Representing Clarification Dialogues in a Speaker/ Hearer Model

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Abstract
This paper shows an extended Discourse Representation Theory (DRT) model which represents clarification dialogue and clarification dialogue acts and relates them to agents’ intentions. Agents’ intentions are linked to the dialogue acts associated with their utterances. The effect dialogue acts have on the speaker and the hearer is translated into an extended computational DRT model and linked to agents’ beliefs. These extensions to DRT allow the demonstration of problematic dialogues that require clarification, a topic neglected in DRT.

1. Introduction
In natural dialogue, hearers are often uncertain about their interpretation of the speaker’s utterance, and request clarification. The important topic of dialogues that are problematic in this sense, what we call here clarification dialogues, has been dealt with both in formal semantics (Ginzburg and Cooper 2001, 2004) and in Conversation Analysis (Schegloff 1987). However, clarification in DRT has been neglected in the literature (Kamp 1984; Kamp and Reyle 1993; Kamp et al. 2005).

As there are different kinds of clarification requests and indeed different possible interpretations of utterances (Purver et al. 2003a; Purver et al. 2003b; Purver 2004), clarification can be initiated for different reasons, and in different forms. Examples (1), (2), (3) and (4) demonstrate how clarification requests can have different forms.

(1) A: Did Tom give a talk?
B: Did Tom give a talk?

(2) A: My neighbour is stalking me.
B: Stalking you?
A: Stalking me.

(3) A: Black Eyed Peas’ new album is called Monkey Business.
B: Monkey?
A: Business.

(4) A: I need to buy some pots and
B: mmm

A: erm
B: pans?
A: pans.

Clarification requests can arise due to problems with consistency and the ‘cognitive aspects’ of context (Bunt 1994). For example,

(2) S1: Fairuz is singing at the Helix this weekend.
H1: That’s nice.
S2: You should get tickets for your wedding anniversary.
H2: Did you say it was this weekend?
S3: Good grief dad, yes, I’ve been talking about this all week.
H3: Oh alright then.

In this example, the father is asked to commit to a course of action, i.e. buy tickets for his wedding anniversary. The degree to which he believes ‘Fairuz is singing at the Helix this weekend’ becomes more significant than merely going along with what his daughter is saying.

(5) A: Mary is in love with Richard.
B: How come? I thought Mary is in love with Tom.

Here, B’s beliefs contradict A’s belief about who Mary is in love with, which causes B to request a clarification. Moreover, the presupposition of ‘remarkable’ or ‘out of the ordinary’ information (Geurts 1999) can give rise to clarification requests. For example,

(6) Speaker: My pet lion requires a lot of attention.
Hearer: Your pet what?

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1 The global aspects of the ‘cognitive context’ are the overall communicative goals of participants, and their overall beliefs, attitudes, intentions and the plans of participants that influence their processing, perception and production. Local aspects of the cognitive context are the current beliefs, plans, intentions and attitudes that are affecting the underlying task and the continuing of communication and current active topics (Bunt 1994).
Speaker: Oh sorry, I mean one of those virtual pets you take care of. This time the hearer requires an explanation for the oddness of the given information, having a pet lion.

Other reasons for clarification may deal with the 'physical aspects' of the context (Bunt 1994). These problems have to do with agents’ processing or perception of utterances. If the speaker’s utterance is not clear, the hearer may ask the speaker to clarify her statement. As a simple example, consider a dialogue between a customer and customer service assistant about a gas heater:

(7) Customer: How long does it take to fix my gas heater?
    Customer Service Assistant: Your what?
    Customer: My gas heater needs fixing.

In example (7) the customer service assistant asks the customer to clarify. In this particular case, the lack of clarity may be attributed to, e.g. not hearing very well. The hearer expects the speaker to provide an explanation, which the speaker is then obliged to provide. If the information is still not clear, the hearer may ask for more clarification and the hearer needs to provide it. This is consistent with conversation analysis research, which assumes that information may be cleared up after an explanation is provided, but also allows for further clarification if needed (Schegloff et al. 1977). If the information is clarified, then the hearer may provide feedback that the information is clear (Bunt 2000). This will be explored further in section 2. Lack of feedback is also considered a form of ‘weak positive feedback’ (Al-Raheb 2005). Generally, after providing an explanation, the speaker’s assumptions are likely to be that the hearer now has no problems with the utterance.

The following section, 2, presents the effects that clarification dialogues and their dialogue acts (Bunt 2000) have on agents’ beliefs. Section 3, briefly outlines the extensions to DRT needed to represent clarification dialogues. This is followed by a representation of a clarification dialogue in the extended DRT format in section 4.

2 ‘Physical aspects’ of the context include, globally, physical circumstances such as place and time and whether the communication is face-to-face or mediated through a communicative channel and locally, the current availability of communicative channels and the availability of the partner at the communicative device (Bunt 1994).

2. Clarification and Agents’ Beliefs

Al-Raheb (2005) argues for the need to represent different degrees or strengths of beliefs according to context. Beliefs also change in response to new information. Agents in a dialogue may form stronger beliefs as the dialogue progresses, requiring moving the content of their weaker beliefs to the stronger belief Discourse Representation Structure (DRS). Furthermore, there is a further belief state, namely, acceptance, the state in which weaker beliefs are placed. When accepted, in this sense, clarified information carries less weight than already believed information.

Thus, in order to realistically model changes to beliefs, as well as the effects of clarification dialogue acts on beliefs, some principles of degrees of belief have been formulated. These principles relate to both Speaker and Hearer, and are outlined separately in the following subsections.

Hearer Degrees of Belief Principles

Principle 1: If the hearer already believes a proposition, and the speaker produces the same proposition, nothing changes in the hearer’s beliefs.

Principle 1 deals with the case where the hearer already has the strong belief about the proposition the speaker is making. In this case, when hearing the same proposition again, the hearer’s beliefs do not change. This is somewhat different for assertions (as distinct from presuppositions), where the speaker may have mistakenly introduced a proposition as an assertion (rather than as a presupposition) and the hearer already believes the proposition.

Principle 2: If the hearer accepts a proposition, and the speaker makes a claim that expresses the same proposition, the hearer’s weak belief is strengthened, and it becomes a strong belief.

Principle 2 covers the case where the hearer has previously accepted a proposition and subsequently that proposition is strengthened by virtue of the speaker’s making an utterance which makes it clear that she believes the proposition. In the extended DRT representation, the proposition moves from the hearer’s acceptance DRS to the hearer’s belief DRS.

Principle 3: If a proposition is uttered by the speaker is new to the hearer, and the hearer decides not to
reject it, the default case is for the hearer to initially accept it.

Principle 3 refers to the case where the hearer holds no beliefs about the proposition prior to the speaker’s uttering it. If the proposition is not rejected by the hearer, it is suggested that the hearer accepts the proposition initially. The proposal that acceptance be considered a default case is also found in Clark and Schaefer (1989).

Principle 4: If a hearer accepts a proposition and the proposition is used again by the speaker, the hearer may attach more strength of belief to the proposition.

Principle 4 is called for when the hearer has initially accepted a proposition uttered by the speaker, and the speaker has since repeated it more than once. In this case, the hearer may strengthen his belief about that proposition. The principle assumed here is that the more a proposition is repeated, the stronger its belief status for the hearer becomes. The proposition now moves from the acceptance DRS to the belief DRS. Generally with a new proposition, the transition of beliefs takes place from the state of accepting to the state of believing. In cases of clarification, the transition takes place from the state of not believing to the state of initially accepting then eventually believing. Principle 4 is a very simplified rule as to how soon human agents decide to strengthen their beliefs about new propositions in order to make it computationally viable. This paper does not speculate as to how that decision is made.

It is also possible to ‘revise’ beliefs that are later doubted by removing them from the belief DRS and adding them to the acceptance DRS. If propositions are falsified, they can be removed from either acceptance or belief DRSs.

Principle 5: If a hearer believes a proposition and later utterances throw some doubt on the proposition, the hearer can ‘downgrade’ the strength of belief to acceptance or reject them altogether.

It is not within the scope of this paper to deal with issues relating to trust, authority, social standing, experts, etc., all of which affect the process of strengthening (or possibly weakening) beliefs. For example, one is more likely to adopt a proposition about global warming coming from an expert on the subject than from an uneducated retired boxer.

Speaker Degrees of Belief Principles

In dialogue it is reasonable to assume that speakers make assumptions about their interlocutor’s belief sets. Feedback (Bunt 2000) helps the speaker infer what the state of beliefs of the hearer is, in particular, the degree of their beliefs. Accordingly, this paper has developed simplified principles, Speaker Degrees of Belief Principles, which correspond to the Hearer Degrees of Belief Principles outlined above.

Principle 1: If the speaker makes an utterance about a proposition and the hearer provides no feedback, i.e. ‘weak positive feedback’, the speaker infers the hearer accepts the proposition.

Principle 2: If the speaker makes an utterance about a proposition and the hearer provides ‘weak positive feedback’, e.g. ‘aha’, ‘okay’, ‘yeah’, the speaker infers the hearer accepts the proposition.

Principle 3: If the speaker makes an utterance about a proposition and hearer provides ‘strong positive feedback’, e.g. ‘I totally agree’, the speaker infers the hearer believes the proposition.

Principle 4: If the speaker makes an utterance about a proposition, which the hearer accepts, and uses more than once in his utterances, the speaker infers the hearer now believes the proposition.

Principle 5: If the speaker makes an utterance about a proposition, which the hearer accepts, and then the hearer commits him- or herself to performing an action related to the proposition, the speaker infers the hearer now believes the proposition.

In the DRT representation of the hearer, the proposition moves from the hearer’s acceptance DRS to the hearer’s belief DRS in the speaker’s representation of the hearer’s acceptance and belief DRSs. The Principles are used as guidelines for the speaker to make inferences about the hearer’s state of mind. It is by no means an exact model of how human agents make inferences about degrees of belief, but rather a formalized approximation of this process’s effects.
3. Extending DRT to Model Clarification Dialogue

Two DRT variants derived from Kamp et al. (2005) are merged and extended in order to appropriately model clarification dialogues. The extensions to DRT model agents’ intentions and link them to dialogue acts. DRT structure is extended to represent different agents, their beliefs (distinguishing ‘strong’ and ‘weak’ beliefs), their intentions and the dialogue acts associated with their utterances. New DRSs are created to represent the agent’s strong beliefs and beliefs about the other agent’s beliefs, ‘Belief DRS’, as well as their intentions, ‘Intention DRS’. A new DRS is introduced to represent weaker beliefs, called ‘Acceptance DRS’. To refer to these DRSs, new DRS labels are added and complex conditions such as ‘attitude(i, ‘ACCEPT’, drs2)’, ‘attitude(i, ‘BEL’, drs4)’ and ‘attitude(i, ‘INT’, drs6)’ are added (cf. Figure 1). To refer to the agent currently represented, the discourse referent ‘i’ is used. To refer to the other agent, ‘you’ is used. Inside DRSs, conditions are labeled according to the information type they represent. Inside DRSs, conditions are labeled according to the information type they represent. Assertions are marked by ‘a’ and presuppositions by ‘p’ in the intention DRS. Believed information is labeled ‘b’ inside a belief DRS, whereas accepted information is labeled ‘c’ inside an acceptance DRS. In addition, two clarification dialogue acts, namely ‘clarify’, and ‘explain’, are added to the DRT language, in order to deal with both clarification and explanation.

The intention DRS differs from the Belief and Acceptance DRSs in that the intention DRS directly links to the current utterance being represented, whereas belief and acceptance DRSs may include previous beliefs or accepted information. This is particularly useful in that the information represented in the intention DRS directly feeds into the speaker’s utterance, and is then inferred by the hearer through the linguistic utterance. The hearer’s intention DRS includes the inferred speaker intentions in uttering the current utterance. This gives the flexibility of being able to model information that the hearer has recognized but has not yet decided to accept or believe and, is therefore, not yet included in either the belief or acceptance DRSs. This is particularly useful for modeling clarification dialogues. For example, the hearer can withhold judgement over an utterance if he first requires clarification. Thus, the extended intention DRS will include the speaker’s recognized intentions, as well as the hearer’s intentions in asking for a clarification, without actually having incorporated the information in question into either the belief or acceptance DRSs when such information is in question or being clarified. The following section, 4, demonstrates an example of this suspended judgment of an utterance.

<table>
<thead>
<tr>
<th>i you</th>
</tr>
</thead>
<tbody>
<tr>
<td>drs2:</td>
</tr>
<tr>
<td>attitude(you, ‘ACCEPT’, drs3)</td>
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<tr>
<td>drs3:</td>
</tr>
<tr>
<td>attitude(i, ‘ACCEPT’, drs2)</td>
</tr>
<tr>
<td>attitude(i, ‘BEL’, drs4)</td>
</tr>
<tr>
<td>drs1:</td>
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<td>drs4:</td>
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<tr>
<td>attitude(you, ‘BEL’, drs5)</td>
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<tr>
<td>drs5:</td>
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<tr>
<td>attitude(i, ‘INT’, drs6)</td>
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<td>drs6:</td>
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</tbody>
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Figure 1: Extended DRT

4. Clarification Dialogue: An Example

This section details an example of a misunderstanding between two agents in a clarification dialogue, the purpose being to illustrate the relationship between dialogue acts and beliefs and their representation in relation to utterances in the extended version of DRT. The dialogue demonstrates the need for clarification as well as the consequences of feedback in relation to the strength of beliefs. In example (8), Player and Ros have different referents in mind, which causes a misunderstanding, resulting in the need for clarification.

(8) **Player1**: The old man thinks he’s in love with his daughter.

**Ros1**: (appalled). Good God! We’re out of our depth here.

**Player2**: No, no, no – he hasn’t got a daughter - the old man thinks he’s in love with his daughter.

**Ros2**: The old man is?

**Player3**: Hamlet, in love with the old man’s daughter, the old man thinks.

**Ros3**: Ha! It’s beginning to make sense!

(Johnstone 2002: from Rosencrantz and Guildenstern are Dead.)

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3 This example is from Tom Stoppard’s, ‘Rosencrantz and Guildenstern are dead’, which is based on Shakespeare’s Hamlet.
The following discussion focuses on the dialogue acts and beliefs expressed by this dialogue. In the first utterance by Player1, the speaker informs the hearer that the old man thinks Hamlet is in love with the old man’s daughter, think(oldMan, love(hamlet, daughter(ofOldMan))). In Figure 2, drs4 shows the speaker’s beliefs, drs5 the speaker’s beliefs about the hearer’s beliefs, and drs6 the speaker’s intentions in making the utterance and the immediate context of the utterance.

However, a misunderstanding over the right referent occurs as Ros, the hearer of Player1, wrongly recognizes the intended referent and assumes Player1 is asserting that the old man thinks Hamlet is in love with Hamlet’s daughter, think(oldMan, love(hamlet, daughter(ofHamlet))). Thus, in Figure 3, which represents Ros’s response to Player1’s utterance, Ros believes Player believes ‘has(h, d)’ and that ‘love(h,d)’, which is the cause of Ros’s appalled reaction. Accordingly, in Ros1, Ros indirectly asks Player to clarify. Figure 4 shows Player’s recognition of Ros1’s utterance. Player infers that Ros requires a clarification, which is represented by the dialogue act used in the intention DRS, ‘clarify’. This indicates to Player that Ros has not accepted nor believed the assertion, ‘Hamlet is in love with the old man’s daughter’. In fact, Player infers that there is a misunderstanding concerning who is in love with the old man’s daughter. Player recognizes that Ros misunderstood Player1’s assertion and Ros now believes Player believes ‘has(h, d)’ and ‘love(h,d)’, think(oldMan, love(hamlet, daughter(ofHamlet))). This is exemplified by the difference between Player’s beliefs, drs4, and Player’s beliefs about Ros’s beliefs about the Player’s beliefs, drs6. Whereas Player believes the old man thinks Hamlet is in love with the old man’s daughter, Player believes Ros believes Player believes the old man thinks the Hamlet is in love with Hamlet’s daughter.

As a response, in Player2, Player attempts to ‘explain’ to Ros that Hamlet does not have a daughter and ‘re-asserts’ that Hamlet is in love with the old man’s daughter, ‘No, no, no – he hasn’t got a daughter – the old man thinks he’s in love with his daughter’, think(oldMan, love(hamlet, daughter(ofOldMan))).

However, the use of ‘he’ does not help Ros, who ‘clarifies’ whether it is the old man who is in love with his own daughter: ‘The old man is?’. This time, Ros, the hearer, associates ‘he’ in ‘he’s in love with his daughter’ with the old man, rather than the intended ‘Hamlet’, think(oldMan, love(hamlet, daughter(ofOldMan)))). Therefore, Ros believes Player2 believes ‘has(m,d)’ and ‘love(m,d)’ – ‘m’ stands for the old man in Figure 5.

Ros2 gives rise to some interesting interpretations, but, the focus here is on the indirect request for clarification expressed by the Ros’s shock. As Figure 5 shows, Ros has

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4 Verbs such as ‘think’ and ‘believe’ are propositional attitudes. The beliefs embedded under them do not necessarily reflect the speaker’s own beliefs. This is why a sub-DRS is introduced to represent the old man’s beliefs at this point.

5 To help demonstrate the focus of a discussion, the relevant part of a DRS is highlighted in bold.
not accepted or believed that the old man is in love with his own daughter by virtue of the propositions not being in either the acceptance or the belief DRS. However, Ros believes that Player believes the old man thinks he is in love with his own daughter, drs5. Consequently, Ros requires a clarification for the oddness of the assertion.

**Figure 3: Speaker Generation: Ros**

Ros2 gives rise to some interesting interpretations, but the focus here is on the indirect request for clarification expressed by the Ros's shock. As Figure 5 shows, Ros has not accepted or believed that the old man is in love with his own daughter by virtue of the propositions not being in either the acceptance or the belief DRS. However, Ros believes that Player believes the old man thinks he is in love with his own daughter, drs5. Consequently, Ros requires a clarification for the oddness of the assertion.

**Figure 4: Hearer Recognition: Ros 1**

Player recognizes that Ros believes Player believes think(oldMan, love(oldMan, daughter(ofOldMan))) in figure 6. This is demonstrated in drs6 and drs6a by 'has(m,d)' and 'love(m,d)'. Consequently, Player, in Player3, 're-asserts' that it is Hamlet, this time saying 'Hamlet' instead of 'he', in order to 'explain' to Ros that it was Hamlet and not the old man who is in love.
Figure 7, represents Player’s recognition of Ros3. Ros indicates to Player that he finally understands and the message is clear. However, Ros does not commit to more than receiving the message correctly, which is why this is considered a case of ‘weak positive feedback’. The dialogue act, ‘weak positive feedback’ is added to the intention DRS, which represents Player’s inferred intention of Ros’s utterance and the immediate context represented by that utterance. In accordance with Speaker degrees of belief principles, principle 1, Player now infers Ros accepts rather than believes that the old man thinks Hamlet is in love with the old man’s daughter and adds this to Ros’s acceptance DRS, drs3. Now that the misunderstanding is cleared, the agents in the dialogue can resume talking about the topic of the dialogue, which is Hamlet’s assumed love for the old man’s daughter.

5. Conclusion and Future Work

This paper presented a computational extension of DRT in order to represent clarification dialogues. New DRSs to model agents’ beliefs, intentions, background and current context were introduced which required extending the DRT language to accommodate these extensions. The extended DRT employs implementable degrees of beliefs for agents involved in clarification dialogues, which
demonstrate the link between agents’ intentions and beliefs and dialogue acts.

References


