Joint information structure and discourse structure analysis in an Underspecified DRT framework

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Abstract

This paper presents the methodology and semantics of a general procedure for the joint analysis of textual data in terms of discourse structure and information structure, which makes use of Questions under Discussion (QUDs). We define a number of pragmatic principles that govern the reconstruction of implicit QUDs.

1 Introduction

This paper introduces major aspects of a method for the analysis of natural language in terms of information structure and discourse structure using *Questions under Discussion (QUDs)*, which will be demonstrated on a short constructed discourse.[1] The main purpose of the paper is to introduce a number of principles that determine the formulation of QUDs, as well as a semantic implementation of the procedure in Underspecified Discourse Representation Theory (UDRT) (Reyle, 1993).

By the term *information structure*, we are referring to a division of clauses into an alternative-evoking *focus* and a *background* (plus some optional, so-called *not-at-issue*, material), largely following the paradigm of *Alternative Semantics*, established by Rooth (1985; 1992) and developed further, for instance, in Büring (2003; 2008; in press), Beaver and Clark (2008), Krifka (2008) or Wagner (2012). In order to determine the information structure of a clause, it is usually necessary to consider the discourse context in which it is uttered, although some aspects of its information structure will be reflected – to a language-specific degree – in its morphosyntactic properties or, when spoken, in its prosodic realization. In line with assumptions made in Klein and von Stutterheim (1987), Ginzburg (1996) and Roberts (2012),

we are assuming that discourse not only consists of the overt spoken or written material but, in addition, contains implicit *Questions under Discussion* that provide the background against which the actual assertions are made. The *focus* of any clause uttered in its respective discourse context can, therefore, be defined as the answer to its current QUD. In the following section, we present a number of principles that will help us reconstruct the implicit Questions under Discussion of a text.

The term *discourse structure* is generally understood to explain the organization of a text into smaller sections and subsections, down to the level of atomic assertions. We assume that a well-formed text can be represented in the form of a single discourse tree. In contrast to various established theories of discourse structure, e.g. Mann and Thompson (1988), Taboada and Mann (2006), or Asher and Lascarides (2003), the current proposal does not depend on the identification of *discourse relations (rhetorical relations)* but assumes that the structure of discourse can be reconstructed with the help of Questions under Discussion, which are supposed to constitute an essential part of discourse trees.

2 Constraints on the construction of implicit Questions under Discussion and discourse trees

A fundamental, and probably uncontroversial, constraint on the formulation of a QUD is that a QUD that immediately dominates some assertion must be congruent with it.

First QUD Constraint (Q-A-Congruence)
QUDs must be answerable by the assertion(s) that they immediately dominate.

In the absence of context, (A)ssertion A_2 in (3) can be the answer to any of the (Q)uestions in (1a)-(1d) but not to question (2).

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(1) a. Q: {What happened?}
    b. Q: {What did they do?}
    c. Q: {Who worked hard?}
    d. Q: {Did they work hard?}

(2) Q: {Who bought a bicycle?}

(3) A$_2$: They worked hard.[2]

If more context is introduced, as in (4), it becomes clear that the questions in (1a-d) are not all equally good.

(4) A$_1$: John and Mary are really proud.

(3) A$_2$: They worked hard.

It seems intuitively clear that question (1c) does not fit in between assertions A$_1$ and A$_2$. The apparent reason is that, in the context of A$_1$, Question (1c) would introduce the phrase *worked hard* as new information, which seems to be dispreferred. Likewise, assuming the polarity question (1d) as the implicit QUD would force us to treat *worked hard* as given information at the level of the answer, and to interpret A$_2$ in the sense of *Yes, they DID work hard*, which seems odd in the current context. Note that apparently there is an important difference between explicit and implicit questions. While explicit questions can be used to introduce new information without causing any problems, the role of implicit questions is confined to enabling a smooth transition between two assertions, without the option of introducing any new material by themselves and thereby changing the actual discourse. We formulate this in a second constraint.

Second QUD Constraint (Q-Givenness)
Implicit QUDs can only consist of given (or, at least, highly salient)[3] material.

The principle of Q-GIVENNESS directly follows from the GIVENNESS principle by Schwarzschild (1999), which, in effect, says that discourse-new information is necessarily focused. Since in a question-answer pair the focus of the answer typically corresponds to a *wh*-pronoun in the question while only the background occurs in both of them, we conclude that discourse-new material is banned from implicit

QUDs. This explains why the Questions (1a) or (1b) represent better transitions from A$_1$ to A$_2$ than do (1c) or (1d)[4] – the latter ones violate Q-GIVENNESS.

(4) A$_1$: John and Mary are really proud.

(1) a. Q: {What happened?}
    b. Q: {What did they do?}
    c. #Q: {Who worked hard?}
    d. #Q: {Did they work hard?}

(3) A$_2$: They worked hard.

But should we prefer question (1a) or (1b)? (1a) evokes a broad sentence focus while (1b) contains an anaphoric pronoun *(they)* and asks for a predicate in focus. The question that contains the anaphoric pronoun creates a higher degree of textual cohesion (Halliday and Hasan, 1976) and is, therefore, preferable. This has been expressed in various principles in the literature which all demand, in some sense, that sentences should be maximally anaphoric or given and, therefore, have a minimal focus; for instance, the principles MAXIMIZE PRESUPPOSITION (Heim, 1991), AVOIDF (Schwarzschild, 1999) or MAXIMIZE ANAPHORICITY (Büring, 2008). Applying this idea to QUDs, we define a third constraint.

Third QUD Constraint (Maximize Q-Anaphoricity)
Implicit QUDs should contain as much given or salient material as possible.

Now, since (1a) violates MAXIMIZE Q-ANAPHORICITY, (1b) is chosen as the actual QUD Q$_2$, in the respective context (indicating question-answer congruence by means of identical subscripts.) Concerning the discourse structure of the example, we assume that answers must be subordinated to their question. Furthermore, questions which make reference to previously mentioned material must be subordinated to the clause containing this antecedent material, as shown in Figure 1.

We take the three principles mentioned above to be hard constraints, which must be fulfilled

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[2]We choose a simple past form in A$_2$ for the sake of having simple representations.

[3]We assume that function words (determiners, pronouns, prepositions etc.), as well as very general concepts like *to happen* are always salient, even if they are not literally given in the discourse context.

[4]Another question that comes to mind is *Why are they proud?*, asking for an explanation, which denotes a proposition rather than a predicate. While this is indeed a likely question in the given context, it is at odds with the intuition that the subject pronoun should be excluded from the focus of A$_2$. An ad-hoc solution to this recurring problem with explanations is to allow for a nesting of two questions: *Why are they proud?* > *What did they do?* and to let A$_2$ function as the simultaneous answer to both of them.

$$Q_1: \{\dots\}$$
$$|$$
$$A_1: \text{John and Mary}$$
$$\text{are really proud.}$$
$$|$$
$$Q_2: \{\text{What did they do?}\}$$
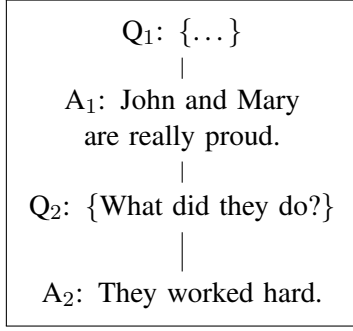$$|$$
$$A_2: \text{They worked hard.}$$

Figure 1: Discourse tree

at any time (with one important exception to Q-GIVENNESS discussed below), i.e. there will be no ranking between them, and it is precisely the universality of the constraints that makes them useful in the analysis of text.

3 Information structure

With the principles defined in the previous Section, we are now able to account for the information structure of our discourse. Definitions are provided in Table 3.

Category	Definition
Focus (F)	Answer to the current QUD
Focus Domain ($\sim$) (Rooth, 1992) Büring (2008)	Stretch of discourse with the same background as the QUD (possibly recurring elsewhere with a different focus)
Background (BG)	Material given in the QUD
Aboutness Topic (T)	Referential entity in the background
Contrastive Topic (CT) (Büring, 2003)	Focused topic, signals a discourse strategy (explanation below)

Table 1: Information structure inventory

As noted above, the QUD determines the focus-background divide of its answer. The information structure of A_2 is, therefore, the one shown in (5).[5]

(5) Q_2: {What did they do?}
  $>$ A_2: [[They$_T$]$_{BG}$ [worked hard]$_F$.]$\sim$

Following Rooth (1992) and Büring (2008), we adopt a holistic approach, i.e. we are not only interested in the position of the focus itself but in the entire combination of focus and background taken together, called a focus domain ($\sim$). In addition, we suggest a definition of *aboutness topics* as backgrounded referring expressions. This means that aboutness topics are necessarily in the background but not all backgrounded information qualifies as a topic, as shown in (6).

(6) Q_{10}: {What is John going to eat?}
  $>$ A_{10}: [[John$_T$ is going to eat]$_{BG}$ spinach$_F$.]$\sim$

Again, we see a background-focus divide but only the referring expression *John* counts as topic.[6]

The next issue in this informal discussion is *parallelism*. Again, focus domains will play a crucial role. We discuss two types of parallelism: a simple one with only one focus per assertion, and a complex one that contains pairs consisting of a focus and a contrastive topic. Explicit parallelisms, like the one in (7)[7], are rare in natural discourse, since they will typically occur in elliptical form and be rendered as simple co-ordinations. In (8)[8], the elided material has been recovered, which is indicated by means of strikethrough text.

(7) $Q_{50.1}$: {Whom can you wire-tap?}
  $>$ $A_{50.1'}$: [[You$_T$ can wire-tap]$_{BG}$ [the President of the United States]$_F$]$\sim$,
  $>$ $A_{50.1''}$: [[you$_T$ can wire-tap]$_{BG}$ [a Federal Judge]$_F$]$\sim$.

(8) Q_{60}: {What will the bill prescribe?}
  $>$ $A_{60'}$: [[[The bill]$_T$ will prescribe]$_{BG}$ [having windows in staff kitchens]$_F$]$\sim$
  $>$ $A_{60''}$: and [[~~it$_T$ will~~ also ~~prescribe~~]$_{BG}$ [the brightness of the home workplace]$_F$]$\sim$.

It seems reasonable to assume that, indeed, most co-ordinations in assertions can be analyzed as remnants of elided parallel statements. In

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[5]For reasons of space, we represent subordination in a tree by means of a $>$.

[6]This is in line with Krifka (2008), who assumes a *topic-comment* distinction that need not be coextensive with BG-F. Our definition makes no use of the *comment* notion. It remains to be sorted out whether one wants to allow for several aboutness topics in one utterance or whether backgrounded referring expressions should compete for topichood according to grammatical and thematic role, animacy etc., cf. Reinhart (1981), Givón (1983), Brunetti (2009).

[7]Quote: Edward Snowden in an interview with German TV (ARD), Jan. 26, 2014.

[8]Ex. translated from *Stuttgart SFB 732 Silver Standard Corpus* (German radio interviews).

information-structural terms, the coordinated elements are (contrastive) foci. The two parallel assertions, whether overtly present in the text or partly reconstructed, function as two partial answers to a common QUD, with whom they share the same background (and, therefore, a structurally identical focus domain). We indicate this by using subscripts of the form $A_{1'}$, $A_{1''}$. Examples (7) and (8) show that parallelisms provide us with a second way of identifying Questions under Discussion. QUDs can simply be determined by collecting the parallel material of two (or more) subsequent clauses, and by replacing the variable – i.e. focal – material by a *wh*-pronoun. We define a fourth constraint.

Parallelism constraint
The background of a QUD with two or more parallel answers consists of the (semantically) common material of the answers.

The PARALLELISM constraint will sometimes collide with, and override, the principle of Q-GIVENNESS defined above, since the parallel, backgrounded material need not always be salient already. This means that a parallelism may sometimes force the interpreter to accommodate a more specific (sub-)question – $A_{50.1}$ in (9) – than the one that would be licensed from the previous discourse alone (A_{50}). The notation is meant to indicate that A_{50} and $A_{50.1}$ stand in an entailment relation, cf. Groenendijk and Stokhof (1984, 16); Roberts (2012, 6f.)

(9) *Context: When you are on the inside and you go into work everyday and you sit down at the desk and then you realize the power you have.*
> Q_{50}: {What power do you have?}
>> $Q_{50.1}$: {Whom can you wire-tap?}
>>> $A_{50.1'}$: [[You$_T$ can wire-tap]$_{BG}$ [the President of the United States]$_F$]$\sim$,
>>> $A_{50.1''}$: [[you$_T$ can wire-tap]$_{BG}$ [a Federal Judge]$_F$]$\sim$.

We now turn to the issue of complex parallelisms, i.e. two subsequent assertions that differ with respect to two syntactic positions.[9] Like in the case

of simple parallelisms, it is again possible to define a common QUD, albeit one containing two *wh*-pronouns (or, at least, a question that expresses variability in two positions). Among the two variable – i.e. focal – positions, one must take precedence over the other. Following Büring (2003), we will call this primary position the *contrastive topic*, the other one the *focus*. Furthermore, each contrastive topic introduces a more specific subquestion. An example is given in (10), in which the subquestions of the main question Q_3 are indicated as $Q_{3.1}$ and $Q_{3.2}$.

(10) Q_3: {Who did what?}
> $Q_{3.1}$: {What did John do?}
>> $A_{3.1}$: [John$_{CT}$ [painted a self-portrait]$_F$]$\sim$
> $Q_{3.2}$: {What did Mary do?}
>> $A_{3.2}$: and [Mary$_{CT}$ [rehearsed a piano sonata]$_F$]$\sim$.

For the sake of completeness – although it will not play a role in the rest of the paper – we briefly sketch our treatment of *not-at-issue* material (more precisely, triggers of *conventional implicatures*), including evidentials, appositions, parentheses, speaker-oriented adverbs and others, cf. Potts (2005), Simons et al. (2010). Generally, we declare some expression to be *not-at-issue* with respect to the current QUD *iff* deleting the expression has no influence on the interpretability and the truth-conditions of the main assertion. As an example, take the evidential phrase *Paul said that* in (11), marked in gray.

(11) Q_{11}: {What is John going to eat?}
> A_{11}: Paul said that [[John$_T$ is going to eat]$_{BG}$ spinach$_F$]$\sim$.

It is crucial to keep in mind that calling an expression *not-at-issue* is merely a statement about its relation to the current QUD. It should not be misunderstood as a negative rating of its relevance to the discourse as a whole. Structurally, we treat not-at-issue content as forming an answer (A_{12}) to a (non-entailed) subquestion, which comes with its own information structure (Riester and Baumann 2013, 221), as shown in (12).

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[9]Researchers working in the SDRT framework might not want to call an example involving CT and F a *parallelism*, since the transition between the two utterances does not license the discourse connector *too*. Instead, at least for some cases, though probably not for all, a CONTRAST relation seems appropriate. What matters for us in this regard is

that the two (or more) assertions containing CT and F might still share some backgrounded linguistic material: *[Fred$_{CT}$ ate$_{BG}$ beans$_F$]$\sim$; [Carl$_{CT}$ ate$_{BG}$ peas$_F$]$\sim$*, which is why we keep using the *parallelism* notion in a broad sense.

(12) Q_{11}: {What is John going to eat?}
  $>$ A_{11}: [John$_T$ is going to eat spinach$_F$]$\sim$.
  $>>$ Q_{12}: {Where does this information come from?}
  $>>>$ A_{12}: [[Paul said]$_F$ ~~it~~$_T$.]$\sim$

4   Construction of QUDs and background-focus structures

Following Kamp (1998),[10] we represent BG-F structures by means of pairs of DRSs (of λ-DRT, Kohlhase et al. 1996), as shown in the lower half of the preliminary DRS for the answer in (3), Figure 2.
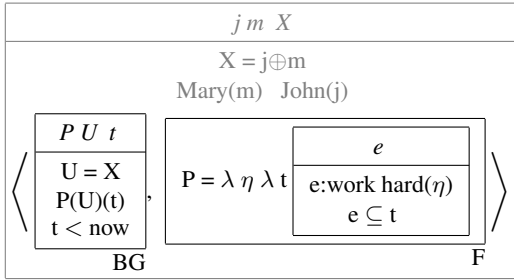
Figure 2:   DRS for A_2:   *[They$_{BG/T}$ [worked hard]$_F$.]$\sim$* (within context)

The first member of this pair represents the background (BG) and the second one the focus (F). The variable P is called the focus-variable and the λ-DRS the focus value. Unification of the two components gives the ordinary meaning of the sentence A_2, and different values for the focus variable P determine its focus alternatives with respect to the first component. The focus alternatives are usually – following Rooth (1992) – claimed to be restricted by a condition C that has to be retrieved from the context in such a way that the alternatives contain at least one other proposition. We have not made this presupposition of focus explicit here, because in cases of parallelism it will be automatically fulfilled and for the other cases we discuss here it wouldn't contribute anything substantial. As the first component of BG-F pairs determines a set of alternatives it also determines the representation of the (implicit) QUD the sentence answers. We only need to let the focus variable be bound by a question operator $\mathcal{Q}$. So, the implicit QUD that A_2 answers will be represented as in Figure 3.[11]

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[10]BG-F structures go back to *Structured Meanings Theory* (von Stechow, 1982; Krifka, 1992).

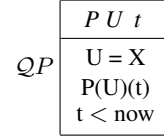[11]For yes-no questions we may assume that P is a polarity operator, i.e. P = λKK or P = λK$\neg$K.

Figure 3: DRS for implicit QUD Q_2: {*What did they do?*}

Our construction of QUDs will, however, be based not directly on DRS-representations but on UDRS-representations (Reyle, 1993). This is necessary, because we need to have access to the different syntactic components of a sentence, which are explicitly present in UDRS representations. Consider (13).

(13) A_2: They worked hard.

The UDRS for (13) is given by the components K_{TENSE}, K_{SUBJ}[12] and K_{VERB}, as specified in Figure 4, with the partial order given in Figure 5. (A more complex example is presented below for sentence (14) in Figures 6 and 7.) The order between the components is such that if a discourse referent occurs free in a component K, then the component in which this discourse referent is declared must dominate K. Temporal information dominates all other components of a clause. A UDRS is turned into a DRS by recursively unifying components bottom-up that immediately dominate each other. As long as there are no scope bearing elements involved the order doesn't matter.[13]
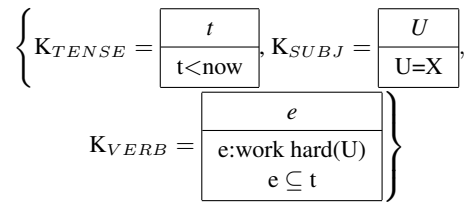
Figure 4: Components of A_2

Givenness

Having constructed the UDRS for A_2 in its context we now look for the maximal set of UDRS-components that are given, i.e. plausibly derivable

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[12]The pronoun *they* is taken to refer to the contextually given X representing *John and Mary*.

[13]The original motivation for UDRT is to have representations that leave the relative scope of quantifiers and other operators underspecified. For details see Reyle (1993).

$$K_{TENSE}$$
$$|$$
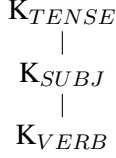$$K_{SUBJ}$$
$$|$$
$$K_{VERB}$$

Figure 5: Partial order on the components

from the current context. This is required by Q-GIVENNESS and MAXIMIZE Q-ANAPHORICITY. Following Asher (1993, 305) we will call this set the *maximal common theme* between the sentence under consideration and its context. We see that K_{SUBJ} is trivially derivable from the context because the referent X is declared in it. K_{TENSE} is derivable too, because simple past presupposes a temporal location time in the past. But no other component may be shown to be given. Hence the relation determined by the complement set of the maximal common theme, i.e. $\lambda\eta\lambda t.K_{VERB}$[14], represents the discourse-new material of the second sentence and determines the focus variable P as provided by the second member of the BG-F pair in Figure 2. The first member of Figure 2 is determined by the merger of the common theme components K_{SUBJ} and K_{TENSE} together with the condition P(U)(t), stating that the focus value is applied to the referential argument U of the subject component and to the time period t.

Parallelism

Suppose we are at step i in the construction of the QUD for discourse $A_1, \ldots, A_n$. Then there are always two options. The first option is to integrate A_i only with respect the previous discourse $A_1, \ldots, A_{i-1}$, as we did just above. However, with this givenness-based method we run the risk of determining too broad a focus, as we already showed in Example (9).[15] The second option is to look ahead and see if there is a parallelism between A_i and A_{i+1}. Let us look at a case of a simple parallelism first.

(14) $A_{3.1'}$: John painted a self-portrait
    $A_{3.1''}$: and ~~he painted~~ a landscape.

The identification of simple parallel sentences as in (14) boils down to finding a non-empty

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[14]The λ-bound variable U has been replaced by η.

[15]From the perspective of speech production, this means that we might sometimes predict the wrong pitch-accent placement.

common theme between the two sentences, here $K_{TENSE} \uplus K_{SUBJ} \uplus K_{VERB}$, where the UDRSs for the two conjuncts of (14) are given in Figure 6, and their order in Figure 7.
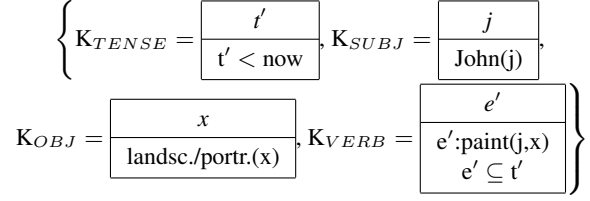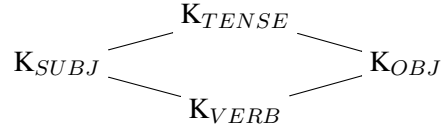

Figure 6: Components of $A_{3.1'}/A_{3.1''}$

Figure 7: Partial order on the components of $A_{3.1'}/A_{3.1''}$

$K_{TENSE} \uplus K_{SUBJ} \uplus K_{VERB}$, the maximal common theme, thus forms the BG and K_{OBJ} specifies the value of a focus-variable x that is newly introduced into the universe of $K_{TENSE} \uplus K_{SUBJ} \uplus K_{VERB}$ and replaces all free occurrences of z in its condition set. For for the second conjunct this gives us the BG-F representation in Figure 8.
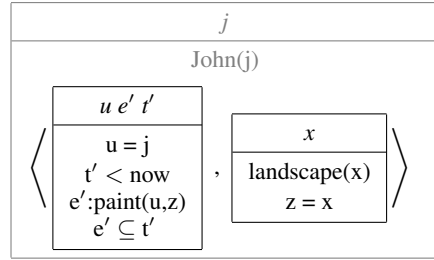

Figure 8: DRS for $A_{3.1''}$: *[[he$_T$ painted]$_{BG}$ [a landscape]$_F$]$\sim$* (within context)

The representation of the first conjunct of (14) is identical to the one in Figure 8, except for the focus variable, which denotes a self-portait and not a landscape. Note that both sentences are now represented as answers to the same question, namely the question that is represented by their first (and identical) components, i.e. *What did John paint?*

We now turn to the case of complex parallelisms. As we said, our notion of parallelism in these cases is not to be confused with the rhetorical relation PARALLELISM as used e.g. in SDRT.

Consider the sequence in Example (15), the information structure of which will be represented by Figure 9.

(15) A_2: John and Mary worked hard last week.
    $A_{3.1}$: John painted a self-portrait
    $A_{3.2}$: and Mary rehearsed a piano sonata.

Figure 9: Information structure of $A_{3.1}$

The occurrences of *John* and *Mary* in $A_{3.1}$ and $A_{3.2}$ are topics. This means on the one hand that we may assume the existence of *subquestions* about the two persons. On the other hand they are contrastive, which means that each of them requires an alternative to be present. In (15) the set of alternatives for the contrastive topics is explicitly given by the group of John and Mary introduced in A_2, but there are also cases where this type of antecedent has to be reconstructed on the bases of two constituents that have been identified as contrastive topics. Our procedure will thus first look for the existence of a structurally isomophic split of the two sentences into the two parts indexed by X and Y in (16).

(16) $A_{3.1}$: [John]$_X$ [painted a self-portrait]$_Y$.
    $A_{3.2}$: [Mary]$_X$ [rehearsed a piano sonata]$_Y$.

We start with the maximal common theme – the BG – of the two sentences; in this case merely the tense information. Furthermore, the BG provides the basis for relating the variable meaning components of X and Y. Let us assume that X is chosen as the sortal key (the contrastive topic) (Büring, 2003) of the two answers $A_{3.1}$ and $A_{3.2}$, and Y functions as the focus. Then, BG is first constrained by identifying the referent of X in $A_{3.1}$ with *John*. This identification is represented in Figure 9 by the CT component. The merger of BG and CT will then result in the BG-F representation of $A_{3.1}$, viz. $<BG\uplus CT,F>$. This structure also identifies the (sub-)question to which $A_{3.1}$ is an answer, namely $\mathcal{Q}P.BG\uplus CT$, the question *What did John do?* This is done in an analogous way for $A_{3.2}$. Finally, the super-question *Who did what?* is determined by BG alone and has, in our case, the form $\mathcal{Q}z\mathcal{Q}P.BG$.[16]

The identification of parallel structures in text is a relatively easy task for a human interpreter. However, we need to say more about how the informal procedure can be made a bit more precise

in an algorithmic form. For the construction of the representation in Figure 9 we proceed as follows. We first build the UDRSs for $A_{3.1}$ and $A_{3.2}$. We will assume that the UDRS representation for the first is given in the form of the already familiar UDRS in Figure 6 and partial order as in Figure 7. The second conjunct has a completely identical structure, with the components shown in Figure 10.

Figure 10: Components of $A_{3.2}$

Then, after having determined K_{TENSE} as the maximal common theme of the two hypothetically parallel sentences, we will *split* the rest of each UDRS, i.e. the set of non-backgrounded components, into two parts, one of which will later represent the focus and the other the contrastive topic. After the split all components in each part are unified (by $\uplus$). The options for splitting are the following (remember that K_{TENSE} is in the background): { K_{SUBJ}, $K_{OBJ}\uplus K_{VERB}$ }, { K_{OBJ}, $K_{SUBJ}\uplus K_{VERB}$ }, { K_{VERB}, $K_{SUBJ}\uplus K_{OBJ}$ }. Note that the splitting must be such that it results in two isomorphic orderings of the resulting UDRSs of the two parallel sentences.[17]

Each element of the split will now be turned into a pair that indicates alternatives to the given meaning, i.e. we form structured representations by introducing a variable that ranges over the semantic type of the component. In Figure 11,

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[16]If, instead, Y is chosen as the sortal key the superquestion is defined in the reverse order of variables $\mathcal{Q}P\mathcal{Q}z.BG$.

[17]For cases as, e.g., *Mary and John went to have a picnic at the seaside. John prepared the lunch. Mary swam.* there cannot be a split of the form { K_{OBJ}, $K_{SUBJ}\uplus K_{VERB}$ } for the second and { K_{SUBJ}, K_{VERB} } for the third sentence. Only 'parallel' splits are possible, i.e. { K_{SUBJ}, $K_{OBJ}\uplus K_{VERB}$ } for the second { K_{SUBJ}, K_{VERB} } for the third.

K_{SUBJ} is split into a variable z ranging over individuals, and the lexical content of *John*; for $K_{OBJ} \uplus K_{VERB}$ we get the type by abstraction over the free variables. After renaming, we thus get P=$\lambda x \lambda t'.K_{OBJ} \uplus K_{VERB}$. The alternatives of P are constrained by applying P to z and t, declared in the other components of the URDS.

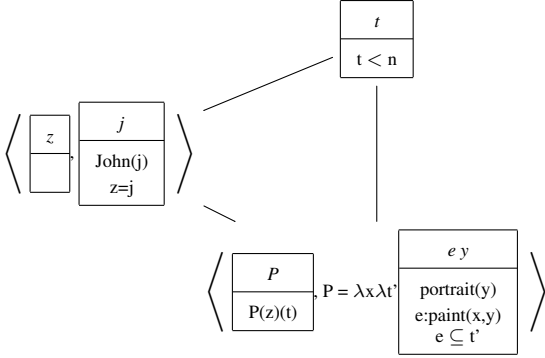Figure 11: URDS of $A_{3.1}$ after splitting into { K_{SUBJ}, $K_{OBJ} \uplus K_{VERB}$ } and structuring the non-backgrounded components

Suppose now, we decide to take the SUBJ to be the contrastive topic and the combination of VERB and OBJ to be the focus, then we will get the final BG-F representation in Figure 9 in the following way. The BG is obtained by unifying the background K_{TENSE} of Figure 11 with the first components of the two structured UDRS components. This is then paired with the second component of the subject, and the result is grouped together with the second component of the VERB-OBJ complex as the final <<BG, CT>, F> representation.

In the final example, (17), we apply the procedure from above to the issue of polarity contrast.

(17) A_5: Yesterday, I talked to John's mother.
$A_{6.1}$ She will praise him.
$A_{6.2}$: I won't ~~praise him~~.

The UDRS structure for $A_{6.2}$ is shown in Figure 12. As above K_{TENSE} can be put into the background. Furthermore, the property of *praising John* is in the background, too. This is represented in the bottom component of Figure 12 by the fact that the variable z ranges over all individuals that the first component of the subject representation may be mapped to. The figure also indicates the structuring of, on the one hand, the subject component (sp representing the speaker) and, on the other hand, of the polarity component.
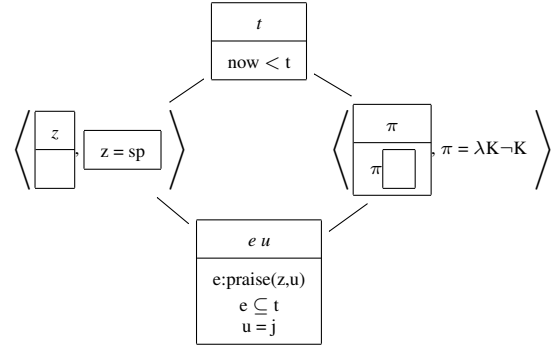

Figure 12: UDRS for $A_{6.2}$

If we want to have a split representation for $A_{6.1}$ in (17), which is structurally similar to $A_{6.2}$, we may introduce a node of the form $\lambda K.K$ (i.e. an identity condition) between its K_{TENSE} and $K_{OBJ} \uplus K_{VERB}$. This will not change the truth conditions of the representation and just serves to make the polarity contrast explicit. If again we take the subject to be the sortal key (i.e. the contrastive topic) we get the following two information-structural representations, in which x is the discourse referent introduced in the first sentence for John's mother.
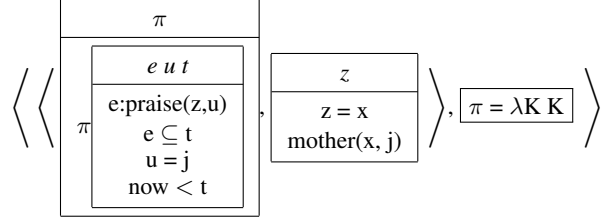

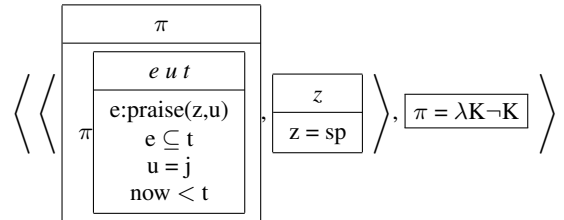Figure 13: Information structure <<BG,CT>,F> of $A_{6.1}$

Figure 14: Information structure of $A_{6.2}$

5 Assembling the QUD tree

Let us now have a look at the discourse as a whole, repeated in (18).
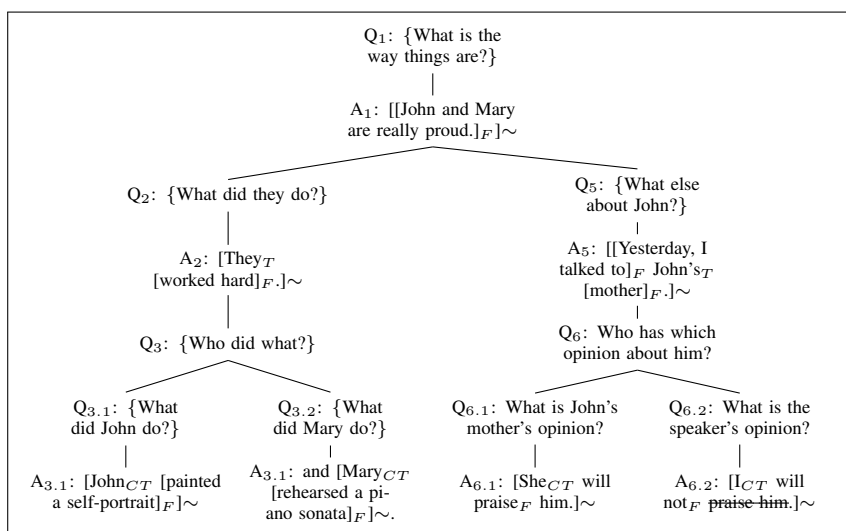
22

Figure 15: Final discourse tree with QUDs

(18) A_1: John and Mary are really proud. A_2: They worked hard. A_3: John painted a self-portrait A_4: and Mary rehearsed a piano sonata. A_5: Yesterday, I talked to John's mother. $A_{6.1}$ She will praise him. $A_{6.2}$: I won't ~~praise him~~.

As we said, each new assertion A_i is either processed against the existing discourse context (thereby determining the background as its given material, and its QUD Q_i as a congruent question which shares with A_i the same background) or might, alternatively, be processed in a forward-looking manner against some following assertion. In the latter case, the QUD and the background constituent are identified as the maximal common material of two parallel assertions.

After it has been determined, each Q_i is inserted as a node in the tree right above A_i; in the parallel case, the two (or sometimes more) parallel assertions $A_{i'}$ and $A_{i''}$ will become sibling nodes of the QUD node. Attachment is only possible at the *Right Frontier* (Asher and Lascarides, 2003), i.e. below any of the nodes at the right edge of the existing tree. The exact attachment site is determined based on the given information within Q_i.

This means, in particular, that any content in the discourse context that is not at the right edge does not count as given in the information-structural sense. The corresponding constraint is the following one:

Attachment constraint (Back-to-the-Roots)
A QUD (and its answers) must attach below any antecedent of its given content, and otherwise as high as possible.

The final tree analysis is shown in Figure 15.

6 Conclusions

In this paper, we have argued that QUDs constitute a vital part of discourse trees that allow us to jointly analyze the information structure and discourse structure of text. The procedure does not rely on the use of discourse relations. It remains to be seen whether the outcome of our analyses is generally comparable to the analyses from other approaches to discourse structure such as SDRT but, in any case, we think that a discourse should have precisely one discourse structure. Finally, by only referring to the semantic content – and not to particular morpho-syntactic or prosodic properties – of discourse, we argue that the procedure will also be applicable in a cross-linguistic setting.

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