# Signalling Elaboration: Combining Gerund Clauses with Lexical Cues

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# Signalling Elaboration: Combining Gerund Clauses with Lexical Cues

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**Abstract.** In this paper, we aim at automatically identifying *Elaboration*. This relation is particularly difficult to spot since it does not have prototypical markers. Our approach focuses on an ambiguous syntactic pattern, the gerund clause, combined with lexical cues. This approach allows us to detect few but accurate cases of inner sentence Elaborations in our corpus, validating the fact that lexical cues are relevant for this task.

**Keywords.** Elaboration, lexical cues, distributional neighbourhood, SDRT, discourse analysis

## 1 Introduction

Description and detection of discourse structure is a major topic of ongoing research (Moore & Wiemer-Hastings, 2003; Péry-Woodley & Scott, 2006). Many formal and functional approaches attempt to model discourse through relations between segments (typically clauses) (Asher & Lascarides, 2003; Grosz & Sidner, 1986; Hobbs, 1990; Mann & Thompson, 1987; Wolf & Gibson, 2006). Anaphora resolution, temporal order of events identification and others empirical problems require knowledge of discourse structure (Grosz & Sidner, 1986; Lascarides & Asher, 1993; Hobbs, 1990). Applied approaches (Baldridge & Lascarides, 2005; Lin *et al.* , 2009; Subba & Di Eugenio, 2009) aim to handle and detect elements of this structure studied by formal and functional approaches in order to develop applications like automatic generation (McKeown, 1985) and automatic summarization (Marcu, 2000), among other natural language processing tasks.

In this paper, we focus on the *Elaboration* relation and on its automated identification, using SDRT's theoretical framework. The *Elaboration* relation is particularly difficult to spot, since it does not have a prototypical lexical marker according to Knott (1996). According to SDRT, the *Elaboration* relation can be lexically marked, but this hypothesis has not yet been tested on the basis of corpus data. We investigate this claim using lexical cues to identify *Elaboration*. This investigation is carried out in the framework of the VOILADIS project[1], which aims to demonstrate the importance of lexical cues for discourse analysis. More specifically, we discuss the lexical resource that we employ to highlight these lexical cues. A practical experiment of inner sentence *Elaboration* detection is presented, combining a lexical resource based on the

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computation of distributional similarity on the one hand, and a weak marker of the *Elaboration* relation, the gerund clause, on the other hand.

Our first aim is to contribute towards the automated identification of the *Elaboration* relation. Our second aim, which follows from the first, is to improve the description and formalisation of this rarely studied relation, in order to expand studies on discourse signalling. We offer two contributions towards this goal: first, we extend the study of the devices that are used to mark this relation by showing that it is lexically signalled. Second, we collect examples that could be used to evaluate the adequacy of theoretical frameworks to real-world data.

# 2   On the *Elaboration* relation

## 2.1   *Elaboration* within the framework of SDRT

Segmented Discourse Representation Theory (Asher 1993, Asher and Lascarides 2003) is a formal theory of discourse. SDRT is an explanatory model making use of semantic information, world knowledge and pragmatic principles in order to explicit the rhetorical link between clauses. Discourse relations are described in two steps: first, they are associated with *triggering rules* to infer them and second, discourse relations entail *semantic effects*. SDRT claims that while discourse structure must be sensitive to non-linguistic information like world knowledge, it is conceptually and computationally more efficient to take into account linguistic knowledge to which we have direct access. *Triggering rules* to infer relations use both linguistic cues like discourse markers, syntactic constructions, verb tense, aspect and mood, argument structure, logical operator, quantifiers ; informations about lexical semantics ; and non-linguistic information about word knowledge and pragmatic principles.

The relation of *Elaboration* relates two propositions only if the second proposition provides more detail about the eventuality (state or event) described in the first. In the SDRT framework, the *triggering rule* to infer *Elaboration* is based on information about lexical semantics and world knowledge. More specifically, *Elaboration* can be non-monotonically inferred if there is a subsumption relation between the types of the eventualities involved. The Subtype predicate ($Subtype_D$) means that the type of the second eventuality is a subtype of the first one in the lexical semantics of the predicates or by some piece of shared knowledge dependent on the given discourse (D). For instance, *Elaboration* is inferred between constituant $\pi_a$ and $\pi_b$ (representing respectively segments (a) and (b)) in the following example :

(1)     (a) Martha ate a lovely meal. (b) She devoured lots of salmon. (Asher & Lascarides, 2003, p.282)

We can non-monotonically infer that the type of the second event "devour lots of salmon" is a subtype of the first one "eat a lovely meal" thanks to lexical semantics.

*Non-monotonically* means that this inference can be cancelled if other monotonic inferences are established like in the following example :

(2)     (a) Martha ate a lovely meal. (b) And then she devoured lots of salmon.

The discourse markers "And then" monotonically indicates that $\pi_b$ (representing (b)) is attached to $\pi_a$ (representing (a)) by *Narration*.

In the framework of SDRT, the lexicon is an important (but not exclusive) information source for inferring $Subtype_D$ predicate. The lexicon includes information about the semantic type of objects that are denoted by common nouns, verbs and so on. A subtype is related to a supertype by some notion of substituability: the subtype inherits many supertype characteristics and has some specific differences ; the subtype can be substituted by the supertype but the reverse is not necessarily true. The concept of subtype is closely related to the linguistic notion of hyperonymy.

In the example (1), sentences (a) and (b) include words that are semantically linked. First, the type of the event described in $e_b$ "devour" is a subtype of the type of the event described in $e_a$ "eat". Second, the word $meal$ must be lexically specified to be of type $food$ and $salmon$ is also of type $food$ but this lexical information is not directly coded in the type hierarchy. More lexical information are needed like, for instance, that the property of the event "meal" is to eat it ; that all words of type "food" have this property ; and that "salmon" is food derived from the animal salmon.

This information at the lexical level between predicates ("eat" and "devour") and arguments ("meal" and "salmon") sharing a same $\theta-role$ (here patient) allow us to infer $Subtype_D$ between the constituents $\pi_a$ and $\pi_b$ (build from $a$ and $b$) at the discourse level.

## 2.2   Signalling of *Elaboration*

(Scott & de Souza, 1990; Knott, 1996; Knott *et al.* , 2001) observed that *Elaboration* is a relation for which there are no obvious surface signals, so that automatic identification using prototypical discourse markers is impractical. It is therefore necessary to find different ways (other than traditional markers) to automatically detect this relation. Marcu (2000) uses algorithms based on discourse markers and word co-occurences, and finds that discourse markers "specifically" signal *Elaboration*. However, that marker is not frequent and covers few cases of *Elaboration*. Marcu (2000) also reports on a non-linguistic marker, based on the number of sentences in a paragraph or the number of paragraphs in a section : If this number is small and no discourse markers are used, the relation between the sentences or paragraphs is generally *Elaboration*. *Elaboration* is particularly difficult to spot also because discourse markers are generally ambiguous, as shown by Bras2007 for the french adverbial "d'abord" *(first)* that requires subordination with a constituent above him in the discourse structure via *Elaboration Explanation Result* or *Flashback* relation. In this paper, we investigate the use of lexical cues to detect *Elaboration*, as suggested by the SDRT model. However, this development is not straightforward; the next section discusses difficulties inherent to the subtype predicate and the requirements for the resource used in this task.

# 3   Using lexical cues for identification of *Elaboration*

## 3.1   From $Subtype$ to lexical similarity

At first glance, it may seem that a resource providing information about hypernymy could be the right resource in order to detect automatically *Elaboration*. However *Elaboration* exhibits a wider range of lexical relations. The *Elaboration* relation, at the discourse level, is based on relations at the lexical level; however, those relations are diverse and not restricted to the lexical subtype relation. Since these relations emerge in discourse, the lexical phenomena involved can be different from these found in classical resources. Such relations can be established by

discourse, and may be tightly related to a specific enunciation (Mortureux, 1993). We illustrate this issue in the following examples.

(3)     [Un véhicule a effectué une spectaculaire sortie de route, hier vers 18 h 15, sur l'A36.]1
        [La voiture circulait dans le sens Mulhouse-Montbéliard]2 [lorsqu'après être passée à
        hauteur du 35e RI,]3 [elle a quitté la chaussée sur sa droite.]4
        *[A vehicle left the road in a spectacular fashion yesterday around 6.15 on the A 36.]1*
        *The car vas travelling from Mulhouse to Montbéliard]2 [when after reaching the 35th*
        *RI,]3 [it left the road on the right-hand side.]4*

In example (3), three lexical links allow us to infer $Subtype_D(\pi_1, \pi_4)$ : "véhicule" (*vehicle*)/"voiture" (*car*), "sortie" (*exit*)/"quitter" (*leave*) and "route" (*road*)/"chaussée" (*roadway*). While the first link, "véhicule" (*vehicle*)/"voiture" (*car*), is clearly classified as hyperonymy, the "route" (*road*)/"chaussée" (*roadway*) link is in fact meronymy, and the "sortie" (*exit*)/"quitter" (*leave*) link is more subtle to categorize, since cross-category relations are generally not listed in typologies.

(4)     (...) [qui rappelle la vocation des bénévoles de l'association :]32 [être un soutien pour
        la paroisse,]33 [apporter une petite contribution financière aux travaux grâce aux man-
        ifestations et aux dons,]34 [accomplir de multiples tâches et démarches touchant aux
        bâtiment paroissiaux,]35 [contribuer à la convivialité entre les paroissiens.]36
        *[...which calls to mind the role of the Association's volonteers]32 [in being a support*
        *to the parish,]33 [in contributing a small amount financially to works through activities*
        *and donations,]34 [in completing many tasks and procedures dealing with the parish*
        *buildings]35 [and in contributing to parishioners' conviviality.]36*

Here, events in segments 33 to 36 are subtypes of "vocation des bénévoles de l'association" (role of the Association's volunteers). At the word level, $Subtype_D(\pi_[32], [\pi[33] - \pi_[36]])$ rests on links between "vocation" (*vocation*) and words such as "soutien" (*support*), "accomplir" (*to complete*), "tâche" (*task*) or "contribuer" (*to contribute*). These links are established in discourse, and will most probably not appear in a generic resource, since they do not match a classical lexical relations. Such links are more accurately referred to as lexical similarity relations.

## 3.2   Selecting the appropriate lexical resource: distributional neighbours

We have seen that the *Elaboration* relation seems indeed lexically marked, but that the links involved are softer than subtype. In order to automatically detect this relation, the resource chosen is crucial: it should contain these links for their automated usage. As stressed in the previous section, a generic resource seems poorly fitted to this task. We have focused on a resource built from corpora, taking into account semantic proximity links, possibly across parts of speech. In particular, we have chosen the *Voisins de Wikipédia* database, a resource built by distributional analysis. The principle of distributional analysis is to pair words based on their shared contexts, following Harris (1968) hypothesis. The paired words share second-order affinities: they do not need to appear together in the corpus, but their environments are similar (Grefenstette, 1994). The lexical relations put in evidence are then paradigmatic.

The *Voisins de Wikipédia* database was build from a full archive of the online encyclopedia

Wikipedia, which contains more than 194 millions words. The archive was processed through the Syntex-Upéry chain developed by Bourigault (2002). First, a syntax analysis is performed. Then, all <governor, relation, dependant> triplets are listed, an example triplet is: <circuler, à bord de, voiture> (<*travel, in, car*>). The triplets are then transformed in <predicate, argument> couples, where the predicate is a combination of two components: the governor and the relation, in the previous example <circuler_à bord de, voiture> (<*travel_in, car*>). The similarity between distributions is computed for each predicate couple and each argument couple using Lin's score: Predicates are paired based on their shared arguments; reciprocally, the same pairing is performed on arguments, based on their shared predicates. Thus, arguments "véhicule" (*vehicle*) and "voiture" (*car*) are paired through predicates such as "circuler_à bord de" (*travel_in*), "capot_de" (*hood_of*), "conduire_obj" (*to drive_obj*) , etc.

The obtained resource contains 4 million pairs, covering a large panel of relations. An example of neighbourhood links projected on the text sample (3) is provided below. Only links between two sentences appear.



Here, aforementioned links relevant for identifying the *Elaboration* relation are observed: "véhicule" (*vehicle*) / "voiture" (*car*), "sortie" (*exit*) / "quitter" (*leave*), and "route" (*road*) / "chaussée" (*roadway*). Other links participating in global lexical cohesions are observed, but these links are not involved in the *Elaboration*. Finally, many links are not relevant in this context, for example "route" (*road*) and "traverser" (*to cross*).

The plethoric nature of this resource is a strong barrier against its broad usage. Even though relations relevant to our task are put in evidence by projecting neighbours in the text, many other irrelevant neighbourhood links will interfere, making a direct inference to the discourse level impossible. It is therefore necessary to define more restrictive markers, by taking into account more elaborate criteria than the simple presence of neighbourhood links. We choose to experiment on detection based on targeted neighbourhood links combined with the presence of a weak elaboration marker: gerund clauses.

## 3.3   Combining the neighbours with a weak cue: the gerund clause

Since the information provided by the neighbours is too plethoric we propose to combine it with an ambiguous cue of *Elaboration*. Such a combination should be more reliable than each cue considered separately since the conjunction of two ambiguous cues builds a stronger cue. Gerund clauses are the perfect candidate for this combination: some gerund clauses could be considered as elaborations of the main clause and they are easy to extract with SYNTEX.

The gerund clause establishes a syntactic subordination between two verbs: two processes are linked in this way. The different semantic values expressed by the gerund clause are not conveyed by the gerund itself but depend on the combination of the two linked verbs. The interpretation is done *a posteriori* and determined by the semantic relationship between the verbs and other elements given by the context (Halmoy, 1982).

Our analysis reveals that gerund clauses in French can be linked to the main clause with two main discourse relations. For (5) and (6), we infer an *Elaboration* relation:

(5)     Les Britanniques réagissent en emprisonnant ou en tuant les derniers chefs.
        *The British react by imprisoning or killing the last leaders.*

In (5), the main clause introduces an underspecified event "réagir" *to react* and the two gerund clauses introduce two events that specify it "emprisonner" *to imprison* and "tuer les derniers chefs" *to kill the last leaders*.

(6)     Puis on irrigua les alentours en creusant un canal derivé du Zab Supérieur.
        *Then, the surrounding areas were irrigated by digging a canal leading from the River Zab Supérieur.*

In (6), the main clause introduces the event "irriguer" (*to irrigate*) and the gerund clause introduces the event "creuser" (*to dig*). "Irriguer" and "creuser" are semantically linked. The activity denoted by the type of event "irriguer" can involve the activity denoted by the type of event "creuser". So, we can infer $Subtype_D$ between the type of events "irriguer" and "creuser".

However, gerund clauses are not always elaborations of the main clause like in the following example:

(7)     Dans la ville de Koriko, Kiki, accompagnée de son chat noir Jiji, va distribuer des colis en volant sur son balai, grâce à ses pouvoirs.
        *In Koriko town, Kiki, with her black cat Jiji, delivers parcels while flying on her broom, thanks to her magical power.*

In (7), the gerund clause gives background of the main clause. The *Background* relation are typically used for setting the stage of an event. In (7), the main clause introduces the event "distribuer des colis" (*to deliver parcels*) and the gerund clause gives background information "voler sur son balai" (*to fly on her broom*).

Our main idea is that verbs and objects in the main clause and the gerund clause will generally be neighbours in *Elaboration* cases and not in *Background* cases. Considering our examples (6) and (7), it seems to us that "irriguer" (*to irrigate*) and "creuser" (*to dig*) could be found as neighbours but not "distribuer" (*to deliver*) and "voler" (*to fly*).

With this hypothesis in mind, we set up the experimentation presented in the next section.

## 4   Experimental validation

### 4.1   Motivations and strategy

The goal of the presented experiment is to reliably identify *Elaborations*: we aim for the highest precision. This task is challenging: it is sparsely attempted in the literature and the attained reliability is low. Nevertheless, such attempts are required for a better understanding of the *Elaboration* relation.

While this task is interesting in itself, our experiment will also illustrate the improvement

brought by taking into account lexical phenomena for discourse analysis, and show the relevance of lexical neighbourhood for detecting these phenomena. If using lexical neighbours brings a significant performance improvement, we will also validate the fact that *Elaboration* is a lexically marked relation.

In order to reach these goals, we chose to use the lexical neighbours in combination with a weak clue for *Elaboration*, the gerund clause. Two combination strategies are tested.

- In a first run, *Elaboration* is detected if verbs in the main clause and in the gerund clause are neighbours (these candidates are noted by GN in the following), *Cf.* (8).

- In a second run, *Elaboration* is detected if verbs in the main clause and in the gerund clause are neighbours, **and** if the verbs objects are connected by at least one neighbourhood link (GNON in the following), *Cf.* (9).

(8)    ... et les villages *contribuaient* également à ce grand projet religieux *en envoyant* des vivres.
       *(...) and villages also* contributed *to this great religious project by* sending *supplies*

(9)    Les Skrulls (...) *élargissent* leur **empire** en *englobant* dans celui-ci les **mondes** moins avancés qu'ils rencontrent.
       *The Skrulls (...) were* expanding *their **empire** by* incorporating *the less evolved **worlds** they discovered.*

We will compare the results of these two combination strategies to the results obtained by considering only the gerund clause (G in the following). The observed performance differences will allow us to quantify the improvement brought by using lexical neighbours to enhance *Elaboration* detection.

## 4.2   Extraction of *Elaboration* candidates

In this experiment, the corpus used is a fraction of the french Wikipedia: 45'823'899 words from 5'106'831 sentences, which amounts to roughly one fifth of the online encyclopedia. This corpus has been pre-processed with SYNTEX. All sentences featuring a [verb clause, gerund clause] pair are extracted (G). Two subsets of these candidates are then produced, by taking into account constraints of lexical neighbourhood on the verbs pairs (GN) and on the verb objects pairs (GNON), as explained in the previous section. The following table gives the number of candidates obtained depending on which markers were used.

| G | GN | GNON |
|---|---|---|
| 18571 | 375 | 193 |

The number of *Elaboration* candidates is small considering the corpus size. Nevertheless, in the current state of research on this relation, defining a reliable marker is a significant improvement, even if the number of matches is small.

## 4.3    Annotation of extracted candidates

Each text was independently annotated by two experts in discourse relations[2]. We annotated 314 examples, approximatively 100 for each case (G, GN, GNON) presented randomly to the annotators with the question: *Is the gerund clause an elaborating segment of the main clause?*

The agreement rate between experts is 89% (280 cases of agreement *vs* 34 cases of disagreement). The kappa score (Cohen, 1960) is 0.70, which highlights a moderate to good inter-annotator agreement. This reveals the difficulty of the task. The kappa score is, however, good enough to consider an automatisation of this task.

In a second run, we explored the 34 examples for which we disagreed, in order to make sure the reference annotation was as reliable as possible and to analyze the types of inter-annotator variation. The discussion allowed us to refine the annotation for the vast majority of disagreement cases. Finally, only 9 cases resulted in the experts disagreeing; such cases include texts for which two interpretations are possible. To ensure meaningful results, these 9 marginal cases were discarded from the reference which was subsequently used to evaluate the results of the automated elaboration detection, cf. next section.

## 4.4    Results and perspectives

The table below summarizes the results obtained when testing the three strategies for *Elaboration* detection.

|          | Extracted | Annotated | Elab. | Not Elab. | Precision | Confidence interval |
|----------|-----------|-----------|-------|-----------|-----------|---------------------|
| **G**    | 18571     | 102       | 62    | 40        | **60.8%** | 9.45%               |
| **GN**   | 375       | 100       | 81    | 19        | **81.0%** | 6.59%               |
| **GNON** | 193       | 104       | 99    | 5         | **95.2%** | 2.8%                |

These results confirm that the gerund clause is indeed an ambiguous cue, since only $60.8\%$ of the candidate are *Elaboration*. The number of annotated candidates is small considering the amount of gerund clauses extracted; this results in a wide confidence interval. However, the performance difference between G and our two strategies is large enough to ensure that these two strategies bring a significant improvement. With the first strategy (gerund clause and main verb are neighbours), 81% of the cases are *Elaboration*. The second strategy (gerund clause and main verb are neighbours *and* the verbs objects are linked by neighbourhood) is very reliable, with 95% precision. These results are highly promising.

The cases where our markers failed were analysed. In a few cases, the failure is caused by an irrelevant neighbourhood link. For example, in the context of example (10), the link between "marcher" (*march*) et "incendier" (*burn*) is irrelevant. In various cases, a different marker can be observed, which could be used to cancel the *Elaboration* inference. This is illustrated in example (11), where the strong lexical marker of *Contrast* relation "mais" (*but*) appears.

(10)    Ils *marchent* la campagne en *incendiant* toutes les habitations.
        *They* marched *the countryside,* burning *down every dwelling they found.*

(11)    Le roi d'Espagne lui accorda une décoration qu'il accepta, *mais* en refusant la pension qui y était attachée.

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[2]The authors of this paper.

> *The king of Spain accorded him a decoration that he accepted* while *refusing the pension that was attached to it.*

These considerations suggest that our good results can still be improved upon, by taking into account other types of markers, signalling an other discourse relation on the one hand, and by a more elaborate filtering for the neighbours on the other hand.

# 5    Conclusion and outlook

We have presented a practical experiment dedicated to the detection of *Elaboration*. While *Elaboration* is often considered as a relation without prototypical lexical discourse markers, our aim was to find signalling devices for the identification of *Elaboration*. We combined an ambiguous cue, the gerund clause and information provided by the lexical neighbours resource.

The results of our experiment are encouraging. We validate on a corpus the fact that *Elaboration* can be lexically marked as suggested in the SDRT framework. With this contribution, we also follow the objectives of ANNODIS project[3], which aim to construct an annotated corpus for the study of discourse organisation in order to improve description and formalisation of discourse relations with real-world data.

The prevalence of lexical cues for discourse structuration is commonly accepted, but they are still neglected in NLP applications because of the difficulty to pick out lexical links in texts. This contribution validates lexical neighbours as a relevant resource to use for this task, in the case of *Elaboration* detection. In the course of the VOILADIS project, we hope to generalize the usage of lexical cues for all aspects of discourse analysis.

Nevertheless, our approach detects a few cases of *Elaboration* in the whole corpus. Improvements could be made by detecting *Elaborations* between sentences. First we will continue to combine neighbours and weak cues of *Elaboration* such as the adverbial expressions "d'abord" (*first*), "dans un premier temps" (*at first*). Second, we will investigate the role of the neighbours by taking into account the density of neighbours between two sentences, the syntactic position of the neighbours, etc.

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