Discourse Relations and Propositional Attitudes

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Abstract. We propose a procedure how discourse should be processed when segments are not asserted by the writer but attributed by her to other sources.

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1 Introduction

SDRT (Segmented Discourse Representation Theory [1]) introduced the notion of a *veridical discourse relation*. A discourse relation R is veridical iff the following rule is valid: $R(\alpha, \beta) \Rightarrow K_\alpha \wedge K_\beta$. In words, if $R(\alpha, \beta)$ is true then the propositional contents of its arguments, noted as K_α and K_β, are also true. Most discourse relations are veridical (*Narration*, *Contrast*, *Evidence*, *Elaboration*, *Result*, *Explanation*, ...).

However, the only examples presented in [1] concerning veridical discourse relations are simple to the extent that they only include assertions of the writer, as in (1a) analyzed with $Narration(\alpha, \beta)$.[3] When at least one argument of a discourse relation is not asserted by the writer but attributed to another source as in (1b) the situation becomes far more complex. In (1b), β is attributed to Jane. The semantics of the verb *claim* implies that the writer commits to Jane committing to the content of β but the writer doesn't commit to the content of β: she may think that it is false. In other words, independently of the fact that a discourse relation is veridical, the expressed propositional attitude (full assertion, or some weaker form of assertion) towards the content of a discourse segment must be evaluated relative to one or several source(s), e.g. the writer and Jane for the segment noted as β in (1b). [1] discusses in great detail complex issues related to dialogue, but in our understanding, they do not discuss attribution in monologue which is the subject of this paper. Our main point is to take into account propositional attitudes so as to handle monologic discourses which do not only contain writer assertions.

(1)a. (Fred will go to Dax for Christmas)$_\alpha$. Afterwards (he will go to Pau)$_\beta$.
   b. (Fred will go to Dax for Christmas)$_\alpha$. Jane claims that afterwards (he will go to Pau)$_\beta$.

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[3] *Narration* in SDRT is called *Sequence* in RST.

Moreover, following the annotation in the Penn Discourse Tree Bank (PDTB) [8,6], we argue that it should be one of the goals of discourse analysis to indicate the sources of the discourse relations at play in a discourse structure. For example, it will be shown in Section 4.2 that the source of *Narration* is Jane in (1b) and the writer in (2a). Furthermore, the propositional attitude of the discourse participants towards the semantics of a "discourse constituent" $R_{s_k}(\alpha, \beta)$ may vary. For example, it will be shown in Section 4.2 that the writer commits to the temporal sequential order of Fred's trips given by *afterwards/Narration* in (2a) but doesn't in (2b).

(2)a. Fred will go to Dax for Christmas. Jane doesn't know that afterwards he will go to Pau.
  b. Fred will go to Dax for Christmas. I believe that afterwards he will go to Pau.

In sum, discourse in which some segments are not asserted by the writer — which are quite frequent in the journalistic genre — require a new paradigm for discourse analysis in which each discourse constituent of the form $R(\alpha, \beta)$ is annotated with information on the sources of its elements (R, α and β) and the propositional attitude of the relevant agents towards their semantics. This paradigm crucially relies on information about which discourse participants believe which proposition to what degree, as expressed in FactBank [11].

Section 2 gives a brief introduction to FactBank. Section 3 presents our new paradigm for discourse analysis. Section 4 explains the new paradigm.

2   FactBank

FactBank is an English corpus annotated with expressed propositional attitude, which it calls "factuality" [10,11]. FactBank is not concerned with discourse relations and discourse analysis. It is concerned only with events (eventualities) whose propositional attitude values are worked out clause by clause, without taking into account the discourse context or world knowledge: these values come only from lexical semantic knowledge, in particular semantic properties of verbs with a sentential complement and presence of modality or polarity markers, the interaction between these various factors being modeled.

The propositional attitude assigned to an event e is relative to the relevant sources at play, the writer and other agents. Therefore, a propositional attitude is represented as $f(e, s) = x$, where s refers to the agent who has expressed the attitude towards e.[4] The value x, the propositional attitude, is a pair $(Mod(x), Pol(x))$ with a modality value and a polarity value. There exist

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[4] In fact, the propositional attitude assignments are more complex because of nested sources as in *Julie said that Jane claims Fred will go to Dax*. However, nested sources will be ignored in this paper. This allows us to make the following simplification : we use $f(e, s)$ instead of $f(e, writer - s)$ used in FactBank for a source s different from the author.

four modality values (with an order relation), certain (CT), probable (PR), possible (PS), unknown (U), and three polarity values, Positive ($+$), Negative (-), unknown (u). However, there exist only 8 (and not 12) pairs $(Mod(x), Pol(x))$ abbreviated as $Mod(x)Pol(x)$ because four pairs don't exist: $U+$, $U-$, PRu and PSu.

Let us give some illustrations of propositional attitudes. In the discourses in (3a) consisting of a single assertion of the writer, $f(e_\alpha, Wr) = CT-$ which means that according to the writer, it is certainly the case that e_α will not happen, with e_α corresponding to the event described in the "positive" version of α, i.e. *Fred will go to Dax*. In (3b), $f(e_\alpha, Wr) = PR+$ which means that according to the writer, it is probably the case that e_α will happen, where e_α is the event described in the version of α without modality marker, i.e. *Fred will go to Dax*. In (3c), $f(e_\alpha, Wr) = Uu$ which means that the writer doesn't know what is the factual status of e_α or doesn't commit to it; in contrast, $f(e_\alpha, Jane) = CT+$. In (3d), $f(e_\alpha, Jane) = Uu$ and $f(e_\alpha, Wr) = CT+$. In (3e), $f(e_\alpha, Jane) = CTu$ and $f(e_\alpha, Wr) = Uu$.

(3)a. (Fred will not go to Dax)$_\alpha$.
   b. (Fred will probably go to Dax)$_\alpha$.
   c. Jane said that (Fred will go to Dax)$_\alpha$.
   d. Jane does not know that (Fred will go to Dax)$_\alpha$.
   e. Jane knows whether (Fred will go to Dax)$_\alpha$.

We conclude with a remark on the PDTB. As said in Section 1, information on sources and propositional attitude on each element of a discourse constituent $R(\alpha, \beta)$ (i.e. R, α and β) is annotated in PDTB [8], and the new paradigm we propose is inspired by work on the PDTB. However, propositional attitude information in the PDTB is not as elaborate as in FactBank, as explained in [11]. For a more detailed discussion of the PDTB, see [4].

3 New paradigm for discourse analysis

We postulate that, in a dynamic approach, updating the discourse analysis with a new discourse segment should be performed in four steps:

(i) Work out the propositional attitudes $f(e, s) = x$ for all events e and relevant agents (including the writer) s in the new segment, using only linguistic knowledge as in FactBank.
(ii) Update the discourse structure with the new segment using one or more discourse relations, based, on the one hand, on the propositional attitude towards these events, and on the other hand, on other linguistic knowledge as well as world and pragmatic knowledge.
(iii) Identify the source(s) of the newly introduced discourse relations.
(iv) Possibly revise and/or complete the propositional attitudes according to the updated discourse structure. The propositional attitude assignments after the update of the discursive analysis with the segment identified as n are noted $f_n(e, s)$.

We have split the operations performed in steps (ii) and (iii) for sake of clarification. However, we don't claim that these operations must be performed sequentially. On the other hand, we do claim that they must be performed after step (i) and we will show evidence for this claim. Step (iv) naturally comes up after steps (ii) and (iii) and we insist on the fact that this step is crucial for many NLP applications such as textual entailment, question-answering and dialog, since it is in this step that the propositional attitude information relevant for such applications is computed [7].

4   Arguments for the New Paradigm

4.1   Propositional Attitude Revision

This section explains — using a quite simple example — the revision of a propositional attitude, the operation which is performed in step (iv) in our paradigm. The example in (4a), in which both segments are attributed to the writer, is analyzed with $Evidence(\alpha, \beta)$. Consider (4b) in which β is attributed to another source (Jane); (4i) shows the propositional attitudes, and (4ii) the discourse structure for (4b). This discourse structure with the relation $Evidence$ relies on the fact that the writer endorses what Jane said: there is no relation $Evidence$ in (4c). Therefore interpreting (4b) with $Evidence_{Wr}(\alpha, \beta)$ implies $f_\beta(e_\beta, Wr) = CT+$. There is thus revision of the propositional attitude value for e_β relative to the writer: $f_\beta(e_\beta, Wr) \neq f(e_\beta, Wr)$.

(4)a. (The neighbors have gone on vacation)$_\alpha$. (Newspapers are accumulating on their doorstep)$_\beta$.

   b. (The neighbors have gone on vacation)$_\alpha$. (Jane told me that)$_{\beta_{att}}$ (newspapers are accumulating on their doorstep)$_\beta$.

   i $f(e_\alpha, Wr) = CT + \ \wedge \ f(e_\beta, Wr) = Uu \ \wedge \ f(e_\beta, Jane) = CT+$

   ii $Attribution_{Wr}(\beta_{att}, \beta)^5 \ \wedge \ Evidence_{Wr}(\alpha, \beta)$

   c. The neighbors have gone on vacation. Jane claimed that newspapers are accumulating on their doorstep, but that is wrong.

   In [5], it is postulated that there exist two uses of reportative verbs like *say*, an "evidential" use as in (4b) and an "intensional" use as in (4c). With the evidential use, the writer endorses the content of the embedded clause (noted γ), which corresponds to $Mod(f(e_\gamma, Wr)) \neq U \ \wedge \ Pol(f(e_\gamma, Wr)) \neq u$, while she doesn't with the intensional use, $f(e_\gamma, Wr) = Uu$. Our examples above support this claim. However, one of the main arguments put forward in [5] is that evidential uses of reportative verbs allow felicitous anaphoric links from indefinites under the scope of embedding verbs to elements in extensional (non

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[5] As in RST [9], the relation *Attribution* is used to link an attribution text span (e.g. *Jane told me*) to the attributed text span. $Attribution_s(\gamma_{att}, \gamma)$ implies that s claims that the source of γ is given in γ_{att}. In the examples presented in this paper, γ_{att} is built around a verb introducing a clausal complement and the source of γ is the referent of the subject of this verb.

modal) contexts, while intensional uses don't. Yet, the situation seems more complex. For example, *think* in (5a) should be considered as intensional (as there is nothing for which evidence is being supplied), and, in accordance with [5], (5b) is incoherent. On the other hand, (5c) is coherent thanks to the discourse connective *as a matter of fact*. Thus, it seems preferable to postulate that there is a single use of reportative verbs, with different values assigned to $f(e_\gamma, Wr)$ and $f(e_\gamma, source(\gamma))$ depending on the discourse context, and a possible revision of these values after discourse structure update. The constraints on anaphoric reference to indefinites are really based on the propositional attitudes. We leave an elaboration of a precise account to future work.

(5)a. Jane thinks that her husband has a mistress. She is supposed to be a redhead.
   b. # Jane thinks that her husband has a mistress. She is a redhead.
   c. Jane thinks that her husband has a mistress. As a matter of fact, she is a redhead; he is indeed cheating on her.

4.2   Propositional Attitudes for Discourse Constituents

First, we address the following question: what does it mean to assign a propositional attitude to the event described in a segment such as β in (6a) which includes a discourse connective (*afterwards*), an anaphoric element? The modality introduced in β_{att} (*I think*) has scope over Fred's trip to Dax or over the temporal succession of his trips, as shown in the coherent discourse in (6b). Therefore, we propose to segment (6a) as shown, with the propositional attitudes in (6i) and the discourse structure in (6ii). The segment β_1 corresponds to β without the discourse connective. So a propositional attitude can be assigned to e_{β_1} in a standard way, see (6i). The notation $seq(e_\alpha, e_{\beta_1})$ corresponds to the temporal succession of e_α and $e_{\beta1}$. $seq(e_\alpha, e_{\beta_1})$ is expressed through *afterwards* in (6) and not through an eventuality expression, however the temporal succession of two events can be expressed with a "discourse verb" [3] such as *precede* or an NP such as *succession*. Therefore, $seq(e_\alpha, e_{\beta_1})$ is an element to which a propositional attitude value can be assigned, see (6i). The discourse structure in (6ii) indicates that *Narration* (attributed to the writer) links β and β_1, which is accurate.

(6)a. (Fred will go to Dax for Christmas)$_\alpha$. (I think that)$_{\beta_{att}}$ (afterwards (he will go to Pau)$_{\beta_1}$)$_\beta$.
   i $f(e_\alpha, Wr) = CT + \land (f(e_{\beta_1}, Wr) = PR + \lor f(e_{\beta_1}, Wr) = CT + \land f(seq(e_\alpha, e_{\beta_1}), Wr) = PR+)$
   ii $Attribution_{Wr}(\beta_{att}, \beta) \land Narration_{Wr}(\alpha, \beta_1)$
   b. Fred will go to Dax for Christmas. I think that afterwards he will go to Pau. However, it is possible that he will not go to Pau or that he will go to Pau before going to Dax.

We are now going to address the (difficult) issue of determining the source of the discourse relation in a discourse constituent. In (7), segmented as (6),

Narration is necessarily attributed to the writer because of the semantics of the factive verb *know* used in a negative form.

(7)   (Fred will go to Dax for Christmas)$_\alpha$. (Jane doesn't know that)$_{\beta_{att}}$ (afterwards (he will go to Pau)$_{\beta_1}$)$_\beta$.
  i $f(e_\alpha, Wr) = CT+ \ \wedge \ f(e_{\beta_1}, Wr) = CT+ \ \wedge \ f(seq(e_\alpha, e_{\beta_1}), Wr) = CT+$
      $\wedge \ f(e_{\beta_1}, Jane) = Uu \ \wedge \ f(seq(e_\alpha, e_{\beta_1}), Jane) = Uu$
  ii $Attribution_{Wr}(\beta_{att}, \beta) \ \wedge \ Narration_{Wr}(\alpha, \beta_1)$

On the other hand, in (8a), which differs from (7) only by the verb and polarity used in β_{att}, *Narration* must be attributed to Jane. $Narration_{Jane}(\alpha, \beta_1)$ implies that Jane is aware of Fred's trip to Dax, as shown by the incoherence of (8b). This results in f$_\beta(e_\alpha, Jane) = CT+$ with "completion" of the propositional attitude value for e_α relative to Jane. Indeed, α being asserted by the writer, no value is assigned to $f(e_\alpha, Jane)$. That is the reason why we speak of completion (and not revision) of the propositional attitudes.

(8)a. (Fred will go to Dax for Christmas)$_\alpha$. (Jane thinks that)$_{\beta_{att}}$ (afterwards (he will go to Pau)$_{\beta_1}$)$_\beta$.
  ii $Attribution_{Wr}(\beta_{att}, \beta) \ \wedge \ Narration_{Jane}(\alpha, \beta_1)$
  b.   #Fred will go to Dax for Christmas, which Jane does not know. She thinks that afterwards he will go to Pau.

In conclusion, propositional attitude information is crucial to identify the sources of the discourse relations at stake. This is why step (iii) in our paradigm should be performed after step (i).

4.3   Updating the Discourse Structure

This section, whose aim is to explain why the update of the discourse structure must take into account propositional attitudes, focuses on the veridical relation *Contrast*, lexically marked with *yet* or *but*. $Contrast_{Wr}(\alpha, \beta)$ is often observed when there is an "unexpected result", as illustrated in (9a) in which *breastfeeding* normally entails $\neg$ *constipated*. When at least one of the arguments of *Contrast* is attributed to a source other than the writer through factive verbs (*confirm* or *discover*) as in (9b-d), $Contrast_{Wr}(\alpha, \beta)$ can be maintained.

(9)a. (Bébé is being breastfed)$_\alpha$, yet (he is constipated)$_\beta$.
  b.   (Jane has confirmed that)$_{\alpha_{att}}$ (she is breastfeeding Bébé)$_\alpha$, yet (he is constipated)$_\beta$.
  c.   (Bébé is being breastfed)$_\alpha$, yet (Julie has discovered that)$_{\beta_{att}}$ (he is constipated)$_\beta$.
  d.   (Jane has confirmed that)$_{\alpha_{att}}$ (Bébé is being breastfed)$_\alpha$, yet (Julie has discovered that)$_{\beta_{att}}$ (he is constipated)$_\beta$.

However, there are a number of examples built on the patterns in (9b-d) for which $Contrast_s(\alpha, \beta)$ cannot hold for any source s. First, consider examples on the pattern of (9b) with β asserted by the writer, α attributed to another source: in (10) $e_\alpha = e_\beta$, in (11) α entails that β cannot happen.

(10)a. (Jane does not know that)$_{\alpha_{att}}$ (Fred will go to Dax)$_\alpha$, but (he will)$_\beta$.
  b. (Jane does not think that)$_{\alpha_{att}}$ (Fred will go to Dax)$_\alpha$, but (he will)$_\beta$.
  c. (Jane thinks that)$_{\alpha_{att}}$ (Fred will not go to Dax)$_\alpha$, but (he will)$_\beta$.
  d. (Jane suspects that)$_{\alpha_{att}}$ (her husband is cheating on her)$_\alpha$, but (he is probably not)$_\beta$.

(11)a. (Jane thinks that)$_{\alpha_{att}}$ (only Fred will go to Dax)$_\alpha$, but (Paul will go, too)$_\beta$.
  b. (Jane suspects that)$_{\alpha_{att}}$ (her husband is cheating on her)$_\alpha$, but (he is faithful to her)$_\beta$.

When asserting β in (10) or (11), the writer gives evidence that Jane is wrong concerning her propositional attitude towards e_α: technically, in (10), $f_\beta(e_\alpha, Wr) = f(e_\beta, Wr)$, in (11), $f_\beta(e_\alpha, Wr) = CT-$ and in both cases $f_\beta(e_\alpha, Wr) \neq f(e_\alpha, Jane)$.

The situation is similar with examples such as (12a-b) in which α is asserted by the writer and β attributed to another source. The semantics of such examples is mainly that the propositional attitude of Jane and the writer diverge towards e_β: $f(e_\beta, Jane) \neq f_\beta(e_\beta, Wr)$. Finally, in (12c) with $e_\alpha = e_\beta$, $f_\beta(e_\beta, Jane) \neq f_\beta(e_\beta, Julie)$.

(12)a. (Fred will go to Dax)$_\alpha$, but (Julie does not think that)$_{\beta_{att}}$ (he will go)$_\beta$.
  b. (Fred never cheats on his wife)$_\alpha$, but (she suspects that)$_{\beta_{att}}$ (he is sleeping around)$_\beta$.
  c. (Jane thinks that)$_{\alpha_{att}}$ (Fred will go to Dax)$_\alpha$, but (Julie does not think that)$_{\beta_{att}}$ (he will go)$_\beta$.

It can be argued that each example of this section — except (9a) — can be analyzed with a *Contrast* relation between two complex segments analyzed with an *Attribution* relation, see the discourse structure in (13a) for (9d) or (12c), in which the complex segments are surrounded by brackets. The attribution text spans must then be considered as implicit for the segments asserted by the writer, corresponding to *I know* or *I affirm* and noted $\overline{\alpha_{att}}$ or $\overline{\beta_{att}}$. See for example (13b) for (12a).

(13)a. $Attribution_{Wr}(\alpha_{att}, \alpha) \wedge Attribution_{Wr}(\beta_{att}, \beta)$
       $\wedge Contrast_{Wr}([\alpha_{att}, \alpha], [\beta_{att}, \beta])$
  b. $Attribution_{Wr}(\overline{\alpha_{att}}, \alpha) \wedge Attribution_{Wr}(\beta_{att}, \beta) \wedge$
     $Contrast_{Wr}([\overline{\alpha_{att}}, \alpha], [\beta_{att}, \beta])$

The discourse analyses in (13) are quite plausible, however it should be noted that distributivity rules — see [2] for distributivity rules over complex segments — such as $Contrast_{Wr}([\alpha_{att}, \alpha], [\beta_{att}, \beta]) \Rightarrow Contrast_{Wr}(\alpha, \beta)$ and the variants of this rule when α or β is asserted by the writer cannot be maintained: they are valid in (9b-d) but not in (10)-(12) for which $Contrast_{Wr}(\alpha, \beta)$ doesn't hold.

Moreover, consider (14) which is identical to (9b) except that *say* is used in α_{att} instead of *confirm*. This discourse is ambiguous in that the writer's opinion can be twofold: either she thinks that Jane is lying or she doesn't.

The lying case implies that the propositional attitudes towards α of Jane and the writer differ ($f_\beta(e_\alpha, Wr) = CT-$ and so $f_\beta(e_\alpha, Wr) \neq f(e_\alpha, Jane)$) as in (10) or (11), and the writer underlines this difference. The non-lying case implies that Jane and the writer share the same propositional attitude towards α ($f_\beta(e_\alpha, Wr) = f(e_\alpha, Jane) = CT+$) and the writer underlines the contrast between α and β as in (9b).

(14)   (Jane said that)$_{\alpha_{att}}$ (she is breastfeeding Bébé)$_\alpha$, but (he is constipated)$_\beta$.
    i $f(e_\alpha, Jane) = CT+ \ \wedge \ f(e_\alpha, Wr) = Uu \ \wedge \ f(e_\beta, Wr) = CT+$

In sum, it seems that we can postulate Rule 2 with a disjunction in the right part. Determining which member(s) of the disjunction is (are) true depends both on the semantics relation between α and β and on the propositional attitude value assigned to $f(e_\alpha, Wr)$. Similar rules could be postulated as well when α is asserted by the writer, β being or not asserted by the writer.

Rule 1 $Contrast_{Wr}([\alpha_{att}, \alpha], [\overline{\beta_{att}}, \beta]) \Rightarrow Contrast_{Wr}(\alpha, \beta) \ \vee \ R(\alpha, \beta)^6$

In conclusion, the various examples discussed in this section about *Contrast* show that the discourse structure crucially depends on the event propositional attitude information. That is the reason why we claim that step (ii) should be performed after step (i) in our new paradigm for discourse analysis (Section 3).

5   Conclusion and perspectives

We have proposed a new paradigm for discourse analysis in which expressed propositional attitude information (such as that given in FactBank) plays a crucial role. This article sketches an initial outline for this new paradigm and a number of (technical) issues that still require attention. Specifically, we have seen that the "lying" interpretation requires an explicit modeling of the difference between expressed and inferred (revised) propositional attitude.

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^{6} We have not found an appropriate name for R with $R(\alpha, \beta) \Rightarrow f_\beta(e_\alpha, Wr) \neq f(e_\alpha, source(e_\alpha))$. This relation is close to *Correction* as defined in [1] but should not be confused with it.

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