Positing and resolving bridging anaphora in deverbal NPs

Elena Not, Lucia M. Tovena, Massimo Zancanaro
IRST, Istituto per la Ricerca Scientifica e Tecnologica,
I-38050 Povo TN, ITALY.
Fax: +39 (461) 302040
{ not | tovena | zancana}@irst.itc.it

Abstract

This paper explores the idea that the operations of positing and resolving bridging anaphora in NPs with deverbal heads can be successfully guided by considering as possible implicit relations those suggested by the argument structures of the corresponding verbs. We exploit the event/result reading distinction, combined with other aspectual information. From there, we work out the idea that there is one particular argument, termed the *favourite*, that plays a key role in correctly situating the NP referent within the discourse.

1 Introduction

This paper explores the idea that the operations of positing and resolving bridging anaphora in NPs with deverbal heads can be successfully guided by considering as possible implicit relations those suggested by the argument structures of the corresponding verbs.

Bridging is a referential phenomenon occurring when the referent of a linguistic expression can be determined only by recovering a meaningful implicit relation with an already mentioned entity or event. For example, in the following Italian sentences, the correct interpretation for *richieste* requires the identification of the implicit relation between the set of requests for underwriting and the bond to be underwritten.

ex. *Un nuovo prestito obbligazionario* al tasso del 7% e della durata di tre anni verrà emesso domani dal Banco Ambroveneto, ... *Le richieste* verranno accettate dal 2 al 14 ottobre. [A new bond loan ...will be issued tomorrow by Banco Ambroveneto, ... The requests will be accepted from the 2nd to the 14th of October.]

The literature describes two basic approaches to deal with bridging in CL: the first consists in working mostly at the semantic level interpreting bridging as a kind of implicature the reader draws to support the coherence of discourse (Asher and Lascarides, 1998, pp.1-2). The second, exemplified by (Bos, Buitelaar, and Mineur, 1995), relies primarily on augmenting the lexicon annotating for each noun its possible meaningful relations. We believe that, at least for the particular kind of bridging we are concerned with, the second approach is most promising given that, in some cases, a limited amount of lexicon annotation can greatly enhance resolution efficiency and efficacy: by using algorithms and rules relying on linguistic information we can significantly constrain inference on cognitive processing. Our contribution goes along the lines proposed in (Grosz and Sidner, 1998).

We are interested in deverbal nouns (e.g. "building" derived from "to build", and "request" derived from "to request") and we endorse the claim that bridging occurring in NPs with a deverbal noun head should be resolved by considering as possible implicit relations those suggested by the argument structure of the corresponding verb, cf. *inter alia* (Badia and Saurí, 1998) and (Rozwadowska, 1988) for investigations on thematic restrictions on derived nominals. We think that the way the verb argument structure maps onto the noun argument positions depends on whether the deverbal nouns denote an event, or a resulting state or participant in the corresponding eventuality. The idea of exploiting the *event/result* reading distinction, combined with other aspectual information, was primed by the linguistic data collected during corpus analysis and proved to be quite promising. We then take it one step forward and work out which is the noun argument whose (covert or overt) presence is needed for a proper understanding of the text. This idea is captured by the notion of *favourite*.

Our work fits in the context of automatic information extraction. In connection with the FACILE European project (LE 2440), we developed a module for texture resolution[1] (TRM) to be integrated in a system of information extraction from Italian financial news. The TRM tracks entities as they

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[1]The *texture* of a text is "related to the listener's perception of coherence" and is "manifested by certain kinds of semantic relations [called cohesive ties] between its individual messages" (Halliday and Hasan, 1985). Examples of cohesive ties are: coreference, bridging and coclassification.

are introduced in the discourse and uses a set of declarative rules to guess which cohesive ties hold for a certain referring expression. An exploratory corpus analysis (on 13 Italian financial news for a total of 1467 words) showed that bridging is a frequent anaphoric phenomenon (43,3% of the total cohesive links). Moreover, NPs with a deverbal noun as head amounted to 19.6% of the NPs in the corpus and 21% of the bridgings came from deverbals. Building on observations made on our corpus, we first formulated hypotheses for bridging resolution in linguistic terms. Then we went back to our corpus to verify their consistence with respect to the data. Finally, we turned them into heuristics that help recognise the thematic role played by modifiers in nominalisations and that suggest where missing arguments should be recovered from the discourse context.

2 Properties of deverbal nominalisations

There is an assumed parallelism in argument structure between deverbal nouns and the verbs to which they are related, but its strength is said to vary. (Grimshaw, 1990) distinguishes between *event* nominals, that express an event or a process whose existence is entailed, and *result* nominals, that name/denote the output of the event or an entity related to it but do not entail the existence of the corresponding event. Event nominals obligatorily have an argument structure derived from the associated verb and assign specific thematic roles. For instance in:

ex. La costruzione della casa richiese tre anni
[The construction of the house took three years]

la casa is assigned the role of patient in the thematic grid of the corresponding verb *costruire*.

Result nominals, by contrast, take a kind of semantic participants that are more loosely associated with the argument structure and the corresponding thematic roles. For instance, the *di* NP phrase in

ex. la costruzione di Daniele è la più bella
[the construction of Daniele is the nicest]

can be interpreted as referring to the agent, i.e. the constructor, but also to the mere possessor of the building. Encoding in the lexicon the *event/result* reading distinction for a nominalisation is straightforward when using a conceptual dictionary like WordNet (Fellbaum, 1998): it's enough to search up in the hierarchy. For example, the noun *building* belongs to different synsets (i.e. it has different senses): one has *entity* among its hypernyms (and thus it expresses a *result*) and the other two have *act* as hypernym (and thus they express an *event*). Thus this noun has both *event* and *result* readings.

The difference in the way arguments are realised in the two readings is relevant for our purpose. In the task of texture resolution, we have to find out precisely how to interpret PP modifiers[2], possessives and other potentially referential expressions surrounding a nominal, and when to posit a bridging anaphora and to which entity.

Nominalised expressions in English and Italian do not share always the same syntactic forms. English nominals have several argument positions that can map into the basic verb arguments (subject, direct and indirect objects), cf.(Macleod et al., 1997) for a computational treatment. They are (i) possessives (e.g. "His announcements", "Daniel's appointment"); (ii) pre-nominal noun modifier (e.g. "The State Department announcement"); (iii) postnominal prepositional phrase (e.g. "The announcement of the White House"). In Italian, the grammar of nominalisation phrases is somewhat simpler. Arguments can be expressed either by a possessive[3] or relative pronouns, classified as prenominal modifiers (e.g. "il suo annuncio" [his announcement], "il cui annuncio" [whose announcement]), or PPs, here called postnominal modifiers (e.g. "l'annuncio del presidente" [the announcement of the president]), cf. (Renzi, 1991) for a description.

Only PPs of the form *di* NP (lit. *of* PP in English) raise interesting questions from our point of view, since PPs other than *di* NP can be interpreted directly by looking at the argument structure of the related verb, broadly speaking. The major difficulty comes from roles assigned to verb argument positions which are not 'identified' by specific prepositions, because these roles can be mapped into the same position in the corresponding nominals. Indeed, nominals derived from transitive verbs potentially bring in ambiguities, since the thematic roles of agent and patient can both be assigned to possessives and PPs of the form *di* NP (e.g., agent: "la telefonata di Maria" [the telephone call by Maria] vs. patient: "l'emissione di nuove azioni" [the new share issue]). Besides, note that a PP of the form *di* NP can discharge also other roles, for instance an oblique such as material (e.g. "la costruzione di mattoni" [the construction made of bricks]). Furthermore, it can be used to express roles in relations that are not necessarily part of an argument structure, such as possession.

The literature offers discussions on patterns for coding nominalisations and their arguments (Meyers et al., 1998), (Badia and Saurí, 1998). It is noted that whether or not a position is filled may affect the interpretation of other positions. It is also dis-

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[2]Here modifiers is a cover term for complements, adjuncts and so on.

[3]Note that morphological agreement goes with the nominal. Semantic agreement (with the possessor) is not allowed.

cussed the status of 'optional' arguments to nouns. In some sense, these papers try to give 'maximal' descriptions of nominalisations. Our concern is different. We want to identify the texture of a text. Therefore, we want to know when a bridging can be safely posited and how to resolve it. To this aim, 'minimal' descriptions are best suited because they trigger the hypothesis that there is a bridging in a reduced number of cases, with a higher degree of certainty and provide precise information for its resolution. We capitalise on the observation that in the interpretation of a nominalisation there are preferences in the assignment of a certain thematic role in a certain context, and that one of the basic complements appears to be singled out. This type of preference is different from the distinction between obligatory and optional complements. We describe this situation via the notion of *favourite argument* which has semantic and syntactic facets:

- From a semantic point of view, the notion of favourite captures the following idea. For each nominal, there is a thematic role (the favourite argument) that must be assigned for the referent to be correctly situated within the discourse context. For example, for the Italian nominal *costruzione* (construction) derived from the verb *costruire* (to construct) the favourite is the thematic role of patient. In the sentence:

  ex. La costruzione della casa richiese tre anni. [The construction of the house took three years.]

  the patient (i.e. the house) is essential for the interpretation of the sentence. Were it missing, as in "La costruzione richiese tre anni", we would be forced to search in the previous discourse for a coreference or a bridging link on the construction.

  We hypothesize that the favourite role is unique, even if not necessarily the same for all nominals. It can be overtly assigned, by mapping it into the unique argumental position realised, provided it is of a compatible form[4], or into one of the arguments if there are more. Otherwise, one must assume that there is an understood relation of coreference or bridging. Given our hypothesis that the favourite role is unique and provides the minimal and sufficient information to recover the cohesive texture of discourse, no bridging is posited on arguments other than the favourite.

  Evidence in support of a unique favourite comes from the consistent preference recorded in naturally occurring instances, and from the use of

recovering strategies in case of potential mismatches between the favourite's qualification and world knowledge. For instance, in "la costruzione di Daniele richiese tre anni" [the construction of Daniele took three years], the predicate forces a reading as event of the deverbal. The favourite is the role of patient, whereas world knowledge would prompt the role of agent for *di Daniele*. As a matter of fact, the primary interpretation of this sentence is something like 'the construction of the statue portraying Daniele ...', which accommodates the role of patient.

- From a syntactic point of view, the notion of favourite expresses the fact that there must be an explicit or implicit modifier to which the favourite thematic role is assigned. Both possessives and PPs of the form *di* NP are compatible forms for the semantic favourite, but in case of competition, the PP is preferred. The favourite position is the one closest to the noun.

Our notion of favourite argument differs from the notion of *core* thematic role in (Barker, 1995) in at least three respects. First, the favourite does not identify a role discharged by the deverbal itself, as it is the case of the core role. Instead, it expresses a condition applying to a (overt or covert) modifier of the deverbal. Second, it is not used to encode the distinction between event and result readings of the deverbal. Indeed, such a distinction is presupposed for the favourite to be computed. Third, it identifies a participant in the relation expressed by the deverbal. Moreover, the favourite does not identify the relation itself via the instantiation of the event variable, for the cases of event reading, nor the role that is discharged by the deverbal, for the result reading, as in (Barker, 1995). Note that this last point does not preclude the possibility of having event positions in the argument list of the predicate representation of the corresponding verb.

2.1 Heuristics for thematic roles assignment

Starting from observations made on our corpus of Italian financial news, we define heuristics for the identification of the semantic favourite using aspectual information. Beside the event/result dichotomy, we further distinguish results as originating from stative (*to know*) or eventive (*to construct*) predicates. We also distinguish eventives where the existence of a participant is affected by the existence/happening of the event described by the predicate (*to construct a house*) from eventives where it is not (*to capture a lion*). Let's call the former an E(xistence) A(ffecting) type of predicate. Our hypothesis is that this distinction is more relevant than other aspectual

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[4] Selectional restriction or other semantic checks are used to test compatibility. An example of non-compatible form is *la costruzione di ieri* [the construction of yesterday].

subspecifications because we are concerned with referential issues.

We worked out the following heuristics for the interpretation of modifiers:

- Whenever there are several PP modifiers, the favourite thematic role must be assigned to the modifier closest to the nominal which has a compatible form. World knowledge tells us that *collegio* and *convento* are collective entities that can be agent in an event of construction or buildings and hence be patient. However, the following example allows only the interpretation of patient for *collegio*.

  ex. La costruzione del collegio del convento
  [The construction of the boarding school of the convent]

  As for *convento*, it can be the agent or the possessor.

- In the absence of a modifier that can act as the favourite, there must be coreference or a bridging anaphora on the favourite.

- For a nominalisation which is a *result*:
  If it is an EA predicate, the nominal denotes the entity affected by the event, e.g. the patient, and the corresponding theta role cannot be discharged overtly. The search space for the interpretation of the modifiers is pruned accordingly. The favourite is the agent but, because a result is an object and not an event, other relations such as possession cannot be ruled out:

  ex. La costruzione di Maria venne giudicata come la più solida.
  [The construction of Maria was considered as the firmest.]

  If it is not an EA predicate, then patient is the first role to be discharged in the case of an eventive predicate.

  ex. La cattura di Mario ci sorprese.
  [the capture of Mario surprised us.]

  In the case of a stative predicate, a modifier is more likely to discharge the role of agent/possessor.

  ex. La conoscenza di Daniele è sconfinata.
  [Daniele's knowledge is unlimited.]

- For a nominalisation which is an *event* the role assigned to the direct object of the corresponding predicate must be discharged by the favourite[5] and it is discharged by a PP of form *di* NP.

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[5]For the sake of brevity, let's assume that it is always the patient.

ex. La costruzione della casa fu lunga e laboriosa.
[The construction of the house was long and tiresome.]

If there are more than one PP modifier, the PP discharging the patient role occurs closest to the nominal.

In cases where a deverbal nominalisation may have in principle both result and event readings, as in the case of *costruzione*, some additional aspectual or semantic information can help to discriminate the reading occurring in the discourse context under consideration:

- Modifiers may have discriminating power:
  If there is a modifier that can be identified as the patient (we can use standard selectional restrictions such as animate...), then the reading as result is ruled out, as in:

  ex. La costruzione della casa ...
  [The construction of the house ...]

  On the contrary, if there is a single modifier, which is a PP of form *di* NP, that can be identified unambiguously as the agent, then the nominal is a result, as in:

  ex. La costruzione del bambino ...
  [The construction of the child ...]

- If information on the role of the modifiers helps in interpreting/identifying the type of nominal and vice versa, we fall in a bit of a circular process. However, sometimes the discriminating power of predicates can help in disambiguating the word sense. If the predication is about the temporal dimension, then the reading as result can be ruled out, as in *the building was slow*. If the predication is about the physical/spatial dimension, then the nominal is a result, as in *the building is high*.

2.2 Corpus based verification of the heuristics

The exploratory corpus analysis we conducted on Italian financial news confirmed the validity of the linguistic hypothesis given above. Texts were annotated systematically with an SGML tagging: for each deverbal nominalisation the reading (whether event or result) and aspectual class (whether state, activity, accomplishment or achievement) are marked, and for each corresponding modifier, its linguistic form and its thematic and syntactic role with respect to the originating verb are specified. See figure 1 for a sample of annotated text.

Contrary to what we expected, the corpus analysis revealed that the aspectual class does not contribute significantly to the positing and resolving of

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<news id = "10" > La Banca Agricola Manto-
vana ha deliberato di dar corso ad <np id = 60
> una <head type = "event" aspect = "ac-
complishment" > emissione </head> <pp prep
= "di" theta = "patient" syntax = "direct-
object" > di obbligazioni non convertibili </pp>
<pp prep = "di" theta = "measure" syntax =
"adjunct" > dell' importo complessivo di 100 mil-
iardi di lire </pp> </np> ......L' <head type =
"event" aspect = "activity" > offerta </head>
</np> partirà dal prossimo 14 ottobre. </news>
```

Figure 1: Sample of annotated text.

bridgings, given that the event/result distinction is
a sufficient predicting factor. Table 1, summarizes
our corpus-based findings.

In the table, under the column "other" we have
grouped occurrences of deverbal nominalisations
whose analysis falls outside the scope of this re-
search. They are coreferential anaphora, specific ref-
erences, generic references, nominals with *di* PP ex-
pressing the only obligatory thematic role, nominals
with bridging on the only obligatory thematic role.

3 Computational use of the heuristics for positing and resolving bridging

The heuristics described above can be profitably ex-
ploited in a system for automatic information extrac-
tion to improve the efficacy of the texture resolution
module.

The Texture Resolution Module (TRM) we devel-
oped in connection with the FACILE project tries
to identify the reference function that each NP plays
in a text (anaphora, generic reference, specific refer-
ence, iota (unique) reference, predicative function)
and tries to guess possible cohesive ties (Not and
Zancanaro, 1998). The key idea underlying the
TRM design is to consider the process of texture
resolution as a three step process:

1. for each referring expression, determine the ref-
   erence function which may apply according to
   the linguistic form of the NP (for example, pro-
   nouns are never considered as potential iotas);

2. for each guess of anaphoric reference function,
   look for potential antecedents (coreference is
   tried first; if this search fails or is not satis-
   factory, try other cohesive ties, like bridging or
   coclassification):

   (2.a) select the search space where to look for
         antecedents;

   (2.b) collect all the entities in the search space
         which can be taken as referent for the con-

sidered expression. Different tests are ap-
plied, for example checking semantic com-
patibility and eliminating redundant solu-
tions;

3. for each sentence,

   (3.a) test the compatibility of the guesses made
         separately on each referring expression wrt
         intrasentential constraints (for example, C-
         command and contraindexing);

   (3.b) order the alternative guesses according to
         intersentential preferences (like centering).

The heuristics presented in §2.1 can be used to
refine step 2 in the algorithm:

2. for each guess of anaphoric reference function:

   • if the NP is a deverbal nominalisation then:

     – look for potential antecedents for a
       coreference.
     – If a hypothesis of coreference could not
       be verified (or is too weak for the TRM
       to be completely satisfied with it), then
       look for possible bridgings. As a first
       step, look in the conceptual dictionary
       and:

       A) If the nominalisation has only
           one possible reading (either result
           or event) then apply the appropriate
           heuristics for interpreting modifiers:

           · if a compatible modifier is found
             that discharges the favourite, then
             no other bridging relations are
             looked for;
           · if there are no compatible mod-
             ifiers, so that the favourite role
             cannot be discharged, a bridging
             is guessed and the potential an-
             tecedent is looked for in the previ-
             ous discourse as in steps (2.a) and
             (2.b)[6];

       B) If the deverbal nominalisation can
           have both result and process read-
           ings, then:

           · verify whether semantic checks on
             the modifiers or other aspectual in-
             formation help to discriminate be-
             tween the two readings, using the
             heuristics. If a discrimination suc-
             ceeds, then proceed to step [A].
           · otherwise, try to guess possible
             bridgings for both result and process
             readings.

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[6]For the sake of simplicity, the discussion focusses only on
anaphoric links. However, these observations can be general-
ized to cataphora too.

	agent in favourite position as *di* PP	patient in favourite position as *di* PP	bridging on agent	bridging on patient	other	total
result, EA	3		4		2	9
result, not EA (eventive)		3		3	4	10
event		17		9	13	39
ambiguous					8	8
agentive					5	5
total	3	20	4	12	32	71

Table 1: Corpus analysis results.

- else, proceed as usual, looking for potential antecedents:

(2.a) select the search space where to look for antecedents;

(2.b) collect all the entities in the search space which can be taken as a referent for the considered expression. Different tests are applied, for example, to check for the semantic compatibility and to eliminate redundant solutions;

4 Conclusion and Future work

This paper presents an extension of computational approaches to bridging in deverbal NPs that use the verb argument structure. Unlike other works on nominalisations which aim at a full description of the status of each argument in the deverbal noun, our approach is mainly concerned with the coding of the 'minimal' information which is necessary for safely positing and resolving bridging phenomena. Minimal descriptions are best suited for our computational task because they trigger the hypothesis that there is a bridging in a reduced number of cases, with a higher degree of certainty and provide precise information for its resolution.

For a deeper evaluation of the effectiveness of the heuristics presented here, we plan to extend our texture resolution algorithm according to the computational rules described in section 3, in order to run verification tests on a larger corpus. In this second phase, additional effort will be invested for the annotation of separate training and test corpus which will be used for a more objective evaluation of precision and recall. Another issue we would like to investigate is the extension of our notion of *favourite* to other cases of nominal roles, for example meronyms and attributes. This would not require additional annotation in the lexicon, given that in a conceptual dictionary like WordNet meronyms are already present and there are plans to insert attributes (Fellbaum, 1998).

References

Asher, Nicholas and Alex Lascarides. 1998. Bridging. Technical report, HCRC.

Badia, Toni and Roser Saurí. 1998. The representation of syntactically unexpressed complements to nouns. In *Proceedings of the Coling-ACL98 workshop on "The Computational Treatment of Nominals"*, pages 1–9, Montréal.

Barker, Chris. 1995. *Possessive Descriptions*. CSLI Publications, Stanford CA.

Bos, Johan, Paul Buitelaar, and Anne-Marie Mineur. 1995. Bridging as coercive accommodation. In Manandhar et al., editor, *Proceedings of the workshop on "Computational Logic for Natural Language Processing"*, Scotland.

Fellbaum, Christiane. 1998. *WordNet: an electronic lexical database*. MIT Press, Cambridge, MA.

Grimshaw, Jane. 1990. *Argument structure*. MIT Press, Cambridge, MA.

Grosz, Barbara and Candace Sidner. 1998. Lost intuitions and forgotten intentions. In Marilyn Walker, Aravind Joshi, and Ellen Price, editors, *Centering in Discourse*. Oxford University Press, pages 39–51.

Halliday, M.A.K. and Ruqaiya Hasan. 1985. *Language, context and text: Aspects of language in a social-semiotic perspective*. Deakin University Press.

Macleod, C., A. Meyers, R. Grishman, L. Barrett, and R. Reeves. 1997. Designing a dictionary of derived nominals. In *Proceedings of Recent Advances in Natural Language Processing*, Tzigov Chark, Bulgaria, September.

Meyers, Adam, Catherine Macleod, Roman Yangarber, Ralph Grishman, Leslie Barrett, and Ruth Reeves. 1998. Using NOMLEX to produce nominalizations patterns for information extraction. In *Proceedings of the Coling-ACL98 workshop on "The Computational Treatment of Nominals"*, pages 25–32, Montréal.

Not, Elena and Massimo Zancanaro. 1998. The texture resolution module: a general-purpose customizable anaphora resolutor. Technical report,

44

IRST, Istituto per la Ricerca Scientifica e Tecnologica.

Renzi, Lorenzo, editor. 1991. *Grande grammatica italiana di consultazione*, volume 1. il Mulino, Bologna.

Rozwadowska, Bozena. 1988. Thematic restrictions on derived nominals. *Syntax and Semantics*, 21:147–165.