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To cite this version:

Nicholas Asher, Myriam Bras, Anne Le Draoulec. Causal relations in the semantics of the French adverb "alors". MICRAC workshop, Jun 2009, Toulouse, France. hal-00959694

HAL Id: hal-00959694

https://hal.science/hal-00959694v1

Submitted on 17 Mar 2014

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MICRAC Workshop
Toulouse June 8-10 2009

Causal relations in the semantics of the French adverb *alors*

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In this work, we investigate the causal relations possibly conveyed by the French adverb *alors* (*then, at that time, so*) in Natural Language texts. This work is part of a broader project to provide a systematic analysis of French temporal connectives within Asher's formal framework of *Segmented Discourse Representation Theory* (Asher 1993, Asher and Lascarides 2003). Among the linguistic markers that establish a temporal relation between the eventualities introduced by two clauses (henceforth *discourse constituents*) to be discourse linked, temporal connectives are distinguished by the fact that they introduce at the same time some sort of discourse relation. It was shown that *puis*, which induces a temporal connection between constituents, is just such a connective; its role in SDRT is to impose a relation of Narration and to block causal relations like Result (cf. Bras et. al. 2001, Borillo et. al 2004).

The adverb *alors* can also be such a temporal connective under specific conditions. On the base of linguistic analysis of *alors* (cf. *inter alia* Jayez 1981, 1988a&b; Franckel 1987; Gerecht 1987; Hybertie 1996; Reyle 1998), three major uses of *alors* in assertions can be distinguished: temporal uses (with or without a consequential value), merely consequential uses (close to *donc* 'therefore'), and other uses where *alors* is a kind of « structuration » marker.

Le Draoulec and Bras (2007) studied the temporal uses of *alors* when it relates two assertions describing events. They showed that the temporal value is necessarily associated with a consequential value only when *alors* is in clause initial position. 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). Moreover, the temporal value itself depends on the sentential position: clause initial *alors* gives rise to a relation of temporal succession between the events; clause internal or final *alors* denotes a temporal relation of concomitance or coincidence.

In this talk, as in (Bras et. al 2009), we focus on uses of *alors* in initial position, still restricting the study to clauses describing events. We investigate which discourse relation(s) is (are) able to express the consequential value necessarily involved by *alors*. In examples like (1), SDRT predicts a discourse relation of Result between the two constituents:

(1) *Olivier a fait tomber la carafe. Alors elle s'est cassée.*
Oliver dropped the carafe. *Alors*[1] it broke.

SDRT allows us to deduce the discourse relation Result when one can infer from lexical or domain information the predicate $cause_D$:

Axiom_Result $(?(\alpha, \beta, \lambda) \wedge \text{cause}_D(\alpha, \beta)) > \text{Result}(\alpha, \beta, \lambda)$

In (1), the information needed to infer $cause_D$ is readily available – *tomber*(x) is a permissible cause of *se casser*(x). Initial *alors* goes very well with this inference. However its role is not completely evident in this example, as we would have the same inference for (1) without *alors.*

The role of *alors* is clearer in examples like (2) or (3):

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

[1] In this example *alors* could be translated by *so* or *then*. We prefer not to choose a translation, so as not to blur the problem.

I walked up to the village square. *Alors* I saw him arrive.

(3) *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.

From a strict SDRT point of view, the requisite information needed to infer $cause_D$ for (2) or (3) is lacking. So 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. So the following axiom can not be used to infer Narration.

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

As SDRT does not yet account for the role of *alors*, would predict Narration by default.

Following Hybertie (1996), Le Draoulec and Bras (2007) show that in examples such as (2) and (3), *alors* triggers a discourse relation requiring that 'the event expressed by the first constituent is a necessary condition for the event described by the second constituent'. This relation differs from the extant, similar SDRT relations of Result and Narration.

Asher and Lascarides (2003) don't give a complete definition of Result but they take Result(α,β) to imply that the main eventuality in α is the cause of the main eventuality in β. 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_β *Weakly_causally_depends_on* e_α if and only if (i) if e_α had not occurred, e_β wouldn't have occurred either, in all the worlds closest to α's world, and (ii) (it is true that) e_α occurred and (it is true that) e_β 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's 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 $(\neg K_\alpha \mathrel{\Box\!\!\rightarrow} \neg K_\beta) \wedge (K_\alpha \wedge K_\beta) \wedge (e_\alpha < e_\beta)$, where $A \mathrel{\Box\!\!\rightarrow} B$ 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_α 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 $K_\alpha > K_\beta$[2].Weak causal dependency and causal dependency can hold between events, but they can also hold between event descriptions or facts, elements described by constituents.

[2]Our notion of causal dependency differs from that of Lewis (1973) only in that we replace the counterfactual $(K_\alpha \mathrel{\Box\!\!\rightarrow} K_\beta)$ 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's logic of counterfactuals $(K_\alpha \wedge K_\beta)$ implies $(K_\alpha \mathrel{\Box\!\!\rightarrow} K_\beta)$. Thus using Lewis' definition in our case would reduce our relation of causal dependency to the relation of weak causal dependency.

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:

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_depends_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[3]. *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.

The relation of Weak-Result as defined is appropriate for linking the clauses in (2) and (3). For example, in (3) 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 (1): 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 example (1) both Axiom_Weak-Result and Axiom_Strong-Result will apply: both Weak-Result and Strong-Result will be inferred. For the same example without *alors*, Strong-Result would be inferred too[4].

In the cases we have examined so far, *alors* is a *temporal connective*, in the sense defined above. 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 (4):

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

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

(5) *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 define a discourse relation, Inferential result, expressing the logical link at stake:

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[3] the logical cases will be analysed further

[4] However, unlike the naturally occurring examples we show in (Bras et al. 2009), (1) 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)).

Definition_ Inferential-Result Inferential-Result $(\alpha, \beta) \leftrightarrow (K_\alpha \wedge K_\beta \wedge (K_\alpha > K_\beta))$

Actually, in cases like (6) and (26) we have $\Box(K_\alpha \rightarrow K_\beta)$. $K_\alpha > K_\beta$ is meant for cases like (5). Insofar as $\Box(K_\alpha \rightarrow K_\beta)$ 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 $(?(\alpha, \beta, \lambda) \wedge [\text{alors}](\beta)) > \text{Weak-Result}(\alpha,\beta,\lambda)$

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

Axiom_Inferential-Result[5]

$$(?(\alpha, \beta, \lambda) \wedge [\text{alors}](\beta)) \wedge \neg\ \text{Weakly_causally_depends_on}\ (K_\alpha, K_\beta) > \text{Inferential-Result}(\alpha,\beta, \lambda)$$

Let us illustrate the application of these axioms for (5). 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 $e_1 < e_2$ 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**,** we conclude Inferential-Result.

As a conclusion, we may underline that 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's 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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[5] Inferential-Result differs from the SDRT relation called *Defeasible-Consequence*, used to express conditionals, which is not veridical.

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