A FORMAL ANALYSIS OF THE FRENCH TEMPORAL CONNECTIVE *alors*

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ABSTRACT

This paper presents an analysis of the French adverbial *alors* (*then, at that time, so*). Among the linguistic markers that establish a temporal relation between the eventualities introduced by two clauses, we define as *temporal connectives* those that introduce at the same time some sort of discourse relation. We argue that *alors* can be such a connective. Within the framework of *Segmented Discourse Representation Theory*, our investigation concerning the discourse information conveyed by sentence initial *alors* reveals at least three sorts of relations close to the Result relation of SDRT. *Alors* alone conveys a weak causal relation, which we formalize using Lewis' counterfactual, and encode in the discourse relation Weak-Result. We distinguish it from Strong-Result, which is inferred when lexical or other contextual information suggests a causal, discursive link. We also show that *alors* can, when Weak-Result is blocked, suggest an inferential relation, which we express using the weak conditional already present in SDRT.

Et qu'est-ce que l'autre lui raconte ! Qu'il devrait ajouter un bouton ! Oui ! Un bouton à son pardessus ! à son pardessus ! alors. alors l'autobus est arrivé. Alors j'ai monté dedans. Alors j'ai vu un citoyen qui m'a saisi l'oeil. Alors j'ai vu son long cou et j'ai vu la tresse qu'il y avait autour de son chapeau. Alors il s'est mis à pester contre son voisin [...] RAYMOND QUENEAU, *Exercices de style*, 1947)

[1] INTRODUCTION

This paper presents an analysis of the French temporal connective *alors* (generally translated in English by *then, at that time, so*). It is part of a broader project aimed to provide a systematic analysis of French *temporal connectives* within the formal framework of *Segmented Discourse Representation Theory* (Asher 1993; Asher and Lascarides 2003). We define as a *temporal connective* any adverb that expresses

a temporal (or aspectuo-temporal) relation between two eventualities and, at the same time, implies a logico-pragmatic relation between the two utterances in which the eventualities are described (Le Draoulec and Bras 2006). In other words, temporal connectives are adverbs that play a role at the discourse level in introducing discourse relations.

In previous work, we showed that *puis* is just such a connective. Its role in SDRT is to impose a relation of Narration (whose semantics includes a temporal relation of succession) and to block causal relations like Result (cf. Bras et al. 2001, Borillo et al. 2004). We argue here that *alors* can also be such a temporal connective under specific conditions.

Much work has been done on *alors* (cf. *inter alia* Jayez 1981, 1988b,a, Franckel 1987, Gerecht 1987, Hybertie 1996, Reyle 1998). Our starting point is the work of Hybertie (1996), partly based on the analyses of Jayez, Franckel and Gerecht. Hybertie distinguishes three major uses of *alors* in assertions[1]:

TEMPORAL USES:
    with only a temporal link between the eventualities:

(1)   J'ai rencontré Pierre en 1987. J'étais *alors* une jeune étudiante.[2]
    'I met Pierre in 1987. I was *alors* a young student.'

    with a temporal link and a dependency link (that we'll explain below):

(2)   Je suis allée jusqu'à la place du village, *alors* je l'ai vu arriver.
    'I walked up to the village square. *Alors* I saw him arrive.'

CONSEQUENTIAL USES:
    between eventualities:

(3)   J'étais pressé, *alors* j'ai pris le sens interdit.
    'I was in a hurry. *Alors* I took the one way street the wrong way.'

(4)   Olivier a fait tomber la carafe. *Alors* elle s'est cassée.[3]
    'Oliver dropped the carafe. *Alors* it broke.'

    between two cognitive states in an inferential process:

(5)   Les volets sont fermés, *alors* ils sont partis.'
    'The shutters are closed, *alors* they have left.'
    (I see that the shutters are closed, so I infer that they must have

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[1]   The cases in which *alors* is associated with an interrogative or an exclamative intonation are left aside.
[2]   All the examples below but (4) and (6) are taken from (Hybertie 1996). In the English glosses, we prefer not to choose a translation of *alors*, so as not to blur the problem.
[3]   In (4), contrary to (2), *alors* could be replaced by *donc*.

left).

(6) Ce nombre est égal à 4. *Alors* il est pair. (Jayez 1988b, 158)
'This number is equal to 4. *Alors* it is even.'

and OTHER USES where *alors* is a kind of "structuration" marker:
with only a temporal link between the eventualities:

(7) Oui bonsoir j'habite en moselle, *alors* actuellement il existe une
loi sur le travail à mi-temps pour les femmes [...]
'Yes, good evening. I live in Moselle county, *alors* at present
there is a law concerning part time work for women [...]'

Le Draoulec and Bras (2007) analyze the uses of *alors* that Hybertie classifies as
"temporal uses". Restricting their analysis to uses of *alors* that involve only events,
they showed that the temporal link conveyed by *alors* is associated with a rhetori-
cal relation between constituents only when *alors* is in clause initial position, as in
example (2). This rhetorical relation expresses a dependency link that has been
described by Hybertie as follows: the event expressed by the first constituent is a
"condition for the realization" of the event described by the second constituent.
In these cases only, *alors* meets the requirements of a temporal connective in the
sense defined above.

When *alors* is in a clause internal or final position, its role is merely that of
a temporal anaphoric adverb conveying a temporal relation (with only possible
semantic effects of consequentiality when it is in internal position), as in example
(1).

Moreover, as far as the temporal relation between the events is concerned, the
temporal value itself depends on the sentential position: clause initial *alors* gives
rise to a relation of temporal succession between the events, as in (2); clause in-
ternal or final *alors* denotes a temporal relation of concomitance or coincidence
as in (1).

In this paper we consider the uses of *alors* when it is a *temporal connective*, leav-
ing aside its temporal adverbial uses (examples such as (1) are thus excluded). We
provide a formal analysis of the "temporal uses", and we extend the analysis to
the "consequential uses" in the classification of Hybertie above.

Some of these consequential cases – those linking eventualities – have a tem-
poral value that leads us to group them together with the temporal cases. In this
enlarged set of temporal uses of *alors*, we have developed a new classification on
the basis of the discursive link at issue: the link either provides a dependency link
like the one described by Hybertie, or a cause-consequence relation. *Alors* as a *tem-
poral connective* will be analysed in section 3, where we investigate which discourse
relations are able to account for the different types of dependency/causality as-
sociated with *alors*.

The restriction to clauses describing events is still in force in this analysis – states are left for future research. Thus, we will exclude examples such as (3). For the consequential cases listed above involving cognitive states such as (5) and (6), we will only sketch lines of analyses for cases where events are involved. These cases will form a new class and will be analysed in section 4 where we deal with *alors* as a "logical connective".

Finally, the "structuration marker" cases such as (7) won't be taken into account.

[2]   FRAMEWORK FOR FORMALIZATION: SDRT

[2.1]   *Overwiew of SDRT*

SDRT is a formal theory of the semantics-pragmatics interface. It is an extension of Kamp's Discourse Representation Theory (Kamp and Reyle 1993) that takes discourse relations into account. We will give a brief outline of SDRT here. The reader is invited to refer to (Asher and Lascarides 2003) for a thorough presentation. In SDRT, a discourse is represented by an *SDRS* (Segmented Discourse Representation Structure). It is a recursive structure consisting of labelled elementary DRSs (i.e., Discourse Representation Structures, as described by DRT) representing a single clause and labelled sub-SDRSs linked together by *Discourse Relations*, such as Narration, Elaboration, Background, Continuation, Result, Contrast, Explanation...

These elementary DRSs and the sub-SDRSs corresponding to complex discourse segments are the *constituents* of the SDRS representing the discourse. The elementary constituents describe *eventualities*, i.e. events or states.

Labels are discourse referents. They are used to distinguish different occurrences of constituents, since each occurrence of a constituent in a discourse structure will be affected differently, at least in principle, by the discourse context. The labels for the constituents are essential because a given proposition or semantic content may have many different uses in different discourse contexts[4]. To keep the whole theory within a first order setting, discourse relations take labels as arguments. In our formulation of the axioms for inferring and interpreting the various discourse relations linking constituents, we will use Greek letters (α, β, ...) as variables to represent labels, K_α to represent the constituent labelled with α, and e_α to represent the main eventuality (event or state) described by K_α.

To construct an SDRS for a discourse, we need to add considerably to the construction algorithm posited for DRSs. SDRT defines a "Glue Logic" and an "Update Function" that together determine a new SDRS for a given SDRS K_0 representing the context (the discourse already processed) and a new constituent K_α representing the information to be integrated into that context. The Glue Logic ex-

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[4]   A label can be seen as a kind of speech act discourse referent.

ploits the framework of "Commonsense Entailment" (Asher and Morreau 1991), a logic that exploits both monotonic ($\rightarrow$) and non-monotonic ($>$) conditionals. In Commonsense Entailment (CE), $\varphi > \psi$ means "if φ then normally ψ". From $\varphi > \psi$ and φ, CE entails ψ "by default", that is, defeasibly, in the absence of further information regarding the truth value of ψ[5].

Asher and Lascarides (2003) analyze the Glue Logic as a description logic that makes extensive use of underspecification. We will adopt the convention used in the Glue Logic of adding a third argument to two place predicates like discourse relation predicates: a formula of the form $R(\alpha, \beta, \lambda)$ is to be understood as a constraint on the third argument λ, which is the label of the smallest SDRS containing the formula linking the label α to the label β via the discourse relation R.

As far as the inferential tasks are concerned, the Glue Logic contains:

(i) definitions characterizing which constituents in the contextually given SDRS are open for attaching the current constituent β,

(ii) axioms detailing what discourse relations may be inferred, on the basis of a variety of linguistic and common knowledge clues, in order to actualize the attachment of β to some open constituent α of the contextually given SDRS.

SDRT also contains axioms specifying the semantic effects of the discourse relations, which can be considered as meaning postulates. We will give examples of such axioms in the next section.

The Update Function is in charge of integrating the discourse relations the Glue Logic infers and its choice of attachment sites within the contextually given SDRS representing the structure of the discourse processed so far. This integration may also involve the resolution of underspecifications (e.g., anaphora and ellipses).

SDRT distinguishes coordinating relations from subordinating ones. Explanation and Elaboration are examples of subordinating relations, while Narration is a coordinating relation. Subordinating and coordinating relations affect the Update Function differently. Only subordinating relations may introduce complex SDRSs, in other words, the Update Function may gather several SDRSs into a new complex SDRS only if these constituents are attached to the same site with the same subordinating relation. Asher and Vieu (2005) provide criteria within SDRT for coordinating and subordinating relations. They also postulate that some relations like Result, though in most cases a coordinating discourse relation, may in certain contexts be subordinating instead.

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[5] From $\varphi > \psi$, φ and $\neg\psi$, CE no longer entails ψ, but $\neg\psi$. From $\varphi > \psi$, $\zeta > \neg\psi$, $\varphi \rightarrow \zeta$, φ and ζ, ψ (and not $\neg\psi$) is inferred (Penguin principle). From $\varphi > \psi$, $\zeta > \neg\psi$, φ and ζ, if φ and ζ are logically independent, CE cannot conclude ψ nor $\neg\psi$ (Nixon Diamond).

In SDRT several discourse relations may simultaneously link the same two constituents, thus distinguishing SDRT from other discourse approaches, notably RST (Mann and Thompson 1988). SDRT also allows for multiple "superordinate" parents of a constituent, which means that SDRSs must be graphs and cannot be represented completely faithfully as trees.[6]

In the following, we only present the discourse relations needed to describe the discourse contribution of *temporal connectives* such as *puis* and *alors*: the SDRT relations Narration and Result.

[2.2]   *The Discourse Relation of Narration*

Narration is a relation which is based on the Gricean pragmatic maxim of manner "be orderly". When two clauses are linked by Narration, they describe in sequence two successive events "of the same story".

Narration can be non-monotonically inferred if the two clauses to be related contain clues indicating that their main eventualities are of types that may belong to 'the same story'. This "condition" on the types of the eventualities described by the clauses is formalized by the predicate *Occasion*, which serves as a triggering condition to the non-monotonical inference of Narration in the following axiom, where λ represents the smallest constituent that will end up containing the formula that links α and β once the SDRS for the discourse is constructed and fully specified:

> AXIOM NARRATION
> $(? \, (\alpha, \beta, \lambda) \wedge \text{Occasion}(\alpha, \beta)) > \text{Narration}(\alpha, \beta, \lambda)$

Occasion is a predicate of SDRT's Glue Logic whose semantics involves those linguistic elements available in the logical forms of the discourse constituents that are relevant to inferring Narration. It exploits lexical semantics and shared knowledge in terms of scripts connecting certain event types in sequences in which one event 'naturally' leads to the next, though it is not the cause thereof. For instance, (8) is an example of Narration where *Occasion* holds, since there is clearly in the shared knowledge a script in which, before entering, people knock at the door[7]. This kind of knowledge is represented by AXIOM OCCASION 1.

(8)   Paul frappa à la porte. Il entra.

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[6]   In effect, however, this added expressive power of the theory does not come at great computational cost: Baldridge et al. (2007) show that relational parsers for SDRS graphs have no greater complexity than ordinary tree parsers.

[7]   Cases where *Occasion* does not hold may be illustrated by an example such as

        (i)   Paul frappa à la porte. Il se mit à chanter.
                 'Paul knocked at the door. He began to sing.'

'Paul knocked at the door. He entered.'

AXIOM OCCASION 1
(? $(\alpha, \beta, \lambda) \wedge$ [frapper-à-la-porte$(e_\alpha, x) \wedge$ [entrer$(e_\beta, x)](\beta) >$ Occasion(α, β)

We now turn to another way of inferring Narration, with a monotonic inference this time. This is when a specific discourse marker is present. In (Bras et al. 2001), it was shown that *puis* is such a marker – which endows it with the status of *temporal connective* defined in section 1. Its role in SDRT is described by the following axiom:

AXIOM NARRATION PUIS[8]
(? $(\alpha, \beta, \lambda) \wedge$ [puis]$(\beta)) \rightarrow$ Narration (α, β, λ)

Last, Narration can be inferred between α and β from information relevant to subsequent constituents, one of which is linked to β. An example motivating this sort of rule occurs with a simple discourse like (9):

(9)   Nicholas a travaillé sur son papier, il a dîné avec Myriam et Anne, puis il est reparti pour Teilhet.
'Nicholas worked on the paper, had a meal with Myriam and Anne and then went home to Teilhet.'

The last two clauses are forcibly linked by Narration because of the discourse connective *puis*. But this discursive link leads us to interpret the link between the first and the second clause as one of Narration. It is this sort of situation that the following axiom on Subsequent Relations, is designed to address:

AXIOM SUBSEQUENT RELATIONS
$(?(\alpha, \beta, \lambda) \wedge R(\beta, \gamma, \lambda)') > R(\alpha, \beta, \lambda)$

where R is any discourse relation used in SDRT.

Let us now examine the two major semantics effects of Narration on discourse content. The first one aims at capturing the fact that narratives must cohere in the sense that the events linked by Narration must fit consistently and without significant spatio-temporal gaps as expressed in (Asher et al. 1995) and (Asher 1996) and observed in earlier work on temporal order in narratives (see for example Caenepeel 1989). This doesn't mean that there should be no interval of time between the two events e_α and e_β, but rather that no relevant event, i.e. no event interfering with e_α or e_β, can occur during this interval. This constraint is for-

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[8]   We remark that our axiom does not of course entail that every instance of Narration can be marked by *puis*. In our approach, there is not equivalence between the discourse relation and the presence of the connective.

malized in ([Bras et al. 2001](#)) by the following axiom rewritten in the notation of ([Asher and Lascarides 2003](#)):[9]

> AXIOM NARRATION TEMPORAL EFFECTS
> Narration $(\alpha, \beta) \Rightarrow e_\alpha \supset\subset (\text{post}(e_\alpha) \cap \text{pre}(e_\beta)) \supset\subset e_\beta$

This axiom expresses a meaning constraint on Narration. It uses not the language of Glue Logic itself but the base logic in which the semantics of SDRSs is given. This language is much richer than the Glue Logic and can appeal to notions that are used traditionally in semantics, including the relation of abutment ($\supset\subset$) used in DRT, which is equivalent to the "meets" relation as used in Allen's theory ([Allen 1984](#)), a function $\cap$ taking pairs of events into the maximum interval during which both events obtain; and the functions post-state and pre-state – the post-state of e_α, $post(e_\alpha)$, is a state that begins at the end of e_α and persists by default indefinitely into the future, while the pre-state of e_α is the state that terminates at the beginning of e_α and extends indefinitely far back into the past. The right hand side of the axiom expresses that e_α abuts $post(e_\alpha) \cap pre(e_\beta)$ which in turn abuts e_β. It entails in addition that there is no intervening event whose propositional content interferes with either that of $post(e_\alpha)$ or that of $pre(e_\beta)$, i.e., no event that ends $post(e_\alpha)$ before e_β starts or prevents $pre(e_\beta)$ from holding right after e_α has ended[10]. For illustrations, see ([Bras et al. 2001](#)), ([Borillo et al. 2004](#)).

Narration has a second semantic effect. It is motivated by the intuition that the elements of a Narration must belong to the "same story", i.e., they must have some common subject matter. To this effect, axiom AXIOM NARRATION TOPIC expresses that the constituents held together by Narration must have a common *Topic*. A topic is a simple constituent which is contingent (i.e., not vacuous, not contradictory, not tautological), and subsumes the constituents of a sub-SDRS, in this case, the constituents linked by Narration. If not already present in the context, it has to be added to the SDRS during the update. AXIOM NARRATION TOPIC and the rules of Glue Logic actually imply that Narration can be non-monotonically inferred only if such a topic exists or can be built.

> AXIOM NARRATION TOPIC
> Narration($\alpha, \beta \Rightarrow \neg\Box(K_\alpha \sqcap K_\beta)$

where $\sqcap$ is a merge operation defined in [Asher (1993)](#) for defining topics. The axiom states that the topic of α and β cannot be vacuous, which we formalize in

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[9]   We will forego the use $\varphi_{R(\alpha,\beta)}$ of ([Asher and Lascarides 2003](#)) and use $R(\alpha, \beta)$ instead for ease of reading.

[10] From AXIOM NARRATION TEMPORAL EFFECTS and uncontroversial ordering assumptions on events and their pre- and post-states *(Event(e) → pre(e) $\supset\subset$ e $\supset\subset$ post(e))*, we can deduce a relation of temporal precedence between the events e_α and e_β: $e_\alpha \prec e_\beta$, which was the original temporal effect of Narration in ([Lascarides and Asher 1993](#)).

SDRT as a necessary truth.

To illustrate these structural effects, let us consider the simple example (8) again. This small text clearly tells the story of Paul arriving at someone's home or office. Such a "topic" is inferred only because the two sentences are textually linked together and in this order.

[2.3] *The Discourse Relation of Result*

Result can be non-monotonically inferred on the basis of lexical semantics or of some shared knowledge on the types of eventualities in α and β as in (10):

(10) Tarzan poussa Jane. Elle tomba.
      'Tarzan pushed Jane. She fell.'

For this example, some information that generalizes on the event types of pushing and falling suggests to the reader a causal link that the narrator most likely wants to express. The presence of such clues indicating a possible causal link is expressed by the predicate *Cause$_D$* where *Cause$_D$(α, β)* means that α describes an eventuality which is a possible cause for β's main eventuality[11]. For instance, the following axiom encodes a plausible piece of shared knowledge:

> AXIOM CAUSE$_D$ 1
> (? $(\alpha, \beta, \lambda) \wedge$ [change_of_force$(e_\alpha, x, y)](\alpha) \wedge$ [change_of_position(e_β, y)]
> $(\beta)) \rightarrow$ Cause$_D(\alpha, \beta)$

SDRT relies on a lexicon to infer that *pousser*(e_α, x, y) is an instance of *change_of_force*(e_α, x, y) and that *tomber*(e_β, y) is an instance of *change_of_position*(e_β, y) in order to deduce that *Cause$_D$(α, β)* holds in this particular case. SDRT then allows us to deduce the discourse relation Result when one can infer the predicate *Cause$_D$* (we simplify the axiom of Asher and Lascarides (2003) as we will not consider different aspectual classes):

> AXIOM RESULT
> (? $(\alpha, \beta, \lambda) \wedge$ Cause$_D(\alpha, \beta)) >$ Result (α, β, λ)

A Result relation between constituents α and β represents the narrator's intention to signify that β is a result of α (or α results in β). It has the semantic effect of implying a causal link between the main eventualities of the constituents it relates, which we write using the formalism of Asher and Lascarides (2003) as follows:

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[11] The causal link expressed by *Cause$_D$* is neither entailing nor being entailed by *Occasion*. We remind the reader that *Occasion* and *Cause$_D$* are not Discourse Relations but predicates specifying information from a variety of knowledge sources leading to the inference of the Discourse Relation at stake: Narration or Result.

AXIOM RESULT SEMANTIC-EFFECTS
Result$(\alpha, \beta) \Rightarrow$ Cause(e_α, e_β)

The predicate *Cause*(e_α, e_β), to be read e_α causes e_β, implies, among other things, that if e_α and e_β are events, the first temporally precedes the second $e_\alpha \prec e_\beta$.

Asher and Lascarides (2003) don't give any explicit marker of Result, as we did above for Narration with *puis*. We mention that *puis*, together with the explicit marking of Narration, is a kind of "negative clue" for Result, as it blocks the inference of this relation (Bras et al. 2001)[12]:

AXIOM RESULT PUIS
(? $(\alpha, \beta, \lambda) \wedge [\text{puis}](\beta)) > \neg$ Result (α, β, λ)

It was also suggested in (Bras et al. 2001) that Result may be monotonically inferred on the basis of the presence in β of an explicit marker of causation, such as the conjunct *donc* (*therefore*):

(11)   Max a eu son bac. Donc il a pu entrer à l'université.
         'Max passed his A-levels. Therefore he could go to the university.'

But *donc* has other meanings, which do not express a "material" consequence, but rather a logical or argumentative consequence, which contradicts the temporal counterpart of *Cause,* as in:

(12)   Il a réussi à faire l'exercice, donc il a bien compris le cours.
         'He succeeded in solving the problem, therefore he understood the class well.'

As a matter of fact, in order to define an axiom such as AXIOM NARRATION PUIS, we need a detailed study of the lexical marker. Such an analysis for *alors* is spelled out in the next section.

[3]   *alors* AS A TEMPORAL CONNECTIVE

[3.1]   *Formalization in extant SDRT*

In this section we specify which extant discourse relations of SDRT are able to express the consequential value necessarily involved by *alors* when it plays the role of a temporal connective.

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[12]   For instance, the reading we get in an example such as

(i)   L'acide tomba dans le liquide. *Puis* une explosion se produisit.
         'The acid fell into the liquid. *Puis* an explosion happened.'

is one in which the author does not commit himself regarding a possible causal relationship between the events and tries to objectively tell the story of what happened during the chemical experiment.

Let us first examine example (4) repeated below:

(4)   Olivier a fait tomber la carafe. *Alors* elle s'est cassée.

According to the AXIOM RESULT given above, SDRT predicts a discourse relation of Result between the two constituents described by example (4): the information needed to infer *Cause$_D$* is readily available – *tomber*(x) is a permissible cause of *se casser*(x). Although SDRT does not specify sentence initial *alors* as a discourse marker of Result to draw this inference, sentence initial *alors* in this case would not block the inference but rather lead to the same conclusion. However, in real texts, it is difficult to find examples similar to (4), and in any case, (4) itself is not an example of perfectly idiomatic French. *Alors* doesn't appear to fit in contexts where the *Cause$_D$* predicate expresses an "objective" causal link, such as the one conveyed by (4). Actually, the kind of attested examples with *alors* where Result can be inferred thanks to *Cause$_D$* are cases where the causal link is more "subjective", as in (13) and (14) below[13]:

(13)   Mme Couze a dit d'abord qu'on ne te voyait plus jamais et que ces messieurs du restaurant devaient te regretter. *Alors* Mme Londe a répondu: Une de perdue, dix de retrouvées. (Julien Green, *Léviathan*).
        'Mme Couze first said that we never saw you any more and that the gentlemen at the restaurant must miss you. *Alors* Mme Londe responded: one lost, but ten found.'

(14)   Il fit ses comptes et s'aperçut qu'il avait tant donné de traites au porteur, qu'il ne lui restait plus que cinquante mille francs. *Alors* il se fit en lui une réaction étrange: lui qui venait d'abandonner cinq millions, il essaya de sauver les cinquante mille francs qui lui restaient. (Alexandre Dumas père, *Le Comte de Monte-Christo*)
        'He did the books and then noticed that he had given so much to the porter that he only had 50 000 francs left. *Alors* he had a strange reaction: he who had just lost five million now tried to save the 50 000 francs that he still had.'

Examples (13) and (14) are clear cases of the Response relation, along the lines of Sandström (1993, 63): "*Response* is the relation between an event e_1 and an action e_2 which it evokes in a sentient agent". In SDRT these cases are subsumed under Result because of their causal nature (Bras et al. 2001, 137). So here again, in the extant SDRT framework, Result can be inferred thanks to *Cause$_D$* without the help of *alors.*

In order to understand the role of *alors*, it is necessary to consider examples where *alors* is responsible for the causal link at stake, such as in (2), repeated

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[13]   All our attested examples are taken from the textual database Frantext: http://www.frantext.fr.

below, or the constructed example (15). Without the connective, (2') and (15')
lack any causal link of that sort and are rather marginal examples of Narration,
given a null context.

(2)   Je suis allée jusqu'à la place du village, *alors* je l'ai vu arriver.

(15)   Il m'a rejointe. *Alors* je me suis souvenue que j'avais oublié mes clés.
         'He joined me. *Alors* I remembered that I had forgotten my keys.'

(2')   Je suis allée jusqu'à la place du village, je l'ai vu arriver.

(15')   Il m'a rejointe. Je me suis souvenue que j'avais oublié mes clés.

In the examples (16)-(18) extracted from real texts, we find evidence of this causal
relation:

(16)   Elle ne vit pas le télégramme. Un peu plus tard elle ressortit avec un jeu de
         boules de pétanque en matière plastique contenu dans une espèce d'étui
         à claire-voie. *Alors* elle vit le télégramme, le ramassa et le lut et courut
         vers la plage. (Jean-Patrick Manchette, *Trois hommes à abattre*)
         'She didn't see the telegram. A little later she came out with a pair of
         plastic bacci balls contained in a sort of see through carrying case. *Alors*
         she saw the telegram, picked it up, read it, and ran towards the beach.'

(17)   Puis les allées commencèrent de monter assez raide et, bientôt, Joseph
         se trouva sur le plateau. *Alors* Joseph leva la tête, vit le ciel et poussa un
         long soupir. Jamais il ne songeait à regarder le ciel. (Georges Duhamel,
         Chronique des Pasquier)
         'At that point the streets started to climb pretty rapidly and soon Joseph
         found himself on top of the plateau. *Alors* Joseph raised his head, looked
         at the sky and let out a long sigh. Never did he think to look at the sky.'

(18)   Je l'ai emporté dans ma chambre. Avant de l'ouvrir, je me suis assise et
         je l'ai posé sur mes genoux. *Alors* je me suis souvenue que je l'avais eu il
         y avait très longtemps, et que, lorsque je l'avais regardé pour la première
         fois, je n'étais pas dans la maison de M. Drapeur. (André Dhôtel, *Le Pays
         où l'on n'arrive jamais*)
         'I brought it into my room. Before opening it, I sat down and placed it on
         my knees *Alors* I remembered that I had possessed it long long ago and
         that when I had gazed on it for the first time, I was not in the house of M.
         Drapeur.'

From a strict SDRT point of view, the requisite information needed to infer *Cause$_D$*
for (2) and (15)-(18) is lacking. For instance in (2), to infer Result we would have
to assume that an event of the type "going to the village square" is normally a
plausible possible cause of an event of the type "seeing someone arrive", which is

not the case. So, with the extant SDRT axioms, we cannot infer Result.

It also seems improbable that *Occasion*, the relevant predicate on eventuality types needed to infer Narration, holds between the two constituents in (2) and (15)-(18), because the types of events exemplified in this text do not specify a stereotypical sequence. So the appropriate axiom AXIOM NARRATION can not be used to infer Narration. As SDRT does not yet account for the role of *alors*, it would predict Narration thanks to the AXIOM SUBSEQUENT RELATIONS. However, this inference does not match our description of the role of *alors*: in these examples, as shown in section 1, *alors* triggers a discourse relation requiring that 'the event expressed by the first constituent is a "condition of realization" for the event described by the second constituent'. This relation differs from the extant, similar SDRT relations of Result and Narration.

[3.2]   *Formalization within an enriched set of discourse relations*
Asher and Lascarides (2003) don't give a complete definition of Result, but they take *Result(α, β)* to imply *Cause(e_α, e_β)*, which means that the main eventuality in α "is the cause of" the main eventuality in β. *Cause* is not to be confused with *Cause$_D$*, it is a predicate that holds between eventualities and not eventuality types as *Cause$_D$* does. Although *Cause* is not formally defined in (Asher 1993), nor in (Lascarides and Asher 1993) and (Asher and Lascarides 2003), we take it to correspond to a strong causal link between e_α and e_β, which we will presently define.

With this informal definition of *Cause* as a "is the cause of" relation, we can account for (4) and (13)-(14) correctly. For (2) and (15)-(18), a strict cause-consequence link is too strong: so we do not want to introduce an axiom stipulating that *alors* would imply Result (after the model of AXIOM NARRATION PUIS). *Alors* does not trigger an inference to the discourse relation Narration either. Rather, it expresses another kind of causal link, that we described above, following Hybertie, as a "condition of realization", which we feel to be somewhere between Narration and Result.

It thus seems necessary to introduce a new relation, that should have weaker causal implications (and for which *alors* would be a trigger). To capture this weaker causal link, we turn to Lewis (1973) who defines several causal relations. In particular, his "causal dependency" relation is close to what we need to express, except that we will restrict our causal links to actually occurring events. Following Lewis, we define the relation *Weakly_causally_depends_on*:

e$_\beta$ *Weakly_causally_depends_on* e$_\alpha$ if and only if
(i) if e$_\alpha$ had not occurred, e$_\beta$ wouldn't have occurred either, in all the worlds closest to α's world, and
(ii) (it is true that) e$_\alpha$ occurred and (it is true that) e$_\beta$ occurred.

We would like to add the requirement that e_α precedes e_β. Formally, we offer the

following definition in SDRT, where we appeal to Lewis' similarity relation that he uses to define counterfactuals and where the causal relation is expressed as holding between event types or facts:

> An event e_β associated with a description K_β (in a discourse constituent α) *Weakly_causally_depends_on* an event e_α associated with a description K_α (in a discourse constituent β) if and only if $(\neg K_\alpha \square \to \neg K_\beta) \land (K_\alpha \land K_\beta) \land e_\alpha \prec e_\beta)$, where A$\square \to$ B is true in a world w if and only if in every world closest to w where A is true, B is true too.

We emphasize that "in every world closest to w" means that the implication has to be considered "other things being equal", and hence defeasible. For instance, for (2), we cannot consider an event of "her climbing up on a wall". Of course that event could have been a cause for the event "her seeing him arrive", but this event occurs in a world that doesn't belong to the closest worlds to w.

Having defined the relation *Weakly_causally_depends_on*, we can formally define the stronger causal relation *Causally_depends_on*:

> e_β *Causally_depends_on* e_β if and only if e_β*Weakly_causally_depends_on* e_α, and $K_\alpha > K_\beta$

Causally_depends_on is stronger than *Weakly_causally_depends_on* in a strict sense, thanks to the formula $K_\alpha > K_\beta$[14].

Weak causal dependency and causal dependency can hold between events, but they can also hold between event descriptions or facts, elements described by constituents.

We have expressed the semantics for our two causal relations in the full SDRT language, *not* the description language in which the Glue Logic axioms for inferring discourse relations is stated. Thus, since we are speaking about the causal relations themselves and not about a description of the occurrence of this relation symbol in some SDRS, as we do in the Glue Logic, we have expressed our definitions using intuitive two place relations, rather than the description language three place formulas.

Our two causal relations permit us to make some distinctions at the discursive level. The first is that we introduce a new discourse relation, which we call *Weak-Result*. As is usual, we constrain the semantics of this relation via axioms about its semantics effects:

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[14] Our notion of causal dependency differs from that of (Lewis 1973) only in that we replace the counterfactual $(K_\alpha \square \to K_\beta)$ in his definition with a normality conditional and we insist that the relation hold between actually occurring events. This replacement is essential if we wish, as we do, to restrict our relations to actually occurring events, since in Lewis' logic of counterfactuals $(K_\alpha \land K_\beta)$ implies $(K_\alpha \square \to K_\beta)$. Thus using Lewis' definition in our case would reduce our relation of causal dependency to the relation of weak causal dependency.

AXIOM WEAK-RESULT SEMANTIC-EFFECTS
Weak-Result $(\alpha, \beta) \Rightarrow$ Weakly_causally_depends_on (K_α, K_β)

This formulation of Weak-Result encodes that it entails the *Weakly_causally_dep-ends_on* relation between the event descriptions in the constituents labelled with α and β. We use this relation to account for non purely logical cases where causes precede consequences (the logical cases will be analysed further).

Alors, as we have seen, is responsible for introducing a relation whose content is just that for Weak-Result. This means that we should introduce an axiom in the Glue Logic and its description language, expressing that *alors* is a trigger for Weak-Result:

AXIOM WEAK RESULT TRIGGERING
$(? (\alpha, \beta, \lambda) \wedge [\text{alors}](\beta)) \rightarrow$ Weak-Result (α, β, λ)

This holds only for clause initial *alors*, according to the description in section 1. When *alors* is not initial, it does not play a role at the discourse level but at the sentence level. Therefore its contribution will be taken into account with compositional semantic rules (i.e. within the constituent representation) and not with discourse rules such as AXIOM WEAK-RESULT.

Let us see how we can now account for our examples with the definition and axiom on Weak-Result given above. The relation of Weak-Result as defined is appropriate for linking the clauses in (15)-(18). For example, in (15) we have: "if he hadn't rejoined me, I wouldn't have remembered"; further, it is both true that "he rejoined me" and that "I remembered"; and finally, the event of his rejoining me precedes the event of my remembering.

On the other hand, Weak-Result is insufficient to describe the discourse link in (4) and (13)-(14): the causal link at stake is stronger than the weak causal dependency: it corresponds to the relation of causal dependency defined above. This leads us to the conclusion that Result is a scalar relation: along with Weak-Result, there is also a relation that we call *Strong-Result*, which can be defeasibly inferred from *Cause$_D$*, and which we define as reflecting the relation of causal dependency and the relation *Causally_depends_on.*

AXIOM STRONG-RESULT SEMANTIC-EFFECTS
Strong-Result $(\alpha, \beta) \Rightarrow$ Causally_depends_on (K_α, K_β)

AXIOM STRONG-RESULT TRIGGERING
$(? (\alpha, \beta, \lambda) \wedge \text{Cause}_D (\alpha, \beta)) >$ Strong-Result (α, β, λ)

For examples (4) and (13)-(14) both AXIOM WEAK-RESULT and AXIOM STRONG-RESULT will apply: both Weak-Result and Strong-Result will be inferred. For the same examples without *alors*, Strong-Result would be inferred too. However, unlike the

naturally occurring examples (13)-(14), (4), as we noted, is not very good, for reasons which remain to be explored. Our intuition is that the objective *versus* the subjective nature of the causality should be taken into account (some hints in this sense are also given by Hybertie 1996).

We note that our constraints are also compatible with what we have said about *puis*. *Puis* signals that we should normally not infer Result. AXIOM RESULT PUIS given above should be replaced by the two following axioms:

> AXIOM WEAK-RESULT PUIS
> (? $(\alpha, \beta, \lambda) \wedge [\text{puis}](\beta)) > \neg\text{Weak-Result}\,(\alpha, \beta, \lambda)$
>
> AXIOM STRONG-RESULT PUIS
> (? $(\alpha, \beta, \lambda) \wedge [\text{puis}](\beta)) > \neg\text{Strong-Result}\,(\alpha, \beta, \lambda)$

This will be consistent with the fact that events in the world be linked via causal dependency or weak causal dependency, as long as these relations cannot be inferred from the information present in the discourse and the context.

We finally examine cases when *alors* combines with *Occasion*, as in (19):

(19)   Pierre est tombé. *Alors* je l'ai aidé à se relever.
        'Peter fell. *Alors* I helped him up.'

In such a case, the extant axioms lead to infer Narration and Weak-Result. The conjunction of these two relations strengthens the discourse connection between the two constituents. (19) is a constructed example, but there are many examples in real texts with a similar interpretation:

(20)   L'empereur se tourna à demi, avec un léger hochement de tête, pour autoriser le ministre de l'intérieur à continuer. *Alors* Rougon entra dans des détails préliminaires. (Émile Zola, *Son Excellence Eugène Rougon*)
        'The emperor turned around halfway with a slight nod of the head, signalling to the interior minister to continue. *Alors* Rougon began to lay out the preliminary details.'

(21)   La grille l'attira. Il serra les barreaux rouillés très fort, comme un prisonnier. Il y appuya son front pour sentir le froid du métal. La porte s'ouvrit. *Alors*, il entra. (Robert Sabatier, *Les Noisettes sauvages*)
        'The ironwork attracted him. He clasped the rusted bars very strongly, like a prisoner. He put his forehead to the metal to feel its cold. The door opened. *Alors* he entered.'

The combination of *Occasion* and *alors* would always seem to yield a coherent discourse in SDRT's terms. That is, they suffice to infer a discourse relation between two constituents with this information. However, this is not the case. Let us for

instance compare (19) with (22):

(22)   ?Pierre est tombé. *Alors* il s'est relevé.
        '?Peter fell. *Alors* he stood up.'

Our intuition is that *alors* better combines with *Occasion* when there is a change of subject as in (19), which is similar, on that point, to (20) and (21). The contrast between (23) and (24) reinforces this hypothesis. Finally the contrast between (24) and (25) illustrates the fact that *puis* is particularly felicitous in the configuration of *Occasion* with a same subject (Bras et al. 2001, 128-129).

(23)   Ils se mirent à table. *Alors* Pierre souhaita bon appétit à tout le monde.
        'They sat down to table. *Alors* Pierre wished 'bon appetit' to everyone.'

(24)   ?Ils se mirent à table. *Alors* ils se souhaitèrent bon appétit.
        'They sat down to table. *Alors* they wished 'bon appetit' to everyone.'

(25)   Ils se mirent à table. *Puis* ils se souhaitèrent bon appétit.
        'They sat down to table. *Puis* they wished 'bon appetit' to everyone.'

We won't try to axiomatize here the prediction of the compatibility between *alors* and *Occasion,* as this would require a more fine-grained description of *Occasion,* taking the change of subject into account[15]. We leave this matter at this stage.

[4]   *alors* AS A LOGICAL CONNECTIVE

In the cases we have examined so far, *alors* is a *temporal connective*, in the sense defined in section 1. We also want to account for cases in which *alors* plays the role of a *logical consequence connective.* This logical role of *alors* is more frequent in discourses describing states, as in (5) and (6) repeated below:

(5)   Les volets sont fermés, *alors* ils sont partis.

(6)   Ce nombre est égal à 4. *Alors* il est pair.

As said above, in this paper, we restrict ourselves to events. But in fact we can also have events in discourses where *alors* expresses a logical consequence:

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[15]   Taking the change of subject into account would help make more precise the frontier between *Occasion* and *Cause$_D$*, as *Occasion* with a change of subject is often very close to *Cause$_D$*. If we take the example of *Occasion* mentioned in section 3, (8), we notice that adding *alors* does not yield a felicitous discourse:

   (8')   ?Pierre frappa à la porte. *Alors* il entra.

Now if we modify (8') by introducing a change of subject:

   (8")   Pierre frappa à la porte. *Alors* Marie lui ouvrit.

we have difficulties in classifying the event type predicate at stake between *Occasion* and *Cause$_D$*.

(26)   Toutes les filles sont arrivées à l'heure, *alors* Marie est arrivée à l'heure.
        'All the girls arrived on time, *alors* Marie arrived on time.'

In order to account for these cases, we introduce a discourse relation, Inferential result, expressing the logical link at stake:

> AXIOM INFERENTIAL-RESULT SEMANTIC-EFFECTS
> Inferential-Result $(\alpha, \beta) \Rightarrow (K_\alpha \wedge K_\beta \wedge (K_\alpha > K_\beta))$

Actually, in cases like (6) and (26) we have $\Box(K_\alpha \to K_\beta)$. $K_\alpha > K_\beta$ is meant for cases like (5). Insofar as $\Box(K_\alpha \to K_\beta)$ implies $K_\alpha > K_\beta$ both cases fit our definition. Further research will have to include the analysis of inferential result involving states and will probably lead to a refined formalization.

We see now that *alors* can trigger both Weak-Result and Inferential-Result. Since Inferential-Result is triggered relative to information that entails the information used to infer Weak-Result, we rewrite our AXIOM WEAK-RESULT, changing the monotonic axiom for a non-monotonic one:

> AXIOM WEAK-RESULT 2
> (? $(\alpha, \beta, \lambda) \wedge [\text{alors}](\beta)) >$ Weak-Result (α, β, λ)

This allows us to introduce a more specific axiom to trigger Inferential-Result.

> AXIOM INFERENTIAL-RESULT TRIGGERING
> (? $(\alpha, \beta, \lambda) \wedge [\text{alors}](\beta) \wedge \neg$ Weakly_causally_depends_on $(K_\alpha, K_\beta)) >$
> Inferential-Result (α, β, λ)

Let us illustrate the application of these axioms for (26). With AXIOM WEAK-RESULT 2 we infer *Weak-Result(π_1, π_2)*. But *Weak-Result(π_1, π_2)* does not hold because the temporal constraint $e_1 \prec e_2$ is wrong. The temporal relation is $e_2 \subseteq e_1$, as obtained by the following reasoning: the proper noun *Marie* in K_2 triggers the presupposition of existence of a girl named *Marie*. We can bind this presupposition if we can infer that this referent is part of the plural referent in the universe of K_1 thanks to the semantics of the quantifier *toutes les filles*. As we have the same event types for e_1 and e_2, and the subject referent of e_2 being a part of the subject referent of e_1, we infer that the event of Marie arriving on time (e_2) is part of the event of all the girls arriving on time (e_1). As the binding of a presupposition is preferred to accommodation in standard theories of presupposition (Van der Sandt 1992) as well as in SDRT (Asher and Lascarides 2003), we are forced to this treatment of the presupposition and to the inference concerning the temporal relation between e_1 and e_2. This means that Weak-Result cannot apply, and by AXIOM INFERENTIAL-

RESULT TRIGGERING[16], we conclude Inferential-Result.

[5] CONCLUSION

Our investigation concerning the discourse information conveyed by sentence initial *alors* has revealed at least three sorts of relations close to the informal gloss given by Asher (1993) and Asher and Lascarides (2003) for Result. We have seen that *alors* alone suggests a weak causal relation, which we have formalized using Lewis' counterfactual. We encoded this information in the discourse relation Weak-Result, which we distinguished from Strong-Result. Strong-Result is inferred when lexical or other contextual information triggers a causal, discursive link. Our definitions immediately imply that both Strong-Result and Weak-Result are veridical relations in the sense of Asher and Lascarides (2003). We also saw that *alors* can, when Weak-Result is blocked, suggest an inferential relation, which we expressed using the weak conditional $>$ already present in the SDRT formalism.

Our analysis of the discursive uses of *alors* in initial position with clauses that involve events paints a uniform but complex picture of this discourse connective. In future work we intend to extend this study to treat uses of *alors* that involve reference to states. Our proposal to analyse Result as a scalar relation should now be put to the test and refined through a systematic comparison of *alors* with other discourse connectives also related to causality such as *donc, du coup* or *de ce fait* (cf. Rossari and Jayez 1996, 2000).

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[16]   Inferential-Result differs from the SDRT relation called *Defeasible-Consequence*, used to express conditionals, which is not veridical. It would be interesting, as one of our reviewers suggests, to compare our treatment of Inferential-Result as triggered by *alors* with the relation triggered by *donc: donc* does not embed within conditionals, while *alors* does. While we have not yet studied the role of *alors* within conditionals, and we have not studied *donc* either, we can offer some suggestions as to how these connectives might differ. The semantics for *alors* that we have given, as well as the general architecture of SDRT, does not preclude the embedding of *alors* within a conditional; when this occurs, this means that two relations hold between the antecedent and the consequent of the conditional, the one specified by *alors* and the one specified by the conditional. There is, however, a clash between these two relations: the conditional does not imply a veridical relation between antecedent and consequent, whereas *alors* does. But notice that *alors* is naturally understood as occurring within the scope of the conditional; this means that we should interpret *alors* as contributing material to the consequent of the conditional, specifying, as it were, the relation between antecedent and consequent. Interpreted in this way, there is no clash; the consequent is to be interpreted on the assumption that the antecedent is true, and so the veridicality of the discourse relation contributed by *alors* is no longer problematic. None of this tells us why *donc* cannot be used within the scope of a conditional. One hypothesis worth exploring, however, is that *donc* introduces the *same* relation as the conditional, plus the constraint that its terms be true. This is, *donc* would have a similar analysis to *alors*, except that instead of allowing us to infer Weak-Result or Inferential-Result, it leads to the inference of a consequence relation, *exactly* the relation introduced by the conditional. Some preliminary evidence that this is so comes from the observation that the deduction theorem of classical logic seems to hold with *donc* : *A, donc B* seems to be equivalent to *Si A, B.* This does not seem to be the case with *alors*. If this analysis is on the right track, then we would have at least a pragmatic explanation for why *si A donc B* is not very good: *donc* at this point is redundant.

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