

Event Coreference between Two Sentences*

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Abstract. Works on temporal relations between two eventualities e_1 and e_2 always suppose that $e_1 \neq e_2$. We will concentrate on cases where $e_1 = e_2$, i.e. on *event coreference*. Unlike *object coreference*, event coreference has rarely been studied in detail, except for (pro)nominal phrases referring to an event. We focus here on event coreference between two sentences. This study will put forward unusual linguistic phenomena, e.g. coreference between existentially quantified elements. These phenomena, which question well-established myths, have to be taken into account in text understanding and text generation. They will lead us to introduce and define new discourse relations which will be discussed in the framework of SDRT.

Keywords: coreference and anaphora, discourse relations, DRT and SDRT.

1. Introduction

Works on temporal relations between two eventualities e_1 and e_2 examine exclusively if one of the eventuality precedes, includes or overlaps the other one (Moens and Steedman, 1988; Asher, 1993; Pustejovsky, 1995). All these temporal relations suppose that $e_1 \neq e_2$. We will concentrate on cases where $e_1 = e_2$, i.e. on *event coreference*.

Unlike *object coreference*, coreference between events has hardly been studied in detail, except for a (pro)nominal phrase referring to an event, see among others (Webber, 1988; Asher, 1993). Nevertheless, there is a number of other cases of event coreference since the description of an event e can be of three types: it is either a (pro)nominal phrase, or a sentence or an abstraction which is not linguistically realized. This last case occurs when e is a sub-event of a complex event. The number of potential cases of event coreference between two successive descriptions D_1 and D_2 of the same event e is therefore $3^2 = 9$. This paper concentrates on event coreference for cases where D_1 and D_2 are both sentences (noted as S_i) as in (1) and (2)¹.

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¹ In (Danlos, 2000), event coreference when D_i is a sentence and D_j ($j \neq i$) is not syntactically realized is examined. More precisely, the case where D_j is the abstract description of the causing sub-event of the complex event described by a causative verb and S_i the sentence describing the cause is examined, see (i) and (ii).

(i) Fred cracked the carafe. He hit it against the sink.

(ii) Fred hit the carafe against the sink. He cracked it.

- (1) Fred took care of a tree. He pruned a cedar.
- (2) Fred pruned a cedar. Therefore, he took care of a tree.

We will assume that a sentence S_i refers to a single event e_i ². This means that we will study S_1 . S_2 . discourses such that S_1 and S_2 refer to the same single event e .

Studying event coreference requires the definition of two types of coreference relation according to the quantity of information conveyed:

Two successive descriptions D_1 and D_2 of the same entity x (event or object) are in a particularization relation noted as $D_2 = PART(D_1)$ iff D_2 conveys some new information about x when compared to the information known from D_1 .

Two successive descriptions D_1 and D_2 of the same entity x (event or object) are in a generalization relation noted as $D_2 = GEN(D_1)$ iff D_2 does not bring any new information about x .

Let us illustrate these two types of coreference with the well known case where x is an object. D_1 et D_2 are then (pro)nominal phrases. In (3a), the demonstrative NP *this New York girl* = $PART(an actress)$. In (3b), the pronoun *she* = $GEN(an actress)$ and in (3c) the definite or demonstrative NP *the / this artist* = $GEN(an actress)$ since *artist* is a hyperonym of *actress*.

- (3) a. Fred had a drink with an actress. This New York girl irritates Mary.
- b. Fred had a drink with an actress. She irritates Mary.
- c. Fred had a drink with an actress. The / This artist irritates Mary.

In the next sections, we will show that the event coreference relation is of type particularization in (1), of type generalization in (2). We will provide a linguistic study of these discourses and formalize the data in the framework of SDRT (Asher, 1993).

² This is a simplification, e.g. a sentence with a plural argument may refer to several events. For example, the first sentence in (i) below with the plural argument *two garments* refers in fact to two events which are described in the second and third sentence. In this paper, plural arguments will be discarded.

- (i) Fred damaged two garments. He stained a shirt on Monday. He tore a tie on Tuesday.

Notation: The symbol X_i^r with $i = 1$ or 2 denotes the predicate or an argument or modifier in S_i with the role r ; for an argument $r = \text{agent, patient, ...}$; for a modifier $r = \text{time, location, ...}$; for the predicate, r is irrelevant.

2. Particularizing and generalizing restatement discourses

2.1. PARTICULARIZING DISCOURSES

A particularization event coreference relation as defined above is to be found in “particularizing discourses” (henceforth PDs) such as (1) or (4).

(4) Fred damaged a garment. He stained a shirt.

In (4), the same event is described in both sentences, with more information in S_2 . S_2 particularizes S_1 since its predicate is a hyponym of the predicate in S_1 (*stain* < *damage*) and the (indefinite) object is a hyponym of the (indefinite) object in S_1 (*shirt* < *garment*), while its subject is a (pronominal) anaphor of the subject in S_1 ³.

The discourse in (4) (when understood as a complete discourse) can only be interpreted as a PD with a particularization event coreference relation. If two events were involved, it would be explicitly indicated either by a cue phrase or by two different adjuncts: in (5a), *next* implies that $e_1 < e_2$; in (5b), *also* implies that $e_1 \neq e_2$; in (5c), the two adjuncts *yesterday* and *today* imply that $e_1 < e_2$. We will say that discourses such as (5) include a “marker of non coreferentiality”.

(5) a. Fred damaged a garment. Next, he stained a shirt.

b. Fred damaged a garment. He also stained a shirt.

c. Fred damaged a garment yesterday. He stained a shirt today.

The particularization interpretation of (4) can be explicitly marked, as in (6) with the cue phrase *more precisely* (which can be called a “marker of coreferentiality”).

(6) Fred damaged a garment. More precisely, he stained a shirt.

³ The two sentences in (4) are in the same tense, which seems to be required for event coreference.

Note however that a third sentence pursuing (4) may alter the interpretation of the two first sentences. In (7) with *also* in S_3 , *also* is implicitly understood in S_2 , therefore S_1 and S_2 do not refer to the same event. In the rest of this paper, only discourses with two sentences considered as complete discourses will be studied.

(7) Fred damaged a garment. He stained a shirt. He also tore a tie.

The PD in (4) gives raise to an unusual phenomenon: the two indefinite NPs *a garment* and *a shirt* are coreferent. This is unusual since it is generally admitted (Kamp and Reyle, 1993; Corblin, 1995) that an indefinite NP has an existential reading (i.e. introduces a new discourse referent) and therefore that two indefinite NPs are not coreferent⁴. This is the case in (8) in which two garments are involved, whereas only one garment is involved in (4). We will see in Section 6 how to compute the coreference of two indefinite NPs in PDs such as (4).

(8) Fred stained a garment. Joe tore a shirt.

A discourse such as (4) in which at least one element in S_2 specifies a corresponding element in S_1 is called a “PD by specification”. Another type of PD is given in (9). In (9), the modifier *during dinner* in S_2 provides temporal information about e ; the other elements X_2^r in S_2 anaphorize or repeat the corresponding elements X_1^r in S_1 .

(9) Fred stained a shirt. He stained it during dinner.

A discourse such as (9) in which at least one element X_2^r in S_2 has no corresponding element X_1^r in S_1 is called a “PD by adjunction”. Specification and adjunction may be combined in a single PD. In (10), *a shirt* specifies *a garment* and the time adjunct in S_2 has no corresponding element in S_1 .

(10) Fred stained a garment. He stained a shirt during dinner.

At face value, one gets a PD based on lexical knowledge when each element X_2^r in S_2 is either a hyponym, an anaphor or a repetition of a

⁴ A few cases exist in which two indefinite NPs are coreferent, see (i) and (ii) taken from (Corblin, 1994).

(i) A man arrived. He was a New Yorker.

(ii) A man, a New Yorker, arrived.

However, the examples presented here with two coreferent indefinite NPs have not been described in the literature, as far as I know.

corresponding element X_1^r in S_1 or has no corresponding element X_1^r in S_1 .

More natural examples of PDs are observed when extralinguistic knowledge is at stake, (11). These PDs are based on an extension of hyperonymy, namely X *compliment* $Y > X$ *tell* Y *that* Y *is pretty* in (11a), and X *be sick* $> X$ *have the flu* in (11b). These extended hyperonymy relations rely on cultural or encyclopedic knowledge. However, as our study is not a lexical semantic study, we will stick to artificial examples of PDs based on pure (non debatable) lexical knowledge, avoiding thereby the noise that would be introduced by discussions on the notion of extended hyperonymy.

- (11) a. Fred complimented Sue. He told her that she is pretty.
 b. Fred is sick. He has the flu.

Our linguistic study is thus not corpus based. Nevertheless it is easy to find real examples of PDs, such as (12a) found in (Asher, 1993) page 1 or (12b) found in "The World according to Garp" (J. Irving) page 274 (the italics are in J. Irving's text).

- (12) a. (...) linguist and philosophers (...) developed a sophisticated understanding of events and states and the expressions that denote them. They developed a typology of such entities.
 b. (You untied the schnauzer and) he ran into the street without looking. No excuse me: he *rolled* into the street without looking.

To summarize, in text understanding, it has to be computed that there is only one garment and one event involved in (4)⁵. In text generation, it must be determined under which conditions a discourse such as (4) may be uttered and which linguistic forms should be produced (Roussarie, 2000). In order to help solving these questions, we will present a linguistic study which states under which conditions a PD occurs.

2.2. GENERALIZING RESTATEMENT DISCOURSES

A generalization event coreference relation as defined in Section 1 is to be found in "generalizing restatement discourses" (henceforth GDs) such as (13).

- (13) a. Fred stained a shirt. Therefore, he damaged a garment.

⁵ See also (Humphreys et al., 1997) for event coreference issues within an information extraction system.

- b. Fred murdered Sue. Therefore, he committed a crime.

While a PD stands mainly at the informational level, a GD stands mainly at the intentional level: the first sentence in (13a) or (13b) describes what the speaker wants the hearer to know about an event e , the second one consists in her restatement of e . By definition, a restatement cannot bring new information, but it can present an event in a new light, for example, if the speaker has the intention to forge links with other data, (14).

- (14) Fred murdered Sue. Therefore, he committed a crime for which he will be brought before the assizes.

(13a) is created from (4) by reversing the order of the sentences (and the anaphoric relations), and by introducing a cue phrase like *therefore*, with an epistemic value (Rossari and Jayez, 1996). S_2 generalizes S_1 because *damage* and *garment* are respectively hyperonyms of the corresponding elements in S_1 . In (13b), S_2 generalizes S_1 because the complex predicate *commit a crime* is a hyperonym of *murder*.

At face value, one gets a GD based on lexical knowledge when each element X_2^r in S_2 is a hyperonym, an anaphor or a repetition of a corresponding element X_1^r in S_1 .

As for PDs, more natural examples of GDs are observed when an extended notion of hyperonymy is at stake, (15). However, we will stick to GDs based on lexical knowledge.

- (15) a. Fred told Mary that she is pretty. Therefore, he complimented her.
 b. Fred has the flu. Therefore, he is sick.

2.3. S_1 . S_2 . DISCOURSES WITH AN EVENT COREFERENCE

In the rest of this paper, a discourse which does not involve an event coreference relation will be marked with the # sign, whether it sounds incoherent or it has an interpretation without event coreference.

In PDs and GDs, each element X_2^r in S_2 which has a corresponding element X_1^r in S_1 stands in a lexico-semantic relation (hyponymy, hyperonymy, anaphor, identity or synonymy⁶) with that corresponding

⁶ PD and GD examples which involve the synonymy relation will not be illustrated in this paper. The reader will check that our conclusions stay valid for those examples, even with converse pairs of synonyms (*receive* and *give*), (i) and (ii).

(i) Mary received a present from Fred. He gave her a necklace.

(ii) Fred gave Mary a necklace. Therefore, she received a present from him.

element. They are the only two kinds of S_1 . S_2 . discourses in which both sentences refer to the same event.

- First, if one (or more) element(s) in S_2 with a corresponding element in S_1 is not in a lexico-semantic relation with that corresponding element, the two sentences cannot refer to the same event: this is the case for (16a) with the two predicates *stain* and *tear*, for (16b) with the two objects *a shirt* and *a tie*, and for (16c) with the two time adjuncts *yesterday* and *today*.

- (16) a. # Fred stained a shirt. He tore it.
 b. # Fred stained a shirt. He stained a tie.
 c. # Fred kissed Sue yesterday. He kissed her today.

- Secondly, if each element in S_2 is in a lexico-semantic relation with a corresponding element in S_1 , but if one element is in the hyponymic relation whereas another one is in the hyperonymic relation, the two sentences cannot refer to the same event. In (17a) or (17b), in which the predicate in S_2 is a hyponym of the predicate in S_1 , *stain* < *damage*, while the (indefinite) object in S_2 is a hyperonym of the (indefinite) object in S_1 , *garment* > *shirt*, no event coreference is involved. However, we will see in Section 5.2 that some PDs include both hyperonyms and hyponyms in S_2 .

- (17) a. # Fred damaged a shirt. He stained a garment.
 b. # Fred damaged a shirt. Therefore, he stained a garment.

- Finally, the two sentences should not bring the same amount of information or the same view on the information conveyed. Repeating in S_2 the information conveyed in S_1 , as in (18a) or (18b), leads to an incoherent discourse. Therefore, two directions are available: either bringing new information, that is the role of PDs, or restating the information in more general terms so as to forge links with other data, that is the role of GDs.

- (18) a. # Fred stained a shirt. He stained it.
 b. # Fred stained a shirt. Therefore, he stained it.

2.4. HYPOTHESIS

From these observations, the following hypothesis can be put forward:

An event coreference relation is found in a S_1 . S_2 . discourse only if:

- either each element in S_2 is a hyponym, anaphor or repetition of a corresponding element in S_1 if any (a particularization relation is then involved),
- or if each element in S_2 (introduced by a cue phrase like therefore) is a hyperonym, anaphor or repetition of a corresponding element in S_1 (a generalization relation is then involved).

This hypothesis can be seen in terms of “implication”:

- In PDs, S_2 “implies” S_1 : informally, staining a shirt implies damaging a garment, so *Fred stained a shirt* implies *Fred damaged a garment* in (4).
- In GDs, S_1 “implies” S_2 : informally, in (13a) *Fred stained a shirt* implies *Fred damaged a garment*.

In the next section, we are going to provide, in the framework of DRT (Kamp and Reyle, 1993), a formal definition of this notion of “implication” between two DRSs. In Section 4, we will show that the conditions to observe a GD consisting of two sentences are based on an implication relation between the DRSs associated with the two sentences. On the other hand, we will see in Section 5 that the matter is more complex for PDs.

3. Implication between two DRSs

In logical terms, a hyponymy relation between nouns such as *cedar* < *tree* translates into:

$$\forall x \text{ cedar}(x) \Rightarrow \text{tree}(x)$$

Therefore, the following implication is valid:

$$\exists x \text{ cedar}(x) \Rightarrow \exists y \text{ tree}(y)$$

Similarly, a hyponymy relation between verbs such as *prune* < *take care (of)* leads to:

$$\forall u, v \exists e_1 \text{ prune}(e_1, u, v) \Rightarrow \exists e_2 \text{ take-care-of}(e_2, u, v)$$

And an (extended) hyponymy relation between adverbials such as *this morning* < *today* (*this morning* = *today in the morning*) leads to:

$$\forall e_1 \text{ this-morning}(e_1) \Rightarrow \text{today}(e_1)$$

We will also use the following implication which is always true:

$$\forall x P(x) \wedge Q(x) \Rightarrow P(x)$$

For example:

$$\exists e_1 \textit{prune}(e_1, f, x) \wedge \textit{lovingly}(e_1) \Rightarrow \exists e_1 \textit{prune}(e_1, f, x)$$

Finally, in order to deal with anaphora, we use implication schemes such as :

$$\exists x \textit{Fred}(x) \Rightarrow \exists y \textit{human}(y) \wedge \textit{male}(y)$$

From these logical implications, we can define an implication relation between two DRSs, noted as \Rightarrow , when the lexical predicates in the conditions are in hyponymy relations. Without going into formal details, this implication relation is illustrated in the following example in which k_1 corresponds to *Fred lovingly pruned a cedar this morning* and k'_1 to *He took care of a tree today*.

k_1	e_1, f, x $\textit{prune}(e_1, f, x)$ $\textit{cedar}(x)$ $\textit{lovingly}(e_1)$ $\textit{this-morning}(e_1)$ $e_1 < n$ $f = \textit{Fred}$	\Rightarrow	k'_1	e_2, y, z $\textit{take-care-of}(e_2, y, z)$ $\textit{tree}(z)$ $\textit{today}(e_2)$ $e_2 < n$ $\textit{human}(y)$ $\textit{male}(y)$ $y = ?$
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Note that such conditions as $y = ?$ in k'_1 are ignored. Of course, two DRSs that only differ in the names of their bound variables are considered as identical (this identity relation is noted as \cong).

4. Conditions for GDs

We are going to show that the conditions for a GD consisting of two sentences are the following:

\mathcal{C}_{GD} A discourse consisting of two sentences is a GD iff (i) S_2 includes possibly an epistemic cue phrase such as *therefore*⁷, and (ii) the DRSs k_1 and k_2 associated respectively with S_1 and S_2 are such that $k_1 \Rightarrow k'_1$ with $k'_1 \cong k_2$ (and $\neg k_1 \cong k_2$).

⁷ The presence of *therefore* is not mandatory: (i), taken from (Corblin, 1995), presents a generalization coreference relation between the first two clauses. Without *therefore*, the presence of a subordinate clause in S_2 is mandatory.

(i) Fred consulted Dr. Larsen. He consulted a doctor because he was feeling tired.

\mathcal{C}_{GD} is obviously respected in a basic example of GD, (2) repeated in (19).

(19) Fred pruned a cedar. Therefore, he took care of a tree.

The condition $\neg k_1 \cong k_2$ is necessary to rule out such examples as (18b) or (20), in which S_2 repeats the information conveyed in S_1 . For such a case, $k_1 \cong k_2$.

(20) # Fred pruned a cedar. Therefore, he pruned it.

In examples such as (17b) and (21), which are not GDs, \mathcal{C}_{GD} does not hold because the verb in S_2 is a hyponym of the verb in S_1 (*prune* < *take care (of)*).

(21) # Fred took care of a cedar. Therefore, he pruned a tree.

Consider now the adjunction of modifiers. In (19), it is possible to insert any adjunct in S_1 while maintaining the generalization interpretation. (22a) with *yesterday* in S_1 is a GD. k_1 , the DRS for the first sentence in (22a), includes the condition *yesterday*(e_1) without equivalent in k_2 . Therefore, \mathcal{C}_{GD} holds in (22a)⁸. Similarly, (22b) with an appreciative modifier in S_1 (*lovingly*) and no modifier in S_2 is also a GD for which \mathcal{C}_{GD} holds.

(22) a. Fred pruned a cedar yesterday. Therefore, he took care of a tree.

b. Fred lovingly pruned a cedar. Therefore, he took care of a tree.

It is possible to insert an adjunct in S_2 only if it generalizes an adjunct in S_1 . (23a) with *this morning* in S_1 and *today* in S_2 is a GD. As *this morning* can be viewed as a hyponym of *today*, \mathcal{C}_{GD} holds for (23a). On the other hand, (23b) with *yesterday* in S_2 and no time adjunct in S_1 is not a GD and \mathcal{C}_{GD} does not hold for (23b).

(23) a. Fred pruned a cedar this morning. Therefore he took care of a tree today.

b. # Fred pruned a cedar. Therefore he took care of a tree yesterday.

⁸ In k_2 , the condition $e_2 < n$ could be rewritten $PAST(e_2)$. It is then enough to consider *yesterday* as a hyponym of $PAST$ to see that \mathcal{C}_{GD} holds in (22a).

The reader will check that GDs based on extended hyponymy relations, (15), are such that \mathcal{C}_{GD} holds.

5. Conditions for PDs

We are first going to examine PDs with a corresponding GD, i.e. PDs such as a GD can be created by reversing the order of the sentences and the anaphoric relations (and by introducing a cue phrase such as *therefore*). The conditions to observe such PDs, namely \mathcal{C}_{PD} , are symmetrical to \mathcal{C}_{GD} and are therefore based on the notion of implications between the DRSs representing the two sentences. Next, we will examine PDs with no corresponding GD, for which no implication between the DRSs of the two sentences is involved.

5.1. PDS WITH A CORRESPONDING GD

The conditions to observe a PD with a corresponding GD are the following:

\mathcal{C}_{PD} *A discourse consisting of two sentences is a PD if (i) S_2 includes no marker of non coreferentiality (see Section 2.1) but includes possibly a marker of coreferentiality, and (ii) the DRSs k_1 and k_2 associated respectively with S_1 and S_2 are such that $k_2 \Rightarrow k'_2$ with $k'_2 \cong k_1$ (and $\neg k_1 \cong k_2$).*

The examples in (24) are all PDs with a corresponding GD, respectively (19), (22a), (22b) and (23a). \mathcal{C}_{PD} holds for these discourses as \mathcal{C}_{GD} holds for the corresponding GDs.

- (24) a. Fred took care of a tree. He pruned a cedar.
 b. Fred took care of a tree. He pruned a cedar yesterday.
 c. Fred took care of a tree. He lovingly pruned a cedar.
 d. Fred took care of a tree today. He pruned a cedar this morning.

5.2. PDS WITH NO CORRESPONDING GD

The first type of PD examples with no corresponding GD is illustrated in (25a): (25a) is a PD (the two sentences refer to the same event with more information in S_2) while the discourse obtained by reversing the order of the sentences and the anaphoric relations, namely (23b) repeated in (25b), is not a GD. \mathcal{C}_{PD} does not hold in (25a) in the same way as \mathcal{C}_{GD} does not hold in (25b).

- (25) a. Fred took care of a tree yesterday. He pruned a cedar.
 b. # Fred pruned a cedar. Therefore, he took care of a tree yesterday.

S_1 in (25a) includes a time adjunct (*yesterday*) which is not repeated in S_2 , although it is understood that the pruning event occurred yesterday and that it is the same event as the taking care event. This means that the second sentence of a PD has to bring new information but has not to repeat all the information conveyed in the first sentence. On the other hand, the second sentence of a GD cannot bring new information at all.

The second type of PD examples with no corresponding GD is illustrated in (26a): (26a) is a PD although the verb in S_2 is an **hyperonym** of the verb in S_1 . It has no corresponding GD - (26b) is not a GD - and C_{PD} does not hold. (26a) is paraphrased by (26c) with the anaphoric form *do it*.

- (26) a. Fred pruned a cedar. He took care of it today.
 b. # Fred took care of a cedar today. Therefore, he pruned it.
 c. Fred pruned a cedar. He did it today.

In (26a) or (26c), the new information in S_2 comes from the adverbial *today*, which cannot be omitted: discourses in (27) without such an adverbial are unacceptable.

- (27) a. # Fred pruned a cedar. He took care of it.
 b. # Fred pruned a cedar. He did it.

In (26a), the arguments in S_2 are anaphora of the corresponding arguments in S_1 . Consider the examples in (28) which are identical to (26a) except that one argument (the patient) is not an anaphor of the patient in S_1 : $\text{Arg}_2^{\text{patient}}$ is a repetition of $\text{Arg}_1^{\text{patient}}$ in (28a), a hyperonym of $\text{Arg}_1^{\text{patient}}$ in (28b), and a hyponym of $\text{Arg}_1^{\text{patient}}$ in (28c). These examples are not clearly understood with an event coreference relation, although this interpretation is not excluded (with a specific prosody, e.g. emphasis on *today* in (28a) and (28b), on *cedar* in (28c)), hence the ? sign in front of them. The coreferential interpretation can be enforced with the marker of coreferentiality *more precisely*, (28d).

- (28) a. ? Fred pruned a cedar. He took care of a cedar today.
 b. ? Fred pruned a cedar. He took care of a tree today.

- c. ? Fred pruned a tree. He took care of a cedar (today).
- d. Fred pruned a tree. More precisely, he took care of a cedar.

Given these PD examples with no corresponding GD, one could think that the condition for a PD is that each element X_2^r in S_2 has to be in a lexico-semantic relation with X_1^r in S_1 (if any), whatever this relation may be (hyperonymy as well as hyponymy, anaphora, identity or synonymy). Such a condition for a PD can be intuitively formulated in terms of “unification” of the two corresponding DRSs. For example, in (28c), the unification of the DRSs of the two sentences is possible and gives the DRS for *Fred pruned a cedar (today)* gathering the hyponyms of one or the other sentence. A unification condition supposes that the order of the sentences is not relevant as long as S_2 brings new information compared to the information conveyed from S_1 . And in fact, there exist examples of PDs in which the order of the sentences can be reversed: (29a) and (29b), which differ by the order of the sentences (and the anaphoric relations), are both quite natural PDs with *walk* < *go*. (29a) is a PD in which S_2 brings the information that Fred walked to the station and that this walk took one hour. (29b) is a PD in which S_2 brings the information that Fred’s walk lead him to the station⁹.

- (29) a. Fred went to the station. He walked for one hour.
- b. Fred walked for one hour. He went to the station.

Nevertheless, a “unification” based condition for PDs does not work: (17a) or (30a), in which Pred_2 is a hyponym of Pred_1 (*prune* < *take care of*), while $\text{Arg}_2^{\text{patient}}$ is a hyperonym of $\text{Arg}_1^{\text{patient}}$ (*tree* > *cedar*), is definitively not a PD: it cannot be understood as involving a single event (and a single tree). The insertion of a marker of coreferentiality does not help: (30b) with *more precisely* sounds incoherent. Yet, in (30a), the unification of the DRSs of the two sentences is possible and gives the DRS for *Fred pruned a cedar (today)*, as it is the case for (28c). The contrast between (28c) and (30a) should be explained.

- (30) a. # Fred took care of a cedar. He pruned a tree (today).
- b. # Fred took care of a cedar. More precisely, he pruned a tree.

⁹ In (29), the walking event and the going event are understood as coreferent although the former is atelic while the latter is telic. If the two sentences were unified in a single sentence, it would give *Fred walked to the station in one hour* which is telic with the adjunct *in one hour* (and not *for one hour*).

In conclusion, the condition \mathcal{C}_{PD} is limited to PDs with a corresponding GD. There exist other PDs with no corresponding GD for which \mathcal{C}_{PD} does not hold. In those PDs, S_2 may include a hyperonym of a corresponding element in S_1 . However, the presence of hyperonyms in S_2 is constrained. As a consequence, a unification based condition is too weak. It should at least be stated that an indefinite argument in S_2 cannot be a hyperonym of the corresponding argument in S_1 when Pred_2 is a hyponym of Pred_1 (so as to rule out (30)). In any case, it is clear that the conditions to observe PDs are based on linguistic knowledge. We note \mathcal{C}_{part} these conditions.

Before ending this section on PDs, a remark on the notion of “new information” coming from demonstratives NPs.

5.3. DEMONSTRATIVE NPs IN PDs

In all the examples we have presented so far, $\text{Arg}_2^{\text{patient}}$ (if any) was a pronominal anaphora of $\text{Arg}_1^{\text{patient}}$ or an indefinite NP (as in (31a)). We are now going to examine cases where $\text{Arg}_2^{\text{patient}}$ is a definite NP, (31b), or a demonstrative NP, (31c). The examples with a demonstrative NP are in French since a French demonstrative NP may translate into a definite NP in English, an issue which is out of the topic here. (31b) is an acceptable PD only in a context where a unique cedar exists. (31c) is an acceptable PD only in a deictic use of the demonstrative NP (the speaker points to a particular cedar). In a non deictic use, (31c) is not a PD and is incoherent. From now on, the deictic use of demonstrative NPs is put aside, only the anaphoric use is considered.

- (31) a. Fred pruned a tree. He pruned a cedar.
 b. Fred pruned a tree. He pruned the cedar.
 c. # Fred a élagué un arbre. Il a élagué ce cèdre.
 (Fred pruned a tree. He pruned this cedar.)

Discourses in (32), where $\text{Arg}_2^{\text{patient}}$ is a demonstrative NP, are all acceptable PDs in which the new information in S_2 comes from *hier* (*yesterday*).

- (32) a. Fred a élagué un cèdre. Il a élagué cet arbre hier.
 (Fred pruned a cedar. He pruned this tree yesterday.)
 b. Fred a élagué un cèdre. Il a élagué cet arbre, qui est très vieux, hier.
 (Fred pruned a tree. He pruned this tree, which is quite old, yesterday.)

- c. Fred a élagué un arbre. Il a élagué ce cèdre hier.
(Fred pruned a tree. He pruned this cedar yesterday.)

The coreference between the two patients is of type generalization in (32a) since *arbre* (*tree*) is a hyperonym of *cèdre* (*cedar*) (*cet arbre* = GEN (*un cèdre*)). On the other hand, it is of type particularization both in (32b) and (32c). In (32b), the explicative relative clause brings new information (*cet arbre, qui est très vieux*, = PART (*un cèdre*)). In (32c), the head noun of $\text{Arg}_2^{\text{patient}}$ being a hyponym of the head noun in $\text{Arg}_1^{\text{patient}}$ brings new information (*ce cèdre* = PART (*un arbre*))¹⁰. However, whatever the type of coreference between the two patients (generalization or particularization), the presence of *yesterday* is mandatory in all the examples of (32) (see the contrast between (32c) and (31c)). This amounts to saying that even when an anaphoric demonstrative NP brings new information on the entity it refers to, it does not bring new information on the event involved. This contrasts with indefinite NPs: in (31a), *a cedar* brings new information about the tree involved and this information is considered new in what concerns the pruning event. Similarly for definite NPs, (31b).

In summary, a distinction should be made between new information on an entity *x in itself* and new information on an entity *x* as being a participant in an eventuality.

6. Discourse Relations

It is likely that anybody working on discourse relations would lay down that the discourse relation between the two sentences of a PD is Elaboration. However, we are going to show that it is necessary to postulate the existence of a new discourse relation, called “Particularization”, which implies an event coreference relation. Beforehand, a terminology remark: “particularization” (abbreviated as PART) designates a type of coreference as defined in Section 1; “Particularization” designates a discourse relation between two sentences. These two notions are linked in SDRT (Asher, 1993) in the following way where π_i is the label for the DRS k_i representing the sentence S_i :

$$k_2 = \text{PART}(k_1) \Leftrightarrow \text{Particularization}(\pi_1, \pi_2)$$

¹⁰ (32c) requires an accommodation (Van Der Sandt, 1992): when S_2 is uttered, the hearer suddenly learns that the tree involved in S_1 is in fact a cedar. Therefore, this example is not very felicitous, and should be avoided in a text generation system (Roussarie, 2000). However, we will consider it as acceptable here.

Elaboration is defined in various ways (Hobbs, 1979; Mann and Thompson, 1988; Asher and Lascarides, 1995), but whatever its definition, this discourse relation does not imply an event coreference relation. Let us illustrate this point with a “classical” example of Elaboration, (33a) or its shorter version, (33b). The first sentence denotes an event e_1 which is “elaborated” in the next sentence(s) which bring(s) new information on **one** or **some** stages (sub-events) of e_1 . No event coreference is at stake: a trip by plane cannot be reduced to a takeoff and a landing and even less to a simple takeoff. There exists a number of stages in the trip which are described neither in (33a) nor in (33b).

- (33) a. Nicholas flew from Austin to Paris. He took off at 6 am. He landed at 2 pm.
- b. Nicholas flew from Austin to Paris. He took off at 6 am.

Yet it is necessary to postulate the existence of a discourse relation (Particularization) which implies an event coreference relation. In the framework of SDRT, the infeasible consequence of Particularization is written in the following way:

$$\text{Particularization}(\pi_1, \pi_2) \rightarrow \text{Main-event}(\pi_1) = \text{Main-event}(\pi_2)$$

Only such a discourse relation allows us to preserve well established insights on discourse referents. The argumentation is the following: examples such as (1) or (4) are productive counter-examples to the principle of the existential reading of an indefinite NP (which entails that two indefinite NPs are not coreferent). Hence, two solutions towards this principle are available:

- Given these productive counter-examples, this principle is abandoned and an anaphoric reading of indefinite NPs is proposed to allow the coreference of two indefinite NPs. This solution does not seem appropriate since this principle is nearly always true except in PDs (and in GDs and in some well known exceptions given in note 4).
- This principle is not abandoned. The two indefinite NPs in (1) are given an existential reading: two discourse referents x and y with the complete conditions $\text{tree}(x)$ and $\text{cedar}(y)$ are introduced. The coreference relation $x = y$ is established thanks to the discourse relation Particularization. This discourse relation implies an event coreference relation which implies in turn that the arguments with the same role are coreferent. In other words, it is because Particularization is established between the two sentences of (1) that it is

known that the two sentences refer to the same event and therefore that the two patients *a tree* and *a cedar* are coreferent, i.e. $x = y$.

This last solution seems better. It raises the following question: how can it be established that the discourse relation in (1) is Particularization (which amounts to establishing that (1) is a PD)? The answer to this question lies in linguistic knowledge: the two sentences in a PD follow some strong linguistic constraints which have been described in Section 5. This set of constraints, noted as \mathcal{C}_{part} , allows the computation of the discourse relation Particularization. In SDRT, the rule is the following (where $>$ is the symbol for the default implication):

$$(\tau, \pi_1, \pi_2) \wedge \mathcal{C}_{part} > \text{Particularization}(\pi_1, \pi_2)$$

To sum up, it is necessary to postulate the existence of a new discourse relation, Particularization, which implies an event coreference relation between the event e_1 described in the first sentence and the event described in the second sentence. This discourse relation differs from Elaboration for which only one or some stages (sub-events) of e_1 are specified. Nevertheless, Particularization can be seen as a particular case of Elaboration. Along the same lines, it seems necessary for GDs to postulate the existence of a new discourse relation, Generalization, which implies an event coreference relation and which can be seen as a particular case of Restatement.

Conclusion

Unlike object coreference, event coreference is an issue which has not been really examined (except for (pro)nominal phrases anaphorizing sentences). However, event coreference is a central notion for several types of discourses. This paper focusses on particularizing and generalizing discourses. In (Danlos, 2000; Danlos and Gaiffe, 2000), we have shown that the particularization event coreference relation is involved in some causal discourses analyzed with the discourse relation “Explanation”, while generalization is involved in some causal discourses with “Result”. Therefore, event coreference is a cohesion issue (coreference), see (Halliday and Hasan, 1976), which turns out to be crucial for a coherence issue (establishment of discourse relations).

We have shown that event coreference in PDs requires a new discourse relation, Particularization, more specific than Elaboration which is usually used to analyze discourses such as (1). Particularization (and its dual relation Generalization) is established on the basis of strong linguistic constraints (lexico-semantic constraints on the elements with

the same role). It allows the establishment of an event coreference relation although the events denoted by the sentences are existentially quantified. This event coreference relation implies the coreference of participants with the same thematic role, even if they are existentially quantified.

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