Multi-level disourse relations between dialogue units

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Abstract

In order to analyse what happens in dialogue it is insufficient to consider the content of its segments in isolation. In this paper we propose a meta-model for integrating discourse relations into a standard framework of dialogue act annotation (Bunt et al., 2010), considering in particular the various discourse units involved and the nature of their relations.

1 Introduction

In discourse modelling, we need discourse units and relations betweeen them. This is uncontroversial, but the nature, the purpose and the definitions of units in discourse and their relations are the subject of much controversy (see e.g. Hovy, 1990). To the rhetorical relations identified in monologue (e.g explanation, justification, cause,...), dialogue adds relations such as those between a question and an answer, and between an utterance and feedback about its understanding.

Many frameworks for discourse analysis have attempted to capture discource coherence by integrating all discourse segments into a single structure thanks to discourse relations. Although this has not always been made explicit, the assumption that there is a single "coherence" dimension is strong in many frameworks (Hobbs, 1985; Mann and Thompson, 1988; Asher and Lascarides, 2003). Grosz and Sidner (1986), followed by Moore and Pollack (1992), on the other hand argued for the interplay between several structures to explain discourse phenomena. Petukhova and Bunt (2009) have shown that discourse markers are in general multifunctional, thus requiring a multidimensional approach.

In this paper we propose a meta-model for integrating various types of discourse relations into a standard framework of dialogue act annotation

(Bunt et al., 2010), considering in particular the various discourse units involved and the nature of their relations.

This paper is organized as follows. First, we briefly review the literature on discourse structure (Section 1.1). We describe the relevant aspects of the semantic framework that we will use to study relations between different types of dialogue units in Section 2. Section 3 discusses dialogue units, while the semantic relations between them are discussed Section 4. Section 5 presents an empirical analysis of the scope of different types of semantic discourse relations and of the distances between related segments in two different types of dialogue. Section 6 concludes by summarizing the analysis in a meta-model and outlining perspectives for further research.

1.1 Previous work on discourse structure

A variety of frameworks for modelling discourse structure have been proposed since Hobbs (1979). While Van Dijk (1979) and Polanyi (1998) have attempted a quasi-syntactic approach, most frameworks are more functional and rely on interpretation for deriving a structure of discourse. Relations between discourse segments have in these frameworks been divided into several categories: semantic/ inter-propositional/ ideational/ content-level/ information-level; pragmatic/ intentional/ cognitive/ speech-act; presentational/ structural/ textual; see Hovy et al. (1998) for a discussion of the different categories.

Discourse relations can apply to segments of various size, from syntactic clauses to paragraphs. When considering dialogue, the picture gets even more complicated, with units specific to their interactive nature, such as speech-turns. Some researchers distinguish between macro-, meso- and micro-levels in discourse structuring (e.g. (Nakatani and Traum, 1992) and (Louwerse and Mitchell, 2003)), where the *micro-level* is con-

cerned with relations within a turn or within a single utterance; the *meso-level* concerns relations involving complete contributions in Clark's sense (Clark, 1996), typically an initiative and a reactive, corresponding to grounding units; and the *macro-level* is concerned with entire subdialogues, topic structure and elements of a plan-based analysis.

Although often cited as a crucial issue for linguistics and NLP, discourse structure frameworks face the problem of their empirical validation. It is mainly to address this issue that several discourse annotation projects undertaken have been undertaken in recent years (Carlson et al., 2001; Wolf and Ginson, 2005; Miltsakaki et al., 2004; Reese et al., 2007; Stede, 2008; Prasad et al., 2008). These ambitious projects share a common goal but differ greatly with regard to their theoretical assumptions. A more generic approach to the analysis of these relations would therefore be of great help for comparing and perhaps combining these accounts.

2 Semantic framework

Participants in dialogue produce utterances in order to provoke change in their addressees, and dialogue utterances can therefore be viewed as actions with intended state-changing effects on 'information states' (Poesio and Traum, 1998; Larsson and Traum, 2000; Bunt, 2000). Such communicative actions are called *dialogue acts*, and have two main components: a *semantic* (referential, propositional, or action-related) *content* and a *communicative function*, which specifies how an addressee is intended to update his information state with the semantic content.

In this study we use the semantic framework of Dynamic Interpretation Theory (DIT, Bunt, 2000), which takes a multidimensional view on dialogue in the sense that participation in a dialogue is viewed as performing several activities in parallel, such as pursuing the dialogue task, providing and eliciting feedback, and taking turns.

The DIT framework supports a 'multidimensional' semantics by relating context update operators to different compartments of structured context models which include, besides information states of the usual kind (beliefs and goals related to a task domain), also a dialogue history, information about the agent's processing state, beliefs about the dialogue partners' processing states, information and goals concerning the allocation of

turns, and so on, relating to the various 'dimensions' that dialogue acts belong to. The interpretation of a multifunctional stretch of communicative behaviour corresponds to updating the context models of the communicating agents in multiple ways, combining the effects of each of the component functions.

3 Units in dialogue

The assignment of meanings to certain units in dialogue and the description of relations between them presupposes a way to segment a dialogue into meaningful units. Dialogues can be decomposed into *turn units*, defined as stretches of speech produced by one speaker, bounded by periods of silence of that speaker. Turns can be quite lengthy and complicated, and for most purposes are too coarse to consider as semantic units. Turns may consist of one or more *utterances*. Utterances are linguistically defined stretches of communicative behaviour that have one or multiple communicative functions. The stretches of behaviour that are relevant for interpretation as dialogue acts often coincide with utterances in this sense, but they may be discontinuous, may overlap, and may even contain parts of more than one turn. Communicative functions can be assigned more accurately to smaller units, called *functional segments*, which are defined as the functionally relevant minimal stretches of communicative behaviour (Geertzen et al., 2007).

There are other types of units in dialogue that are relevant for the analysis of relations in dialogue. Dialogue participants indicate their view of the state of the dialogue and make the hearer acquainted with his plans for the continuation of the conversation. Structuring the conversation is an important task in dialogue, which typically starts with an opening and finishes with some closing acts, and in between involves trying to go smoothly from one part to another, from one sub-task to another. In the literature such larger dialogue units are often called *topics* or *sub-tasks*; we will refer to such dialogue blocks as *discourse units*. (This notion of 'discourse unit' is not the same as the notion of 'discourse unit' proposed by (Traum, 1994) for describing grounding in dialogue, which refers to units which consists of an initial presentation and as many utterances as needed to make this act mutually understood. In some cases the two notions do coincide, but not in

general.)

4 Relations between dialogue units

4.1 Functional dependence relations

Dialogue acts are often semantically dependent on one or more dialogue acts that occurred earlier in the dialogue, in the sense that their semantic content can only be determined by taking the semantic content of these preceding dialogue acts into account. This is for example the case for answers, whose meaning is co-determined by the question which is being answered. The example in (1) illustrates this, where the interpretation of A1 clearly depends very much on whether it is an answer to the question B1 or to the question B2.

(1) A1: I'm expecting Jan, Alex, Claudia, and David, and maybe Olga and Andrei.
B1: Do you know who's coming tonight?
B2: Which of the project members d'you think will be there?

Such a semantic relation between dialogue acts has been called a 'functional dependence relation' (Bunt et al., 2010), and is defined as follows:

(2) *A functional dependence relation exists between a dialogue act DA_1 and a previous dialogue act DA_2 if determination of the semantic content of DA_1 requires the semantic content of DA_2.*

The previous dialogue act whose semantic content is needed, like DA_2 in (2), to determine the semantic content of a given dialogue act is called the 'functional antecedent' of that dialogue act. The marking up of the links to functional antecedents allows the annotation to express not just that an utterance is an answer, but also to express to which question it is an answer.

4.2 Rhetorical relations

Rhetorical relations have been proposed as an explanation for the construction of coherence in discourse (Hobbs, 1985; Mann and Thompson, 1988; Asher and Lascarides, 2003; Sanders et al., 1992). The idea is that two text segments or sentences in written discourse, or two segments or utterances in dialogue, are linked together by means of certain relations, for which various terms have been used such as 'rhetorical relations', 'coherence relations', or 'discourse relations'.

A range of taxonomies have been proposed in the literature to define relations in discourse. The well-known set of relations and their organization proposed by Mann and Thompson (1988), forming the core of Rhetorical Structure Theory, consists of 23 relations. This set is, however, not definite and not closed. Hovy and Maier (1995) studied approximately 30 alternative proposals and fused the various taxonomies into more than 400 relations. They proposed a hierarchical taxonomy of approximately 70 relations which are more or less strongly semantic in nature (see Appendix in (Hovy and Maier, 1995)).

Some rhetorical relations, such as *Explanation, Justification*, and *Cause* are clearly semantic, whereas others, like *First, Second,... , Finally; Concluding* are more presentational in nature. The occurrence of truly semantic rhetorical relations is illustrated in example (3) from the AMI corpus[1], where participant A talks about remote controls:

(3) A1: You keep losing them
A2: It slips behind the couch or it's kicked under the table

The events described in these sentences are semantically related by *Cause* relations: *Cause* (slipped; keep_loosing) and *Cause* (kicked; keep_loosing). In cases like this the two sentences are related through a rhetorical relation between the events they contain.

Contrary to what is sometimes believed, semantic rhetorical relations are not always relations between events. Consider the following example, where A and B discuss the use of remote controls:

(4) A: You keep losing them
B: That's because they don't have a fixed location

In this example the 'event' in the second utterance (*having a fixed location*) does not cause the *losing* event in the first utterance; on the contrary, the second utterance says that the fact that *no* having-a-fixed-location event occurs is the cause of the *losing*. Saying that a certain type of event does not occur is not describing any event, but expressing a proposition about that type of event. This means that the causal connection between the two utterances is not between two events, but between the *proposition* made in the second utterance and the event in the first utterance. In this paper we will use the term 'inter-propositional relation' for rhetorical relations between the semantic contents of two dialogue acts.

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[1]See http://www.amiproject.org/

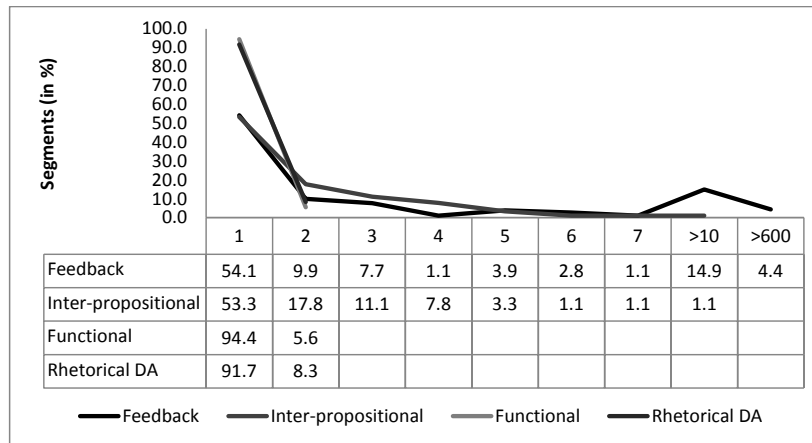|	1	2	3	4	5	6	7	>10	>600
Feedback	54.1	9.9	7.7	1.1	3.9	2.8	1.1	14.9	4.4
Inter-propositional	53.3	17.8	11.1	7.8	3.3	1.1	1.1	1.1	
Functional	94.4	5.6							
Rhetorical DA	91.7	8.3							

Figure 1: Scope of feedback dependence, functional dependence and rhetorical relations observed in the AMI data.

In dialogue, utterances may be related through rhetorical relations between the *dialogue acts* which they encode. The following examples[2] illustrate this:

(5) A1: Where would you physically position the buttons?
A2: I think that has some impact on many things

(6) B1: Make it very quickly
B2: Because we're supposed to finish this

Utterance A2 in (5) encodes an Inform act which has an *Motivation* relation to the question encoded in A1; it tells the addressees what motivated A to ask the question A1. In (6) utterance B2 encodes an Inform act which has an *Explanation* relation to the Instruct act in B1. Note that in both cases there are no rhetorical relations between the events described in these utterances.

4.3 Feedback dependence relations

Feedback acts in dialogue provide or elicit information about the processing of something that was said earlier, and refer explicitly or implicitly to the relevant segment, as in example (7), or to its interpretation, as in (8)[3]:

(7) A1: Is this flight also available on Thursday?
B1: On Thursday you said?

(8) D1: Twelve fifty is that whole sale or retail like on the shelf?
B1: That's a good question

Being concerned with the perception of what A said, the feedback act in (7B1) refers to the preceding utterance; in (8) the feedback act is at the

level of evaluating what speaker D has said, thus referring to the interpreting of the preceding utterance as a certain type of dialogue act.

(Allwood, 1992) argues that feedback morphemes and mechanisms, whether they occur as a single utterance or as part of a larger utterance, are probably the most important cohesion device in spoken language. This type of dependence relation is called a *feedback dependence relation* (Bunt et al., 2010).

(9) *A feedback dependence relation is a relation between a feedback act and the stretch of communicative behaviour whose processing the act provides or elicits information about.*

A feedback act does not necessarily refer to a single utterance, but may also relate to a larger stretch of dialogue; even to the entire preceding dialogue, like the global positive feedback expressed by a pre-final *Okay*. The scope and distance that may be covered by the various kinds of relations in discourse are analysed in the next section.

5 Scope and distance

While a feedback dependence relation can target an utterance, a functional segment, a dialogue act, a turn unit, or a part or a group of those, functional dependence and rhetorical relations are grounded in meaning and follow more restricted patterns of linking units in dialogue. We investigated the linking patterns of the different types of relations for two corpora of annotated dialogues, the AMI meeting corpus and a French two-party route explanation dialogues collected at the University in
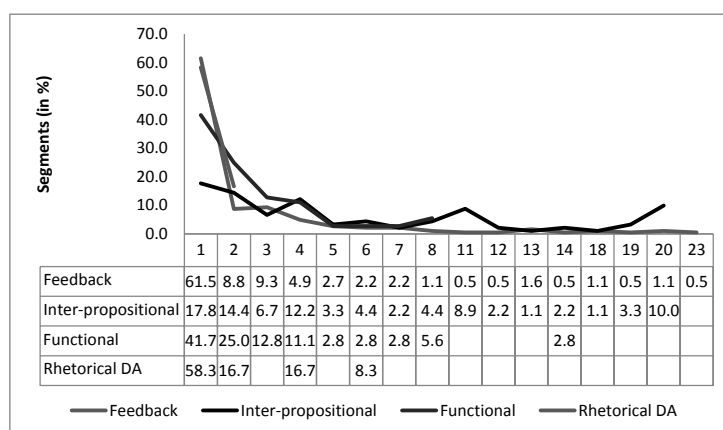
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[2]From the AMI meeting corpus - ES2002a.
[3]From the AMI meeting corpus - ES2002a.

Figure 2: Distance of feedback dependence, functional dependence and rhetorical relations observed in the AMI data.

	1	2	3	4	5	6	7	8	11	12	13	14	18	19	20	23
Feedback	61.5	8.8	9.3	4.9	2.7	2.2	2.2	1.1	0.5	0.5	1.6	0.5	1.1	0.5	1.1	0.5
Inter-propositional	17.8	14.4	6.7	12.2	3.3	4.4	2.2	4.4	8.9	2.2	1.1	2.2	1.1	3.3	10.0	
Functional	41.7	25.0	12.8	11.1	2.8	2.8	2.8	5.6				2.8				
Rhetorical DA	58.3	16.7		16.7		8.3										

—— Feedback   —— Inter-propositional   —— Functional   —— Rhetorical DA

Aix-en-Provence[4].

For analysing these patterns it is helpful to look at the *scope* and *distance* covered by a relation, which we define as follows:

- the scope of a discourse relation is the number of functional segments (called the *target*) that a given segment (called *source*) is related to;

- the distance covered by a discourse relation is the number of functional segments between the source and the target segments.

Our analyses shows that four types of attachment in term of distance and scope can be distinguished for the way in which discourse relations connect a source segment to other units in dialogue:

1. Last segment: A relation links the source segment to the previous functional segment: both scope and distance are 1.

2. Local attachment: The source segment has several relations of the same type to segments within the current or preceding discourse unit. The scope of each relation is 1; at least one of the relations has a distance 1, and at least one has distance greater than 1. For example, the next step of a narration introduces a contrast with the preceding segment, while elaborating an earlier segment.

3. Local wide scope attachment: The relation targets a group of segments within the current or preceding discourse unit. The scope is larger than 1, the distance is 1. This is the common with relations such as *Recap*, *Summarize*, *Conclude*.

4. Discourse pop-up: The source segment is related either to a clearly identified earlier segment or to an earlier part of the dialogue (e.g. a group of turn units or a group of discourse units) to which it is only loosely semantically related. Both scope and distance are greater than 1.

Figure 1 shows the scope and Figure 2 the distance for functional and feedback dependence relations, and for inter-propositional and rhetorical relations between dialogue acts observed in the AMI corpus.

Attachments of type 1 occur frequently (29.8% of all attachments in the AMI corpus). For example[5]:

(10) D1: Cost like production cost is twelve fifty or retail like on the shelf?
      B1: Our sale anyway
      B2: Because its probably up to the retailer to sell it for whatever price they want

Segment B1 is an Answer to the Choice Question in D1, and segment B2 provides a Justification for the Answer in B1.

Attachments of type 2 are more complicated. Such attachments are frequently observed in the AMI data and account for 41.5% of all attachments. For example[6]:

(11) D1: Now remote controls are better
      D2: but actually still kind of like a massive junky thing [Contrast:D1]
      B1: Still feels primitive [Elaboration:D2;Contrast:D1]

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[4]For more information see (Muller and Prévot, 2003).

[5]From the AMI meeting corpus - ES2002a.
[6]From the AMI meeting corpus - ES2002a.

The fact that the related segments are produced by different speakers has a consequence that they exhibit not only rhetorical but also feedback dependence relations by implication, e.g. the expression of Agreement in B1 implies positive feedback on understanding D2.

Local wide scope attachment is frequently observed for feedback dependence relations. Very often feedback is provided not to a certain functional segment but to discourse units that are concerned with one of the dialogue sub-tasks or topics. This occurs frequently in multi-party dialogues (19.2% in the AMI meetings). Both positive and negative feedback are observed to sometimes have local wide scope attachments. For example[7]:

(12) B1: We're gonna be selling this remote control for twenty five euro
     B2: and we're aiming to make fifty million euro [Narration:B1]
     B3: so we're gonna be selling this on an international scale [Elaborate:B1&B2]
     B4: and we don't want it to cost more than twelve fifty euros [Narration:B3]
     D1: Okay [PositiveFB:B1-B4]
     B5: So fifty percent of the selling price [Conclude:B3&B4]
     D2: Can we go over that again [NegativeFB:B1-B5]

Feedback elicitation acts may also have local wide scope. Examples are: *Does anybody have anything to add to the finance issue at all?*, *Anybody anything to add here?* and *Any thoughts about this?*. This is often happens when moving from one topic to another.

Muller and Prévot (2003) have shown that in French route explanation dialogues, *voilà (that's it)* is a marker of closure, thus being some kind of wide-scope feedback (type 3) preparing a discourse pop-up of type 4. For example[8]:

(13) B1: So I guess that's it
     D1: Great
     B2: The meeting is over
     B3: Whoohoo

Rhetorical relations may also have scope over larger units, like discourse units. Concerning rhetorical relations like *conclude*, *recap*, and *summary*, it may be noticed that a conclusion, a recap, or a summary is often not expressed by a single dialogue act but by a discourse unit. In such a case, we need to allow for rhetorical relations between discourse units. For example, in

AMI meeting ES2002b after a discussion stretching over some 150 segments about the functionality to be included in a remote control, the participants came to a conclusion proposed in D1-D9 and acknowledged in B5-C2:

(14) D1: Well we want this to be a product that offers simple and all the sort of more tricky features
     D2: but we want them to be in another area
     B2: Think what we absolutely have to have and what would be nice
     B3: To recap you've got volume and channel control
     C1: There's on and off
     B4: Volume and channel and skip to certain channels with the numbers
     D3: rarely used functions may be in a little area but covered up
     D4: things like channel and volume are used all the time
     D5: We just have them right out on top
     D6: so we need to think about having three or more groupings of controls
     D7: like one which are the habitual ones that should be right within your natural grip
     D8: ones that with available features
     D9: And then others with concealed
     B5: Okay
     B6: Any of you anything to add to that at all?
     A1: No
     C2: No

Discourse pop-up attachments are especially observed for feedback dependence relations. Consider the following example[9]:

(15) G13: hop hop hop Esquirol tu continues tout droit (hop hop hop Esquirol continue straight)
     G14: y'a le Classico (there is the Classico)
     R15: euh (uh)
     G16: t'as pas l'air branché trop bars (you do not seem to be into bars)
     R17: euh non (uh no)
     R18: mais je connais pas très bien Toulouse (but I don't know Toulouse very well)
     G19: ah ouais d'accord (ah yeah ok)
     G20: donc Les Carmes tu vois ou c'est? (so Les Carmes, you know where it is?)
     F21: oui (yes)
     G22: bon ben voilfa. (well that's it)
     G23: donc là tu continues sur sur cette rue (so there you continue on this street)
     G24: et tu arrives aux Carmes (and you get to Les Carmes)

Segment G22 concludes and closes discourse unit [G14-G21], and there is a Continuation/Narration relation between G13 and G23.

Discourse markers have been studied for their semantic contribution and for their role in dialogue structuring, as discussed above. Many discourse markers are good indicators for various kind of discourse attachment. Most connectives (*then, but, therefore*) connect minimal units with

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[7]From the AMI meeting corpus - ES2002a.

[8]From The AMI meeting corpus - ES2002b.

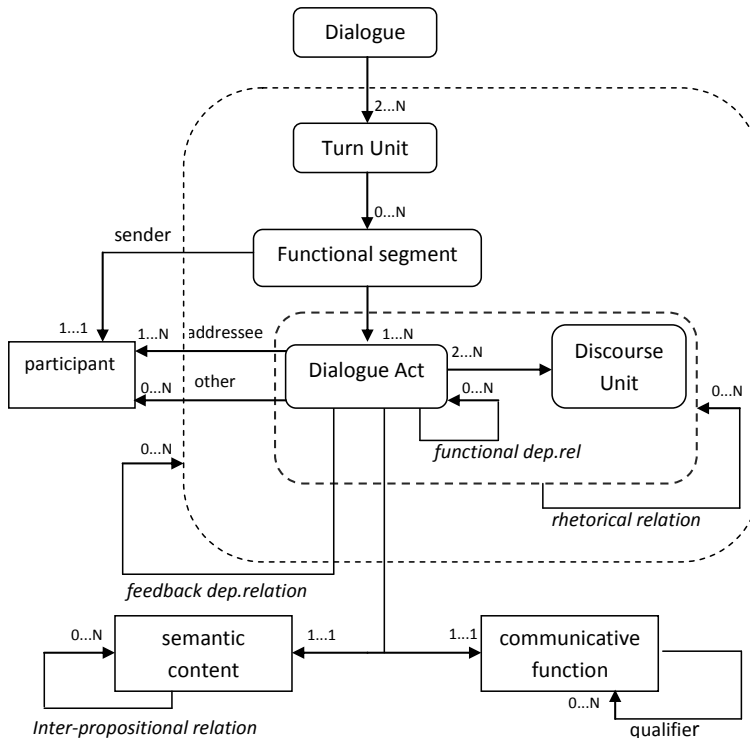[9]From the French route navigation corpus.

Figure 3: Metamodel of dialogue units and relations between them.

attachment of type 1 or 2. Enumerative markers such as (*First, Then, Finally*) can introduce macro-structures resulting in both long-distance and local wide-scope attachment, since usually the entire discourse unit that contains these markers is rhetorically related to another discourse unit.

Our analyses clearly show that different relations exhibit different patterns with respect to attachment. As Figures 1 and 2 show a functional dependence relation normally has a narrow scope (1-2 functional segments), and units related by this type of relation tend to be close to each other in discourse, except in the case of discourse pop-up units. Feedback dependence relations as a rule have either very narrow or local very wide scope; long-distance attachments are rare. Feedback acts can target all types of dialogue units that we have defined: other dialogue acts, turn units, functional segments and discourse units, as well as groups of those. Rhetorical inter-propositional relations have often narrow scope but the related segments may be some distance away from each other. Rhetorical relations between dialogue acts are characterized by (as a rule) narrow scope and short distance, but some rhetorical relations (like *Recap, Conclude*) often link a dialogue act or a discourse unit to one or more discourse units, hav-

ing a wide scope. Figure 3 shows an ISO-style metamodel (cf. Bunt et al., 2010) containing the various kinds of units in dialogue and the possible relations between them.

6 Conclusions and future research

In studying the occurrence of discourse relations in dialogue, we have observed at least four types of relations: rhetorical relations between dialogue acts or between their semantic contents (inter-propositional rhetorical relations); feedback dependence relations; and functional dependence relations between dialogue acts. Some of these relations may also involve larger units or groups of those, and we have seen that the various kinds of relation show significant differences in scope and distance of attachment.

In future studies of the properties of discourse relations in dialogue, such as their scope and distance, it may be useful to distinguish between the semantic and presentational dimensions of rhetorical relations. It may also be noted that the metamodel in Figure 3 has been designed in such a way that it is an extension of the metamodel for dialogue act annotation used in ISO DIS 24617-2 (see Bunt et al., 2010). According to the dialogue act-theoretical framework that we have used, the

semantic content of a dialogue act is typically either an eventuality or a proposition. Adding this distinction to the metamodel would open the way for connecting with the metamodels used in ISO projects concerned with the semantic annotation of time and events, space, and semantic roles, which could be very helpful for clarifying the relations between the semantic phenomena targeted by these projects.

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