on the basis of the continuity hypothesis are "very coarse-grained and unable to make lower-level distinctions" (2017:115). To address this observation, Hoek et al. propose that Sanders et al.'s Cognitive Approach to Coherence Relations (1992, and later work) is a better framework, because it allows cognitive complexity to be determined by distinguishing a series of basic primitives of coherence relations. As we will argue in the following section, we propose that world knowledge and linguistic elements are stronger cues for building and processing temporal relations.

5.2 A cluster of factors

The approach that we put forward in this paper is developed on the basis of the role of linguistic expressions in processing temporal relations. More precisely, our proposal is that a more accurate way to explain the processing of temporal relations is to take into consideration a cluster of factors, including world knowledge (rules, laws and schemes) and linguistic knowledge (connectives, tenses, grammatical and lexical aspect). The example in (42) illustrates a schema that people have relating to how things happen in an airport: first a plane lands, and then passengers get off. This schema, on the basis of which we interpret these two events chronologically, is based on our general world knowledge and personal experience (see Carston 2002; Blochowiak 2014). This information is the most relevant when interpreting these utterances, where a relevant interpretation is understood in the relevance-theoretic pragmatic framework as the interpretation which keeps the balance between (low) cognitive effort and (high) cognitive effects. This information could be overridden in very specific contexts — for example, if the plane had technical problems, and the passengers had to get off in an unusual manner before the plane's actual landing (such as via the slides).

(42) The plane landed. The passengers got off.

Among linguistic factors, there are the linguistic expressions encoding procedural information, and those encoding conceptual information. In particular, verbal tenses (i.e. the categories tense and grammatical aspect) and connectives encode instructions on how to build and manipulate conceptual mental representations of eventualities (i.e. states, activities and events). As noted in section 3, according to the model developed in Grisot (2015, 2018), tense encodes procedural content to locate eventualities with respect to one another, grammatical aspect encodes procedural content to build a completed eventuality (for the perfective aspect) or an ongoing eventuality (for the imperfective aspect), and, finally, temporal connectives guide the hearer in the comprehension process.

Examples (43) to (45) illustrate how grammatical aspect and tense constrain the temporal relation holding between the two events. The semantics of the pluperfect in (43) — which instructs the comprehender to locate the event before the reference point R (which is itself located before the moment of speech: $E < R < S$) — is a very strong cue that the two events should be interpreted chronologically. In contrast, the semantics of the simple past in (44) locates the event as simultaneous to R, and locates both before S ($E = R < S$); as such, it does not constrain the temporal interpretation in a specific way. The perfective grammatical aspect, expressed by

both the pluperfect and the simple past, instructs the comprehender to build mental representations of completed eventualities. As a consequence, the integration of a new mental representation — hence, the construction of a chronological temporal relation — is easier when the situation is expressed using the perfective aspect than it is using the imperfective aspect (Magliano & Schleich 2000; Mozuraitis et al. 2013), as in example (45). Finally, the sequential relation underdetermined in example (44) is specified as chronological and explicitly marked using the connective *before* in (46), and as anti-chronological and explicitly marked using the connective *after* in (47).

(43) Mary arrived at home. John had prepared coffee.

(44) Mary arrived at home. John prepared coffee.

(45) Mary was arriving at home. John prepared coffee.

(46) Mary arrived at home *before* John prepared coffee.

(47) Mary arrived at home *after* John prepared coffee.

In the current paper, we have investigated the role of temporal connectives and two French verbal tenses in processing chronological relations. The main results can be summarized as follows.

Verbal tenses as processing instructions

In the reading experiment, we did not observe a main effect of Verbal Tense in the target regions, which would have been observed had the PC and PS differed in terms of their contribution to the processing of sequential relations. We attribute this result to the fact that their meaning is underdetermined. This means that the meaning of a verbal tense is contextually determined, based on the information provided by the categories of tense and grammatical aspect, which apply to lexical aspect. In the case of the PC and the PS, the fact that they are both perfective verbal tenses means that they instruct the comprehender to build a mental representation of a completed situation. It is easier for a mental representation of a completed — rather than, for example, ongoing — situation to be sequentially linked to a situation that follows. This result also indicates that the PS, by way of its semantic content, does not tell the comprehender how to relate two eventualities temporally. Following Grisot (2015, 2018), this result might be interpreted in terms of the [\pm narrative] feature, which receives contextually determined values for each verbal tense.

In the pre-critical region, we found a main effect of Verbal Tense, according to which the PS was harder to process than the PC. This is explained by the fact that the PS is less frequently used than the PC, the latter passing through the *aoristicization* process and replacing the PS in

regular conversation. This effect disappears later on in the processing of the sentence (in the region of the connective, the subject-verb of the second phrase, and the object of the second phrase).

In the acceptability experiment, the PC was scored higher than the PS. This result, which is consistent with the longer reading times found in the online processing in the pre-critical region, seems to confirm that participants are better habituated to the PC than the PS.

Connectives as processing instructions

In the reading experiment, we found a main effect of the Implicitness variable in the target regions following the connective, according to which longer reading times were found in the implicit condition than in the explicit condition. This indicates that the two tested connectives triggered an integration effect which facilitated processing, in contrast to cases when the comprehender had to infer the temporal relation according only to the information provided by the two perfective verbal tenses. This finding can be interpreted as indicating that these two connectives do have a temporal meaning strong enough to produce an integration effect shown on two target regions: the subject-verb and the object of the second clause. As we will discuss below, a question that requires further experimental investigation is the nature of this temporal meaning: is it semantically encoded, or pragmatically enriched?

This integration effect, triggered by the two connectives, is also linked to the question of the number of cues in a sentence. According to the UID hypothesis, humans tend to spread information evenly across an utterance or a series of utterances, and so do not tend to use a multiplicity of cues to convey a piece of information. In the case of sequential relations, the PC and the PS, as perfective verbal tenses, bias the comprehender towards a chronological interpretation of events. Despite the fact that the two pieces of information are in agreement, shorter reading times and higher acceptability scores were found for the explicit condition than for the implicit condition. These results seem to be in contrast with the UID hypothesis, which would predict that the multiplication of cues is redundant and cognitively costly. A drawback of this hypothesis is that it does not individuate the different types of linguistic information we can deal with. In the case of verbal tenses, speakers of languages in which tense marking is obligatory (such as French and English) cannot choose to drop the verbal tense and use the connective instead. As such, it might be the case that verbal tenses and connectives in these languages cannot be considered as multiple cues, and are instead single cues of a different nature. In contrast, in languages in which tense is an optional grammatical category, speakers might indeed tend to avoid multiplicity of cues of a similar nature.

Processing data did not show statistically significant differences between *ensuite* and *puis*. This means that fine-grained semantic differences linked to the notions of vicinity (of one eventuality to another) and the boundary gap (between the final boundary of the first eventuality and the initial boundary of the second eventuality) do not play a role in processing the chronological relations presented in our experimental items. On the other hand, in the acceptability experiment, participants gave the highest scores to variants containing *puis*, and did not show a particular preference to variants with *ensuite*, nor to variants in which the relation was expressed implicitly. Further research is needed in order to explain the participants' conscious preference for *puis* in the acceptability data, which does not seem to have an impact at the cognitive level.

The interaction between verbal tenses and connectives

Both the reading and the acceptability experiments did not show statistically significant interactions between the two connectives and the two verbal tenses. This means that the two verbal tenses are similarly compatible with the two connectives. This finding is rather surprising, given the clear hypotheses formulated on the basis of the semantic and pragmatic fine-grained descriptions of the PC, the PS, *ensuite* and *puis* (sections 2 and 3). Based on these hypotheses, we should have found two types of interaction effects. The first relates to the PC's higher compatibility with *ensuite* (because of the resultative state associated with the PC, and the gap between the two eventualities associated with *ensuite*), and the PS's with *puis* (because the PS does not produce a resultative state, and *puis* does not require a gap between the two eventualities). The second relates to the hypothesis that the connectives should only have facilitated processing when occurring with an undetermined verbal tense, such as the PC, and not with a verbal tense which already informs the comprehender about the chronological relations holding between the two eventualities, such as the PS.

These findings provide a series of insights for future research, from both methodological and theoretical perspectives. One possible way to improve the method currently used in the reading experiment would be to provide the readers with a larger context before they see each stimulus. This would render the whole reading task more natural, and reduce the risk of perceiving the stimuli as a series of isolated sentences. In an earlier version of the reading experiment, a different experimental setup was used. Firstly, participants were split into groups, one of which saw the *puis* condition, and the other the *ensuite* condition. Secondly, the reading regions were longer, consisting of the whole second sentence (that is, subject, verb and object). This

influenced the reading times, such that no statistically significant difference was found between the implicit and the explicit conditions. In other words, measuring reading times on overly long regions does not allow the connective's possible facilitation effect to be measured. However, this methodological issue did not affect the processing times of the two verbal tenses tested.

As regards theoretical perspective, our experiment provides evidence that both *ensuite* and *puis* facilitate access to the chronological interpretation of the two segments which they link. Our experiment does not allow us to pinpoint the source of this facilitation effect — that is, whether it comes from their semantic encoded temporal meaning, or from their pragmatically enriched temporal meaning. One question that arises at this point is the difference between an encoded (semantic) type of meaning and a pragmatically derived meaning, and whether these two types of meaning affect the processing of discourse relations differently. Two possible answers can be formulated, depending on the type of pragmatic theory adopted, as discussed by Blochowiak & Castelain (2018), (see Noveck & Reboul 2008 for an overview). The first would correspond to the default types of pragmatic account (Levinson 2000), which predict that pragmatic enriched meanings come first by default, while semantic meanings require a second stage to cancel default interpretations. Semantic interpretations will therefore take longer to process than pragmatic ones, because the second stage is effortful and time consuming. Hence, for this type of theory, pragmatically enriched types of meanings will facilitate processing more than the semantic encoded types of meaning.

The second answer would correspond to the cognitive contextual types of pragmatic account, such as the relevance-theoretic account (Wilson & Sperber 2004; 2012), which predict that non-enriched semantic meaning requires less effort to be processed, while pragmatically enriched meaning is built on the basis of the semantic encoded meaning. As such, for this theory, semantically encoded types of meaning will facilitate processing more than pragmatically enriched meaning. For example, in the case of *puis*, the meaning corresponding to *logical succession* — which is for Bras et al. (2001) its semantic encoded meaning — would require longer processing times according to the first type of account, which would not be the case according to the second.

The role of encoded semantic vs. pragmatic meaning, as well as the role of lexical aspect, in processing anti-chronological relations and synchronous relations is worth exploring. Future research questions include the following. How do other French verbal tenses, such as the pluperfect, the imperfect or the simple present, constrain the processing of temporal relations? Our hypothesis is that these verbal tenses present different configurations of the linguistic input

of the categories tense and aspect, and are expected to produce dissimilar effects for the processing of sequential and/or synchronous temporal relations. What is the contribution of the types of eventualities (states, activities and events) and their boundedness status to the processing of temporal relations? Two contrasting hypotheses can be formulated. The first is that, in case of a mismatch attributable to their conceptual content, situation types do not override the information provided by linguistic markers encoding procedural information. For example, when a progressive marker, such as English *-ing*, is applied to a stative predicate, the interpretation corresponds not to a state but to a dynamic situation in progress, as in (48).

(48) John is being silly.

The second hypothesis is that the information provided by lexical aspect interacts with the information provided by grammatical aspect. For example, Magliano & Schleich (2000) tested the role of duration, as a property of eventualities, in the processing of temporal relations in a story. Their experiments revealed that situations with a long duration, such as *writing a novel*, are more frequently understood as ongoing at the moment of speech than short situations, such as *writing a letter*. This effect is observed later in the story, and thus not immediately after the target situation. In other words, the effect of a situation's duration on the interpretation of a series of situations is visible at a later stage of processing. In addition, the influence of the imperfective aspect on the duration of situations persists longer in memory than that of the perfective aspect.

Finally, another question is that of the overt marking of temporal relations using connectives. As we shown in section 5.1, their status as expected/unexpected discourse relations based on the *continuity* hypothesis is problematic, and therefore unconvincing. Moreover, the UID hypothesis's predictions about making use of more than one cue do not seem to be supported by the results of our experiments. All these linguistic — in addition to non-linguistic — elements are crucial to a comprehensive understanding of the processing of implicit and explicit temporal relations.

6 Conclusion

The research questions discussed in this paper and the results of our experiments generate new questions relating to three subject matters. The first concerns the continuity hypothesis, and the problem of its definition, which substantially diminishes its ability to explain processing and to predict the degree of implicitness of discourse relations.

The second is the relation between cognitive and linguistic types of bias involved in

processing discourse relations. Future research should clearly identify what is related to truly linguistic cues, and what is related to purely cognitive bias. Only once this distinction is made could the interaction between the two be assessed.

The third, as our data seemingly indicate, is that a more accurate way to explain the processing of temporal relations and their degree of implicitness is to consider a cluster of linguistic (tense, grammatical and lexical aspect) and non-linguistic (world knowledge) factors. Section 5 covers a number of precise suggestions for future research regarding this cluster of factors.

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